VOLUNTARY HARVESTING GUIDELINES FOR LANDOWNERS IN VERMONT

January 2015

Voluntary Harvesting Guidelines for Landowners in Vermont

Pursuant to Act 24 of 10 V.S.A. § 2750, adopted as the initial voluntary harvesting guidelines for private landowners to help ensure long-term forest health and sustainability on January 15, 2015 by Michael C. Snyder, Commissioner of Forests, Parks and Recreation.

Project Coordinator: Matt Leonard, Forester, Department of Forests, Parks and Recreation

Contributors:

Advisory Committee

John Austin	Vermont Fish & Wildlife Department
Jeff Benjamin*	At Large (University of Maine)
Diane Burbank	Green Mountain National Forest
Louis Bushey	Department of Forests, Parks and Recreation
Richard Carbonetti*	Vermont Sustainable Forestry Initiative
Beth Daut*	At Large (Consulting Forester)
Jamey Fidel*	Vermont Natural Resource Council
Chris Fife	At Large (Plum Creek)
Mike Fritz*	At Large (Landowner)
Phil Huffman*	The Nature Conservancy
Neil Kamman	Department of Environmental Conservation
Bill Keeton*	University of Vermont
Dan Kilborn*	Forest Guild and Vermont Land Trust
Bill Kropelin	At Large (Burlington Electric Department)
Leo Laferriere	Vermont Woodlands Association
Ward Mann	Vermont Forest Products Association
William (Bill) Moore	Legislative Director, Vermont Farm Bureau
Lisa Sausville*	Vermont Coverts
Bill Sayre*	Associated Industries of Vermont
Jim Shallow	Audubon Vermont
Bill Torrey	At Large (Logger)

*Also on the Technical Committee

Technical Committee

Rocky Bunnel	At Large (Logging Contractor)
Dale Covey	At Large (Plum Creek Forester)
MaryBeth Deller	Green Mountain National Forest
Steve Hagenbuch	Audubon Vermont
Paul Hamelin	Vermont Fish & Wildlife Department
Jim Kellogg	Department of Environmental Conservation
Jim Lathrop	At Large (Logging Contractor)
Betsy Lesnikoski	At LargeLarge (Burlington Electric Department)
Rose Paul	The Nature Conservancy
Gabe Russo	At Large (Logging Contractor/Forester)
Tom Yager	At Large (A. Johnson Company Forester)

Forests, Parks and Recreation Staff
Virginia Anderson, Chief of Forest Resource Management
Bill Baron, Forestry District Manager
Jeffrey Briggs, Forester III
Kathy Decker, Forestry District Manager
Paul Frederick, Wood Utilization Forester
Ed O'Leary, Forestry District Manager
Nate McKeen, Forestry District Manager
Alexandra Pastor, Administrative Assistant
Wendy Richardson, Administrative Assistant
Gary Sabourin, Watershed Forester
Barbara Schultz, Forest Health Program Manager
Steven J. Sinclair, Director of Forests
Ray Toolan, County Forester
Sandra Wilmot, Forest Health Specialist and Climate Change Coordinator

University of Vermont Extension Staff
Mary Sisock, Extension Forester

The Vermont Department of Forests, Parks and Recreation would like to acknowledge the hundreds of landowners, foresters, and logging contractors whose work in forest management and harvesting shapes the landscape of Vermont and the contents of these guidelines. Their professionalism and commitment to forest stewardship is demonstrated every day.

Voluntary Harvesting Guidelines to Protect Forest Health and Sustainability

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Voluntary Harvesting Guidelines for Forest Landowners in Vermont

Introduction

The Forests of Vermont

Forests dominate Vermont's landscape, covering 78% of the land. Vermont's forests support critical environmental services and provide habitat for a vast array of plant and animal species. Forests provide the recreation and aesthetic setting for which the state is famous, and economic benefits to forest landowners through a wide variety of forest products.

Eighty percent of the forest is privately owned. For thousands of people, forestland is one of their most valuable financial assets. It can be held to appreciate in value as real estate, and it can provide periodic income through timber sales. Landowners' decisions today determine the future of the forest just as past harvesting operations have had a strong influence in producing the forest we see today. It is critical that the state's many thousands of landowners sustainably manage and harvest their forests in a way that enhances and maintains forest functions and values and keeps forests as forests.

The forests of Vermont are as diverse as the landowners that steward them. They hold a variety of plants and animals that belies the state's small size. Vermont lies within a biological transition zone where the northern boreal forest meets the southern deciduous forests. Combined with a variety of features—from rivers to mountains, bogs, lakes, open land, and forest—our landscape is truly diverse.

Describing our forested landscape goes beyond the trees occupying the site; natural resource professionals consider bedrock, soil conditions, climate, and topography in classifying land. On a broad scale, Vermont's forested landscape can be divided into eight biophysical regions. Each region supports various natural communities.

Recognizing that forests are communities of interacting species and processes can help you protect them and all the benefits they provide.

What Are Voluntary Harvesting Guidelines?

The purpose of this guide is to provide you with a range of tools to guide your decisions and actions when planning and conducting harvesting operations. These recommended practices, or educational tools, are intended to be voluntary. These guidelines are NOT regulations and are not intended to be used to regulate land use or management. The guidelines do, however, incorporate and refer to regulatory provisions that landowners must comply with. There are several state statutes that regulate certain aspects of harvesting activities. For example, harvests supplying electric power generation plants need to be reviewed based on the particular facts and circumstances of each project.

This guide contains a variety of ideas and practices that will help you make decisions on how to care for and sustainably manage your forest. Working forests are an important cornerstone of Vermont's ecology, economy, quality of life, and identity.

There are many options for forest management. This guide cannot cover all of them, but it is intended to help people explore options, opportunities, and choices that are right for them.

Why This Guide and Why Now?
In 2013, the Vermont Legislature passed and the Governor signed into law Act 24, amending Act 170, the comprehensive Vermont Energy Act of 2012. Act 24 requires the Commissioner of Forests, Parks and Recreation to "develop voluntary timber harvesting guidelines that may be used by private landowners to help ensure long-term forest health and sustainability." As directed by the Legislature, the Commissioner and staff of the Vermont Department of Forests, Parks and Recreation "shall draft and adopt the initial voluntary harvesting guidelines by January 15, 2015."

We hope that these voluntary guidelines will provide forest landowners, and the professionals who work with them, practical recommendations and information to help make informed decisions when planning and conducting harvesting operations. Although we provide background information needed to support decision-making, the focus of this document is primarily operational, covering the forest health and sustainability issues you need to know and consider when conducting harvesting operations.

Why Are Forest Health and Sustainability Important?
Forestry has traditionally been defined as the management of forestland for human benefit. A continued flow of forest goods and services depends on maintaining healthy forests. Maintaining healthy forests, the productive capacity of the soil and water, the diversity of flora and fauna, and the interaction and relationship between all forest systems can sustain our forests and the goods and services they provide.

The Legislature directed the Department to develop voluntary harvesting guidelines that help ensure long-term forest health and sustainability. Healthy forests are highly resilient and capable of self-renewal. They maintain forest processes and are structurally complex, ecologically productive, and composed of a diversity of native plants and animals. Forest sustainability is described as the ability to maintain ecological and economic health, productivity, diversity, and overall integrity in the context of human activity and use, while meeting future and current needs.

How Were These Guidelines Developed?
The Department benefited from the participation of a broad array of participants in the form of an advisory committee and technical working groups, including representatives from landowner and industry associations, non-profit organizations, academia, and government agencies. A full list of individuals serving on the advisory and technical committees is included on the inside cover, and we greatly appreciate their time and helpful guidance.

Throughout the process, we held informational meetings, affording ample opportunity for public input and comment on draft guidelines. In addition, the Department maintained a project website that provided general information and updates throughout the process, including, but not limited to, notice of scheduled public involvement meetings.

The authors would like to acknowledge Karen Bennett, editor of *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* for her guidance and support. We drew heavily from the great work from our neighbors to the east.

Why Harvest?

This guide assumes that you will at some point consider harvesting forest products from your land. Such harvesting may be for personal firewood or building materials, for financial gain from selling forest products, for improved wildlife habitat, or some combination of purposes.

The most basic reason for harvesting is that our society depends on wood for many everyday needs. But harvesting is also an important part of the sound management of actively growing forests. It meets an array of landowner objectives, including generating income. Wisely planned harvests help forests thrive while maintaining and even enhancing wildlife habitat and opportunities for outdoor recreation.

Where Can Additional Help Be Found?

Many landowners have little knowledge about harvesting operations. As a result, they risk making uninformed decisions that can lead to negative consequences for their finances and their forest. Landowners may accept the first offer from a logging contractor for a harvest without having an estimate of their forest's potential value or its ecological attributes. Without understanding options for management, they may also unintentionally allow "high grading," which removes high-quality trees and leaves only poorer quality trees, severely reducing future options and potential.

It is highly recommended that landowners seek professional help. Vermont county foresters, employed by the Department of Forests, Parks and Recreation, are available to provide information and technical assistance about managing forestland, free of charge and without obligation. County forester offices are conveniently located around the state. If you are interested in harvesting, wildlife habitat, outdoor recreation improvements, or all of the above, your county forester can guide you. Although limited in the amount of field work they can do for any one landowner, they can accompany you on a walk in your woods to help you discover what is there, discuss your goals and objectives for the forest, and talk about what forest management activities you might consider. One of their most valuable services is to facilitate connections with private consulting foresters.

Securing the services of a private consulting forester to help plan for and oversee a harvest is a wise investment. Studies have shown that the long-term financial value of forests is enhanced when a consulting forester guides the management. Consulting foresters provide crucial guidance in harvesting trees at their maturity and not before, in choosing and supervising logging contractors, and watching out for your interests through the intricacies of a timber harvest.

Forests take decades to grow but can be degraded in just a few days of poorly conducted harvesting. These voluntary harvesting guidelines are meant to provide you with information and recommendations you should consider in making educated decisions about your forest. Well-planned and skillfully accomplished harvests help you

achieve your long-term wildlife, timber production, aesthetic, and recreational goals in a way that protects and enhances the value of your property. The decision to cut trees on your property is an important one; do not be rushed into a bad decision.

Quick Tips for Harvesting

This guide presents a wealth of information on sustainable harvesting and maintaining healthy forests. We realize that not all landowners want this level of detail. For those of you who want a quick guide, here is a checklist of steps to take and actions to avoid during your harvesting operation. These are the major points and not a comprehensive list. They will keep you on track for a successful and sustainable harvest. Use this as a handy checklist before, during, and after harvesting operations.

Preparing for Your Harvest

Steps to take

- Consult a forester from the Department of Forests, Parks and Recreation or a biologist from the Vermont Fish & Wildlife Department.
- Develop a forest management plan by working with a consulting forester.
- Conduct a pre-operation survey to determine the presence of invasive plant species.
- Clearly communicate your harvesting objectives to your logging contractor.

Make sure you avoid

- Harvesting without a written contract.
- Harvesting without understanding the laws and regulations that may apply to your harvest area.
- Harvesting without accounting for existing regeneration or taking steps to stimulate new regeneration.

Conducting a Harvest

Steps to take

- Have an on-site meeting with your logger and forester prior to the harvest.
- Follow your forest management plan. A plan is only good if you implement it.
- Ensure property boundaries and the harvest area are clearly marked on the ground.
- Mark with paint the trees that will be removed.
- Select the harvest system that best meets your management objectives and is suited to your site conditions.

Make sure you avoid

- Cutting the best trees and leaving only defective, deformed trees and undesirable species. The trees you leave behind will make up the next forest.
- Leaving safety hazards near recreational-use areas (snags, large dead limbs, etc.).
- Skidding on public roads and under utility lines.
- Compacting a large percentage of your forest's soil. Soil compaction can reduce site productivity for many years after logging, particularly on clay or silt soils. Moist soils are more prone to compaction than dry soils.

- Harvesting during excessively wet conditions.
- Harvesting on steep areas such as gullies, ravines, outcroppings, and cliffs; and in wet areas, springs, wetlands (including vernal pools), and streams when possible.

Protecting Water Resources

Steps to take

- Familiarize yourself with and follow the regulations entitled *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*. Ensure that acceptable management practices (AMPs) are implemented both during and immediately after harvests to protect water quality.
- Make sure your written contract includes measures to protect forest buffers along streams and other bodies of water.
- Follow the Vermont Wetland Rules as they pertain to logging in and adjacent to wetlands.
- At the close of the job, remove all temporary stream crossing structures as soon as possible.
- Construct stream crossings during periods of no or low flow and perpendicular to the stream's direction.
- Remove any tree tops cut in the harvest from streams or other water bodies.
- Place your log landing away from streams and other bodies of water and on a site that will drain well and stay dry.
- Locate and design skid trails and truck roads so they do not drain into the landing site.
- Stabilize exposed soil adjacent to streams by seeding and mulching.

Make sure you avoid

- Making bridges and culverts too small for high water. Avoid the temptation to undersize to save money. High water is a common event in Vermont.
- Causing ruts on roads and skid trails. Ruts disrupt the natural flow of water through the soil and cause soil erosion.
- Crossing streams more than necessary to bring forest products to the landing.
- Draining water carrying sediment and pollutants directly into streams or intermittent drainages. A discharge of sediment to waters of the state is a violation of state statute and regulations. Instead, divert it off into the surrounding vegetation to filter out sediment and allow it to soak into the soil.
- Driving a skidder into or through a wetland without implementing AMPs.
- Dredging, filling, or altering the natural hydrology of wetlands.
- Allowing oil, hydraulic fluid, gas, diesel fuel, or other chemicals to soak into soil or enter water bodies. Maintaining equipment will prevent leaks and save money.
  Using soil for fill, either alone or in combination with slash, for stream crossings.
- Using forest roads when they are wet, soft, and easily damaged.

Protecting Soil Health and Productivity

Steps to take

- Minimize exposure of mineral soil and maintain organic material during harvesting operations.
- Make a plan to retain some dead trees, fallen logs, and tree tops and branches for nutrient replacement.
- Minimize or avoid locating truck roads and skid trails on steep slopes when possible.

Make sure you avoid

- Skidding on shallow soils, unless under frozen ground conditions, and on steep slopes that are greater than 20% or when soils are wet.
- Removing tops or branches with leaves on them if the harvest is taking place on soils with low-fertility sensitive sites or have recently been harvested, or if utilizing shorter harvest intervals in your management plan.
- Harvesting on steep slopes.
- Safety issues. According the Natural Resources Conservation Service (NRCS), operators may begin to experience equipment limitations on slopes between 25% and 35% grade. They may be unable to operate equipment safely on slopes greater than 35%.

Biodiversity and Wildlife Habitats

Steps to take

- Become familiar with the natural communities on your land and the wildlife habitat your land provides.
- Contact the Vermont Fish & Wildlife Department if you have rare, threatened, or endangered species present on your property.
- When seeding and mulching exposed soil, be sure you are not spreading invasive plants.
- Tell your logger about special places where he/she should avoid harvesting or skidding. These include vernal pools and other unusual habitats.
- Plan your harvest to maintain or expand diversity in the trees that you leave including different sizes, ages, and species.
- Retain and create future snags, cavity trees, and legacy trees for their wildlife values.

Make sure you avoid

- Harvesting areas above 2,500 feet. You need a permit from your Act 250 District Environmental Commission to do so. We recommend reducing harvest intensity at higher elevations and on steep slopes.
  Compromising unique wildlife habitats including deer wintering areas, nesting sites, or areas with mast trees.
- Harvesting in or within 100 feet of vernal pools. Maintain a closed canopy when harvesting adjacent to this zone.

Planning for Change

Steps to take

- Plan to respond to invasive plants on your land that could spread following the harvest.
- Be aware of invasive insects and be ready to respond if you find any during the harvest.
- Improve forest resiliency by maintaining or increasing tree species diversity and forest structure elements.
- Cease operations in extreme weather events.
- Consider the future forest. Regeneration, whether already present or stimulated by the harvesting operation, should be your number-one priority. Protect what you have and harvest in a manner to encourage more of it.

Make sure you avoid

- Harvesting during or immediately following an insect or other pest outbreak. Wait to harvest a stand until at least 3 years after the last major year of defoliation.
- Responding prematurely to a forest disturbance like an ice storm or windthrow. Sometimes the best thing is to leave things alone as part of the natural process.
- Pre-emptively eliminating ash or hemlock from your forest mix if the emerald ash borer or hemlock wooly adelgid is not yet present in your area.

We go into greater detail in following chapters on each of the sections we have just covered. We hope that these quick lists will spark your interest to read further in the chapters to come.

Chapter 1: Preparing for Your Harvest

1.0 Introduction

Whether you own land for privacy, wildlife habitat, recreation, or to produce periodic income from forest products, a properly planned harvesting operation can yield a variety of benefits. Active forest management can enhance the values of forests by adjusting tree species composition, stimulating regeneration, and enhancing growth.

If you are enrolled in Vermont's Use Value Appraisal (UVA) Program (also known as Current Use) or the American Tree Farm Program, you have a forest management plan that considers the capabilities and constraints of the land, your overall management goals, and how to go about achieving them. Every forest landowner would benefit from a plan that outlines a long-term vision, especially if you are interested in harvesting, regardless of the purpose. A consulting forester can assist you with creating a forest inventory and map, writing a plan, and laying out and supervising harvests.

Vermont county foresters can help get you started. County foresters are state employees who can provide you with information about your forestland and what you might be able to do with it. They can refer you to consultants depending on your goals and objectives. A list of county foresters is available at the Department's website (www.vtfpr.org).

1.1 Landowner Goals and Objectives

Your ownership goals are the reasons you own your land. Spelling out those reasons will shape many decisions as you manage your forest. When setting your goals, list all your hopes and dreams for your property. Talking with your county forester, other foresters, wildlife biologists, logging contractors, family, neighbors, and friends can help you develop your goals. Foresters can help make sure your goals are realistic and achievable given the land's capacity.

With goals in mind, you can formulate more specific objectives, strategies, and actions. The more specific and measurable your objectives, the easier it will be to monitor and track whether you are achieving them. Be prepared to adapt or revise your objectives as you learn more about your land from your research and from working with your forester.

Keep in mind that your property is part of a larger landscape and may be affected by the characteristics of the surrounding land use. Similarly, your actions can affect conditions on nearby lands. Considering a broader landscape perspective is especially important when managing for wildlife habitat. Few forest landowners own enough acres to meet all the habitat needs of most wildlife species. The benefits for wildlife on smaller tracts may be highest if management complements conditions of neighboring properties.

1.2 Foresters and Forest Management Plans

You need to know what is actually present in your forest to develop a forest management plan and implement a successful harvesting operation. What species do you have? What are the size, age, abundance, arrangement, and condition of your trees? This information determines when, where, and how to harvest trees to meet your ownership goals and management objectives. Foresters can assist with gathering this information by conducting forest inventories and assessments. The information is used to evaluate the current composition, condition, and economic value of your forest and make management and harvesting recommendations. A forester can map your forest by dividing it into "stands," each one defined by trees of similar species, condition, and age. Different stands may need varying harvesting treatments based on the stand's type and condition. Foresters can help you with planning and oversight of harvesting. Working with a forester will protect your interests and the future of your forest.

There are primarily two types of foresters in Vermont who work with private landowners. County foresters are public employees who provide free technical assistance and stewardship guidance to any landowner as well as administering the Current Use program. They do not, however, write management plans for private landowners.

Consulting foresters are private contractors who work directly for a number of landowners. They offer an array of forestry services including writing forest management plans and designating (marking) trees to be removed during harvest operations. They work for a fee, but are usually well worth the investment to ensure the long-term health and value of your forest. You can locate a consulting forester by asking your county forester for a list of professionals in your area.

As with any professional service, it is best to ask for references. A consultant's livelihood is based on satisfied clients. Before choosing a consulting forester, talk with them on the phone or, better yet, in person on your land to see if you are comfortable with them. The forester you hire serves you and represents your interests in all matters

concerning your forest. Discuss the services you need and the costs associated with these services. Get the cost of services in writing.

There is no licensing or certification of consulting foresters in Vermont (2014), so there are no governing standards. However, the Society of American Foresters (SAF), the Forest Guild, and the Vermont Woodlands Association Certified Consulting Foresters Program have membership criteria, including professional forestry education and/or technical expertise. SAF also has national certification and continuing education programs for foresters. Membership in these organizations is often an indication of a forester's professional commitment, although it is neither a requirement nor a guarantee and there are non-members who may serve you well.

Consulting foresters can provide the following services:

- Conducting forest assessments and inventories.
- Preparing forest management plans, updates, and amendments.
- Appraising forestland and timber value.
- Locating and re-marking existing painted property boundaries.
- Preparing contracts for harvests and other forest management activities.
- Supervising harvesting operations and close-out tasks.
- Designing and supervising construction of woods roads and trails.
- Coordinating state/federal cost-share programs for a variety of forest improvement practices.
- Helping calculate basis, timber depletion, and income for tax purposes.
- Providing information and services for enrollment in Current Use and other programs.
- Integrating uses such as wildlife, Christmas trees, sugarbush development, or recreational trails into forest management plans and in ongoing management.

1.3 Legal Requirements

While this guide concentrates on voluntary tips, facts, and ideas to help you make your own decisions about your land, Vermont has laws and regulations that affect harvesting operations and the income that comes from it. Regulations are in place to protect water quality and rare, threatened, or endangered species. Understanding these laws is important to being a good land steward, and they may have implications for the timing and scope of your harvest.

Here is a list of legal issues/obligations that you may want to review or discuss with your forester and/or logging contractor prior to harvest. Information is available on the website of the department/organization as noted:

- *Acceptable Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont:* Landowners and their logging contractor are responsible for preventing discharges of sediment, petroleum, and logging debris into streams and water bodies during and after harvesting. Failure to do so results in violations of state water quality statutes and regulations with substantial penalty. (Department of Forests, Parks and Recreation)

- *Threatened and Endangered Species:* Under 10 VSA Chapter 123, the taking, possessing, and transporting of state-threatened and state-endangered animals

and plants are prohibited. If the activities of a project could affect a Vermont threatened and endangered species, a permit may be needed. (Vermont Fish & Wildlife Department)

- *Vermont Wetland Rules:* These rules protect the values and functions of wetlands and their adjacent buffers, including temporary or vernal forest pools. Timber harvesting is an allowed use, as long as the natural configuration and flow of water through the wetland is not altered by filling, dredging, or grading. (Vermont Natural Resources Board)
- *Lake Shoreland Protection Act:* A new law that limits activities including trails and harvests near ponds and lakes. The silvicultural exemption requires an approved plan prior to harvest activities. (Vermont Watershed Management Division)
- *Stream Alteration:* The Stream Alteration General Permit (SAGP) ensures that stream alteration activities are regulated in accordance with the requirements of 10 VSA Chapter 41: Regulation of Stream Flow. The stream alteration standards establish design requirements for structure span length, height, and embedment for permanent bridges and culverts on perennial streams. Following these standards will ensure stream stability by matching the dimensions of the structure to the natural stream channel. These standards apply to new or replacement structures that are permanent and are located on perennial streams. (Vermont Watershed Management Division)
- *Stormwater Discharge Permits:* These may be necessary for the construction of structures related to forestry, and cover storm water management. (Vermont Watershed Management Division)
- *Timber Trespass:* This law provides that a person who cuts, fells, destroys, carries away, or substantially damages the trees of another without the permission of the owner, may be assessed a civil penalty per tree or treble damages. When you conduct a harvest, you are responsible for clearly and accurately marking the harvest unit. Failure to mark the harvest unit may result in the assessment of additional civil penalties. (13 VSA Chapter 77, Sections 3606 and 3609)
- *Heavy Cutting:* Vermont statute requires you to file an “intent-to-cut notification” application and receive a determination of approval signed by the Department of Forests, Parks and Recreation if you plan to heavily cut 40 or more acres in one treatment. (Department of Forests, Parks and Recreation)
- *Fire Prevention/Slash Removal:* Slash—defined as portions of trees (leaves, twigs, branches, and wood chunks)—must be cleared for a distance of 50 feet from the right-of-way of any public highway or from the boundary lines of land of adjoining property owners. Slash must also be removed for a distance of 100 feet from standing buildings on adjoining property. (Department of Forests, Parks and Recreation)
- *Act 250:* Vermont’s land use law requires a land use permit for any logging operation over 2,500 feet elevation. Permits are issued by the District Environmental Commissions. The Natural Resources Board administers Act 250. (Vermont Natural Resources Board)
- *Use Value Appraisal (Current Use):* This only applies to properties enrolled in the program. Enrollees follow their forest management plan and report any harvest

activity, submit plan updates every 10 years, see that AMPS are followed, and

allow periodic conformance inspection by the county forester. (Vermont Division of Property Valuation and Review)

- *Town Ordinances/Zoning:* Ordinances and bylaws adopted by towns are not allowed to regulate silvicultural practices. Any that impose a forest management practice that result in a change for land enrolled in the Current Use program must be in properly designated zoning areas and protect specific natural, conservation, aesthetic, or wildlife features and must be silviculturally sound (as determined by the Commissioner of Forests, Parks and Recreation). Towns may restrict the use of curb cuts, bridges, and roads that may affect harvesting, and they may get involved with the siting of log handling areas or mills. (Vermont League of Cities and Towns)
- *Taxes:* In addition to the rules governing Current Use, federal and state tax laws may apply to harvests depending on your situation. (Vermont Department of Taxes; see also www.timbertax.org for helpful guidance)
- *Trucking:* There are numerous permits, limitations, and requirements that affect trucking in Vermont. This responsibility is typically handled by the log trucker. Contact your town for information on any local permits, restrictions, or contact rules.
- *Human Health and Safety:* Federal and state standards have been established to ensure the safety of logging industry workers. Logging is considered a dangerous occupation. Careful consideration of these standards and requirements is recommended before the commencement of any logging operation. [Vermont Department of Labor, US Department of Labor: Employee Standards Administration, and Occupational Safety and Health Administration (OSHA)]
- *Chip Harvesting Requirements for Vermont Public Utilities*: Wood-fueled electrical plants in Vermont are required to obtain fuels from contractors that adhere to the harvesting standards imposed by the Vermont Public Service Board. These same rules require forest owners who supply wood chips to these plants to obtain pre-harvest approval from the Vermont Fish & Wildlife Department.
- *Easements, Covenants, and Deed Restrictions:* These are legal documents and/or deed language that may limit or compel actions that affect harvests or land management activities. Agreements with third-party certification organizations may also direct some activities. Usually these items are attached to the deed for the land.

Research your deed and any easement, forest management plan, or other legally binding agreements and documents that cover the uses of your land to be sure you can harvest the way you intend. Visit your town clerk's office, particularly if you suspect there may be old agreements for access, timber, or water rights on your land or if there may be existing rights-of-way that you may need, or simply to confirm that there are no such constraints. You may also wish to consult with your attorney.

Be sure that you have any necessary permits or agreements in place for the duration of the harvest and through the close-out activities. Your harvesting contract should include language requiring that AMPs and other regulations will be followed during and after the harvest. It should also discuss safety issues and liability protections.

Make sure that your harvest complies with your Current Use plan. If it does not, prepare and receive approval of any amendments to Current Use plans before beginning a

harvest. The same holds true if you are enrolled in forest certification programs such as those offered by the American Tree Farm, the Forestry Stewardship Council (FSC), or the Sustainable Forestry Initiative (SFI), or if your property is encumbered by easements held by a land trust or the state through the Forest Legacy Program. Make sure your harvest is in compliance.

Be sure that both your property boundaries and harvest boundaries are adequately marked. As a courtesy, notify your adjoining neighbors before harvesting begins. If utility lines are close by and could be affected, talk to the power, phone, or other utility companies. Notify a recreational trail organization or your town if you anticipate needing to modify or close existing access during the harvest.

1.4 Planning a Harvest Operation

Pre-harvest planning requires good communication between the landowner, consulting forester, and logging contractor. The three parties need to understand and agree on the expectations for the harvest. Upfront planning can accommodate multiple goals and helps provide a clear understanding of what the harvest will be like.

Ask the following questions of your consulting forester: If forest products are to be sold, will it be by competitive bid, negotiated prices, or contract logging? How often will the consultant monitor the harvesting to assure that the job is done correctly? How will the volume of forest products sold be determined and by whom?

Discuss with your logging contractor and consulting forester where your harvested forest products will be sold, and for how much. Make sure you understand harvesting volume terminology (tons, cords, board feet) so that you know what your logging contractor will be paying you for.

The area of the harvest must be marked on the ground; the property boundaries, and the layout of truck roads, skid trails, and landing should all be clearly designated on a map and flagged on the ground. Walk these with your consulting forester and logging contractor. Understand the reasons for their placement and any constraints or challenges they may present. Discuss any special areas for protecting critical wildlife habitat and specific plans to use parts of the skid trail network for recreational pursuits after the harvest.

Have your consulting forester and logger explain the different silvicultural practices within each harvest area and the desired and expected outcomes of the practices to be implemented. The harvest area will look different once the harvest has been completed. Discuss with your forester what the area might look like post-harvest to avoid misconceptions.

Discuss the harvest schedule and timing. Harvesting is weather dependent, so some flexibility may be required. Discuss potential situations that may justify temporarily shutting down harvest operations, such as periods of prolonged wet weather or during mud season. Agree on the expectations for when and how long the harvest will take place. Agree on a payment schedule, and what is required for the close-out activities.

Make sure you understand safety issues related to roads, trails, or other uses of the

property during the active harvest. Agree on harvesting and trucking hours to avoid potential conflicts with neighbors.

Obtain a certificate of insurance from the logging contractor prior to the equipment arriving. It should have adequate levels of coverage that will protect you from liabilities related to the harvest while the operation is active.

All of these details should be spelled out in a contract. Contact your county forester for a sample contract.

1.5 Harvest Operating Seasons and Timing

Most harvesting activities take place during summer and winter in Vermont. Spring and fall are often too wet for logging. Avoid conducting harvests when soils are saturated with moisture. Harvesting operations conducted when soils are wet can lead to a host of problems, including impaired water quality, muddy and deeply rutted skid trails, and the movement and loss of forest soil and nutrients, as well as tree root damage that can impair tree health and wood quality and value.

Clearly define the harvest area boundaries. In the harvest area, identify ground surface features that might limit harvest activities, including rock outcrops, fragile soils, or steep slopes.

Assess the current access (truck roads, skid trails, landings, and stream crossings), to determine whether it is adequate to support the planned harvesting activities. Consult with an experienced forester, logger, or heavy equipment operator to determine how best to improve or construct access to be resilient to water and soil movement. Use the harvesting equipment that best suits the site and minimizes site disturbance and damage to the residual stand.

It is important to determine the soil type (consulting foresters can help with this). Harvesting on highly erosive soils and on soils that tend to retain moisture should be conducted only under frozen winter conditions or during the driest of summer conditions. Slope (steepness) and aspect (north-, south-, east-, or west-facing) can enhance soil drying conditions or cause soil moisture to be retained.

1.6 Choosing a Logging Contractor

Choosing a logging contractor is an important element to conducting a harvesting operation. Many contractors have years of experience working in the woods and ensuring that landowners' objectives are met. A logging contractor purchases standing trees from you, cuts them, transports them to the landing, and trucks them to market. According to the terms of the contract, he/she pays you based on the volume and value of what is sold. Sometimes the logging contractor is a third-party contractor, working for a mill or other buyer. Your relationship to the logging contractor is that of a seller to a buyer, not that of employer to employee.

If you have already engaged a consulting forester, he/she can be invaluable in helping you choose a logger because of past experience with a number of different loggers.

Consulting foresters can suggest contractors who meet certain standards of

performance or who use specialized equipment suitable for your site or conditions. The county forester can also help you make a good choice.

Your method of selling your timber can affect the way you choose a logging contractor. Sometimes contracts are put out to bid and awarded based on the bid price, the contractor's references and reputation, and the suitability of his/her equipment mix for the job. In other cases, contracts are negotiated between the landowner (or his/her agent, the forester) and the logging contractor.

You should take the same care in choosing a logging contractor that you use when hiring any professional. Once you have a prospective logger, visit his/her past jobs or ask for photos of them. Request the names of the last three landowners the logging contractor worked with, and visit with them. Ask the following questions:

- Did the contractor fulfill verbal and written obligations?
- Did he/she get the job done within the specified time limit? If not, why not? (Be aware that weather unsuitable for harvesting and equipment failure can cause unavoidable delays.)
- Did the contractor communicate well? Did the contractor explain, for example, any necessary changes in the operation? Was he/she flexible in responding to your needs?
- Was the contractor careful to avoid damage to trees, roads, fences, bridges?
- Was the site left in good condition (clean-up was handled well) when the job was done?
- Would you use the logging contractor for future harvests? Why or why not?

Be an informed consumer, particularly if someone approaches you with an unsolicited offer to buy your forest products. Check out the person's past jobs and reputation. Have a forester or another landowner with experience with logging look at any contract documents the person offers.

Foresters and logging contractors have different roles. Sometimes a single person performs both functions. Occasionally foresters and logging contractors work together as a package particularly if they are working for a buyer of forest products. In these cases, make sure that your interests are protected in contracts and during harvest operations. If you do not have a consulting forester or if you are considering working with a forester who is also a logging contractor, call your local county forester for advice.

Ask any prospective logging contractor about his/her certifications and trainings, and those of any crew members. Look for a contractor who has up-to-date training in first aid, safety, and environmental protection. Logging contractors are not required by Vermont law to be licensed, certified, or registered, but there are several voluntary logger education, training, and certification programs in which many logging contractors choose to participate. Many Vermont logging contractors participate in the Vermont Logger Education to Advance Professionalism (LEAP) program, which requires completion of a basic curriculum of workshops and has an ongoing continuing education requirement. New Hampshire and New York have similar logging contractor training initiatives.

1.7 Contracts and Insurance

A written contract protects both the buyer and seller and allows each to see in writing what is expected of them. A well-written contract clearly defines the conditions of the agreement and responsibilities for performance and expenses. Proper contracts are legally binding and help to clearly spell out the expectations and responsibilities of both parties.

Review and discuss the language contained in the harvest contract with your consulting forester and logging contractor on site before signing the contract. You may also want to consult with your attorney. Ask questions to clarify contract obligations or specifications you do not fully understand.

Every contract should reflect the needs and expectations of both parties at the time of the agreement. Certificates of insurance should be obtained from all contractors before work is begun.

A harvesting contract should include, but may not be limited to, the following:

- Names and addresses of the seller, the landowner, and of the buyer and/or logging contractor(s) to be engaged.
- The time period the contract covers as well as the date when the named parties signed it.
- Description and map of the parcel location and harvest area, with all important features including roads, streams, and areas requiring special treatment or protection clearly shown.
- Estimated volume description, including the number of trees marked for harvesting, by species and product type (saw timber is sold by the thousand board feet, pulp wood is sold by the cord or ton).
- A breakdown of the prices to be paid to you, the landowner, for harvested products.
- A payment schedule that describes when you should expect to be paid for the trees harvested. The number of payments and when they become due are often based on a percentage of the total number of acres and/or volumes to be harvested.
- A requirement for your logging contractor to provide a cash bond, bank draft, or letter of credit for the duration of the harvest to protect your interests, and to be returned to the logger at the successful conclusion of the harvest and contract. If the harvest is not done according to the contract, you can use this bond to repair damage or meet agreement deficits.
- General harvest operating conditions, including but not limited to the timing of operations in terms of season(s) and time of day.
- Special operating conditions specific to a harvest practice or how land requiring special protection is to be addressed.
  A clause assigning the responsibility of observing and conforming to all state and federal regulations to your logging contractor, including but not limited to, applying AMPs for maintaining water quality and controlling soil erosion. Be aware that the landowner is ultimately responsible.
- Close-out requirements: A description of the final condition of water crossings, skid trails, landing(s), and truck roads at the conclusion of the harvest. All close-out work should be completed before the logger moves equipment off site.

Logging is among the most difficult and dangerous occupations in the United States. Logging contractors work with heavy equipment and chainsaws, and they also deal with steep slopes, snow, rain, mud, wind, and extreme temperatures. The risks involved in harvesting include accidents resulting in injury, death, equipment damage, and property damage.

A landowner could be held liable if an accident occurs on his/her property during a contracted harvesting operation. Before harvesting begins, be sure you receive documentation from the contractor that he/she carries a package of insurance policies to protect himself/herself and you as the owner of the land being harvested.

Logging contractors should carry insurance that covers:

- *Workers' Compensation:* Protects the logging contractor in case of an accident that results in injury or death of the logging contractor or one of his/her employees.
- *General Liability:* Landowners should be listed on their logging contractor's general commercial liability insurance policy as an "additional insured party."
- *Automobile and Equipment:* Coverage designed to protect logging contractors more than landowners.

Landowners should require insurance certificates from their logging contractor's insurance companies that certify that the insurance cannot be canceled during the course of the logging operation unless a 30-day advance notice is sent by certified mail to the landowner.

1.8 Accounting for Regeneration

Regeneration refers to seedlings and saplings. These young trees are the future forest stand. Seedlings are the youngest class of regeneration, and are usually defined as trees thinner than 1 inch in diameter. Saplings range in size from 1 to 4 inches in diameter at 4 1/2 feet above the ground (a forestry term known as diameter at breast height or DBH). There are various silvicultural strategies used to promote or retain regeneration tailored to each species. The specific techniques and recommendations to favor specific tree and forest types can be found in publications called silvicultural guides. This section will focus on elements that can impact regeneration success for most tree types.

Before the harvest, conduct a forest inventory that includes data on the abundance, size, and species of regeneration present to help you decide on the type of harvest. Determine the species to regenerate, based on your objectives, site capacity, and the presence or absence of advanced regeneration. For example, light thinnings do not stimulate regeneration, but if you already have adequate advanced regeneration in place, it can work well. Manage for a diversity of tree species suitable to the site. If possible, time your harvest to occur in a year that your favored species have plentiful seeds. Consulting foresters can assist with these assessments.

When a harvest removes most canopy trees, consider leaving some mature trees to provide a future seed source and genetic diversity in the event that there is a regeneration failure following the harvest.

Two risks to regeneration stand out: non-native invasive plants (NNIPs) and over-browsing by moose and deer. In your pre-harvest inventory, ascertain the presence of NNIPs, which can crowd out desired regeneration. If invasive plants are present before the harvest, remove them to ensure successful regeneration of preferred species.

Deer and moose browse can be excessive in some areas of the state and have been responsible for regeneration failures. Deer prefer some tree species over others, so they can alter the forest composition. In areas with potential regeneration failures due to over-browsing, contact a forester for treatment advice.

By influencing site conditions, climate change may adversely affect regeneration success for some species, so plan for trees that can adapt to expected changes in moisture, temperature, or growing season.

Some species, particularly red maple and American beech, can regenerate by sprouting from stumps.

Chapter 2: Conducting a Harvest

2.1 Before Work Begins

Before harvest operations begin, meet on-site with your consulting forester and logging contractor. Walk the harvest area with them to be sure the contractor understands the infrastructure layout and knows the location of any important resources that require protection. Revisit any areas within the harvest area that present limitations or challenges in avoiding unnecessary adverse impacts to your forest.

Provide your logging contractor with a harvest map clearly showing property boundaries; the harvest area boundary; and the roads, trails, and landings. The map should also show streams, seeps, vernal pools, and wetlands, along with any other important resources such as rare, threatened, or endangered species; archeological sites; significant natural communities; or critical wildlife habitat that require special operating considerations or protection.

Discuss who pays for any infrastructure improvements necessary to conduct the harvest such as the construction of new skid trails, so there are no misunderstandings or unexpected related costs incurred by either party.

Document the limitations on the job:

- Ensure property boundaries are clearly marked to avoid timber trespass issues associated with your harvest. Foresters can assist with re-marking existing boundary lines prior to conducting a harvest. Foresters can also research deeds and help determine if a survey is required for your parcel if the boundaries are not clear on the ground. Only licensed land surveyors are allowed to establish boundaries common to another owner, when the corners or lines are not known or showing on the ground.
- Clearly mark the location and extent of the harvest area on the ground.
- Mark or flag the locations of truck roads, landings, and skid trails.

- Mark or flag water resources (streams, seeps, vernal pools, and wetlands) present on the parcel.
- Identify and mark or flag other important resources such as archeological sites; rare, threatened, or endangered species; significant natural communities; or critical wildlife habitat that require special operating considerations or protection.
- *Mark with paint the trees that will be removed.*

2.2 Acceptable Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont

The publication *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont* describes the forest practices required on all harvesting operations to ensure compliance with Vermont's water quality regulations. The regulations are published in a booklet format by the Department of Forests, Parks and Recreation for easy reference on logging jobs. Some practices in the publication are underlined. The intent of the underlined forest practices is to minimize the potential for soil erosion and discharges (soil sediment or logging debris) to state waters from harvesting operations. If a discharge results from failure to implement the underlined practices, you can face significant monetary fines.

Projects that involve fill or excavation of 10 cubic yards or more within the top-of-bank to top-of-bank, cross-sectional limits of perennial streams must follow standards set forth in the Vermont Agency of Natural Resources (ANR) Stream Alteration General Permit (SAGP). The purpose of this general permit is to ensure that all stream alteration activities are regulated efficiently and effectively in accordance with the requirements of 10 VSA Chapter 41. A link to the SAGP can be found on the ANR Department of Environmental Conservation Division of Watershed Management website.

Discuss all regulated forest practices related to water quality with your forester and logging contractor before operations commence. Under the Vermont Water Pollution Control Act, no person may discharge waste into the waters of the state without a permit. Therefore, landowners and loggers are responsible for correctly implementing AMPs just prior to, during, and immediately after logging operations. However, a landowner is ultimately responsible for any discharge that occurs on land he/she owns. Therefore, landowners should ensure that a logger working on their land correctly implements AMPs.

The Vermont Wetland Rules allow for silvicultural activities provided the configuration of a wetland's outlet, or the flow of water into and out of the wetland, is not altered and that no draining, dredging, filing, or grading has occurred. Go to the website of the Vermont Wetlands Division for the most up-to-date guidance on logging activity in and around wetlands.

The publication *Timber Harvesting in Vermont, Summary of Laws and Regulations* can be found at the Department of Forests, Parks and Recreation's website. It serves as a useful starting point for determining if permits are needed to proceed with a timber harvest. Landowners, logging contractors, and foresters should be aware of these laws and regulations.

2.3 Construction and Use of Truck Roads, Skid Trails, and Landings

Truck roads, skid trails, and landings make up the access infrastructure that makes forest management possible. Skid (or forwarder) trails are used to bring harvested materials to a landing for further processing and storage and are only intended to be used during the active harvest and then stabilized or "put to bed" until the next harvest. Landings are cleared, dry, smooth areas where harvested materials are brought from the woods, processed, sorted by forest product (logs/sawtimber, pulp/firewood, or chipwood/biomass), and stored until they are trucked to market. Truck roads allow log truck access between the landing(s) and town or state highways, so they must be built to a higher standard than skid trails. Because of the cost of construction, truck roads are often considered as permanent improvements to the property and should be constructed to allow repeated access over many years.

In addition to facilitating harvesting operations, the infrastructure can enhance a landowner's woodlot access and provide or improve forest recreation opportunities. The best protection of waterways and prevention of erosion is a well-designed, properly used, and well-maintained access infrastructure. It can also be the greatest expense of a harvest, especially on woodlands without pre-existing access infrastructure to serve the harvest operation. Making improvements prior to harvesting can be a good investment because it reduces logging costs over the long term, which can lead to higher timber sale revenues in future harvests.

When designing access infrastructure, make sure that the contractor understands any other activities for which the infrastructure is intended to be used after the harvest has been completed. Specific post-harvest activities such as hiking trails may influence the location of a road or trail as well as its grade, stream crossings, or drainage structures.

Lay out any new potential skid trails with flagging first, using the contour of the land as a guide. Record the new skid trails so they can be added to the map of the harvest area. Aerial photos and computer mapping applications can be useful tools when designing access infrastructure.

AMPs provide standards and recommendations for the location, construction, and proper drainage of roads and skid trails to prevent discharges of sediment into water.

A forester or logging contractor well versed in AMPs can lay out a road system that will minimize the potential for erosion, protect water quality and site productivity, and protect or enhance aesthetics while ensuring operational efficiency.

Keep in mind that stream crossing structures (e.g., culverts and bridges) that are intended to be permanent improvements left in place following logging, or that are on large streams, may need a Stream Alteration General Permit. A Vermont ANR river management engineer can determine when a permit is required.

Using existing road systems and landings may not be the best choice, especially if they were constructed many decades ago to meet the needs of the logging equipment of the time or were improperly located. At times these roads or trails are narrow, steep, or too close to streams.

Limit the overall footprint of the access infrastructure to only that which is necessary to effectively serve the harvest area in an effort to minimize potential for soil compaction and erosion.

Avoid steep areas, such as gullies, ravines, outcroppings, and cliffs. Avoid wet areas, springs, wetlands (including vernal pools), and streams, leaving adequate buffers between roads and water bodies or wetlands. Walk the entire harvest area to identify where potentially sensitive sites exist. Again, aerial photos and computer mapping applications can be useful tools to identify sensitive sites to avoid. You may also consult technical resources such as the online *Vermont ANR Natural Resources Atlas* to assist with identifying these sensitive sites.

Consult AMPs when installing drainage structures and sizing stream crossing structures. Consider the use of portable skidder bridges in place of other temporary stream crossing structures during logging.

2.4 Harvesting Methods and Equipment

Harvest method refers to the form that wood is in when it is brought to the landing, namely whole-tree, cut-to-length, or tree-length. The harvest system is the combination of equipment used to conduct the harvest. Many combinations of equipment can be used to conduct the same type of harvest. This section describes the three harvest methods and harvesting equipment commonly used in Vermont.

Harvest Methods

- *Whole-tree*: Trees are severed from the stump, keeping stem, branches, and tops intact and transported from the forest to the landing. The tops are then either turned into chips or returned to the harvest area.
- *Cut-to-length*: Trees are cut into final product lengths at or near the stump and then delivered to the landing as pre-processed forest products (logs, pulp, firewood, or chipwood).
- *Tree-length*: Trees are delimbed and topped at the stump and delivered to the landing as full-length stems only. They are processed into forest product lengths either on the landing or at the final mill destination.

Harvesting Equipment

Regardless of which method is used, the same steps must be taken to harvest trees, load them on a truck, and transport to a mill. Over the last 30 years, use of mechanized harvesting equipment has increased because of its increased output. As a result, the use of conventional manual harvesting equipment has decreased, though it is still used especially on steep, rugged terrain where mechanized harvesting systems are not practical. This section will describe some of the more common pieces of logging equipment currently used.

- *Chainsaw:* This is the most commonly known harvesting tool. They are manual, hand-held cutting devices with a straight bar and a rotating cutting chain.
- *Feller Buncher:* A feller buncher looks similar to an excavator in that it has tracks and a carriage with a fixed boom. Instead of a bucket at the end of the boom, a feller buncher has a harvesting head with a circular saw that can cut and accumulate several stems at a time, depending on size. One person operates the machine from the relative safety of the cab. The operator uses

the machine to lift the entire cut tree and carry it to the trail where it bunches trees for transport to the landing. Feller bunchers are 8 to 11 feet wide, can cut stems up to 24 inches in diameter, and can reach 20 to 25 feet from the center of a trail.

- *Harvester/Processor:* A harvester is a sophisticated machine that fells trees, removes limbs and tops, and then processes each stem into specific product lengths. The harvesting head has feed rollers that pull the felled tree through a pair of clamps or knives to remove the branches. A measuring wheel within the head determines both product length and stem diameter so that products are cut to pre-determined desired lengths. This machine is either on tracks or rubber tires, is 8 to 10 feet wide, can cut stems up to 20 inches in diameter, and can reach up to 33 feet from the center of a trail. Like the feller buncher, the operator works from a cab. In some cases, the harvester does not fell the trees, rather it simply processes stems already harvested. When it is used in this capacity the machine may be referred to as a processor. Since this particular type is a mobile machine, the processor may delimb and process products in the forest or at the landing.
- *Skidder:* There are two types of skidders in logging operations: cable and grapple. Both machines drag trees from the forest to the landing and have large rubber tires with an articulating frame for increased maneuverability. *Cable skidders* are typically smaller and work most often with manual chainsaw felling operations in the tree-length method. A series of short cables fastened to a winch through a mainline cable is used to secure the stems as they are dragged to trailside, and then to the landing. *Grapple skidders* work most often in whole-tree operations by dragging bunches of trees piled by a feller buncher as described above. Instead of a winch and cable system, a grapple skidder has a grappling device whose pincers grasp a group of previously felled and bunched trees, with tops and limbs attached. This machine can also be used to haul tops and limbs from the landing back into the forest, dispersing them in the harvest area for the nutrients they will add to the soils and to protect skid trails from erosion and compaction.
- *Forwarder:* A forwarder is a rubber-tired machine (6- or 8-wheeled) with a bunk to carry processed logs from the forest to the landing. Many forwarders are equipped with tracks that can be mounted onto the tires. The tracks provide better traction and in most cases have a lower impact on soils. Although this machine is most commonly associated with a harvester on cut-to-length operations, it can be used to transport logs that were manually felled and processed in the forest. Forwarders are 8 to 9 feet wide and have a boom with an attached grapple to pick up, load, and unload logs.
- *Delimber:* There are two types of delimbers in logging operations: stroke and pull-through. Both machines remove branches from the stem, typically on the landing in whole-tree harvest operations. Once the branches are removed the stem is piled for further processing or transportation directly to a mill as a tree-length product.
- *Loader and slasher:* A loader and slasher are used to process tree-length stems that are piled on the landing after being delimbed as described above or in the woods before being brought to the landing. The loader loads multiple stems into a bunk where a circular saw slashes them into specified product lengths. The loader then re-piles the products for transport to a mill.

- *Chippers and grinders:* It is increasingly common for commercial logging operations to also process tree tops and limbs (sometimes referred to as biomass, woody biomass, or chip wood) for use in electricity generation facilities or chip-fueled heating facilities. Biomass operations that occur on the landing typically use one of three machines: drum chipper, disk chipper, or horizontal grinder. These operations are usually associated with the whole-tree harvest method described above. Biomass or chip wood is not produced from all whole-tree operations. Sometimes the top wood and limbs of harvested trees are brought back into the woods and scattered.

Harvest Systems

Many combinations of the above machines can be used to conduct a whole-tree, cut-to-length, or tree-length harvest. A few of the more common configurations are as follows:

Whole-tree

- Feller buncher, Grapple skidder, Stroke delimber, Loader and slasher
- Feller buncher, Grapple skidder, Pull-through delimber, Loader and slasher

Cut-to-length

- Harvester (or Processor), Forwarder
- Chainsaw, Forwarder
- Feller buncher, Processor, Forwarder

Tree-length

- Chainsaw, Cable skidder
- Feller buncher, Stroke delimber (in woods), Grapple skidder, Loader and slasher

Harvesting operations are often conducted over difficult, steep, rugged terrain and under a host of conditions that challenge the best logging contractor. Determine what type of harvesting system is most compatible with the type of product being harvested and the unique and challenging features presented by the site. For instance, a small bulldozer could be used to bunch logs to a main skid trail, keeping larger skidders confined to well-built, well-drained skid trails.

2.5 Heavy Cutting

In 1997 the Vermont Legislature passed Vermont's Heavy Cutting Law. The law was enacted in response to public concerns about clear cutting and the potential environmental impacts these cuts might have on Vermont's forests. Known as Act 15, it requires landowners intending to heavy cut 40 acres or more to submit an "intent-to-cut notification" application to the Department of Forests, Parks and Recreation and receive a permit from the Department. A heavy cut is defined by state statute as "a harvest leaving a residual stocking level of acceptable growing stock below the C-line as defined by the US Department of Agriculture silvicultural stocking guides for the applicable timber type."

For more information on Vermont's Heavy Cutting Law, visit the Department's website. Harvest operations smaller than 40 acres in size and harvests where residual stocking is greater than the C-line do not need to submit an intent-to-cut notification application.

Contact your Department of Forests, Parks and Recreation Forestry District Manager for guidance in completing the application (http://www.vtfpr.org/htm/for_forstaff.cfm).

If the heavy cut harvest is not a planned treatment already approved in your Current Use plan, you need to file an amendment to your Current Use forest management plan with your county forester.

2.6 Harvest Administration

A harvest operation entails a number of administrative tasks typically handled by your consulting forester who is representing your interests. Effective harvest administration requires regular visits to the harvest site for communication and coordination with the logging contractor. Administration of harvesting operations should begin when the contractor's equipment is moved on site, and end when the last contract payment has been made, the bond has been returned to the contractor, and all conditions of the contract have been met, including adequate close-out activities to protect forest health and sustainability.

Along the way, the consulting forester monitors operating conditions on the ground to minimize unnecessary impacts or environmental damage in the harvest area. He/she inspects all equipment to ensure it is delivered relatively clean, free of soil and invasive plant materials, and is in good working condition, without fuel and fluid leaks, and has adequate safety equipment, such as a fire extinguisher. The forester oversees the construction of truck roads, skid trails, landings, and water crossings. He/she refers to the forest management plan for the parcel and ensures the harvest is consistent with the silvicultural practices outlined in the plan. On-site harvest inspections throughout the duration of the harvest help ensure that all regulatory requirements (including, but not limited to, AMPs) relating to logging are met during and after harvesting and allows for timely corrective actions when needed.

The consulting forester works with the logging contractor on a harvest close-out plan to stabilize the harvested area. On larger parcels, it is recommended to close out areas in which harvesting has been completed as operations progress, rather than waiting to do so at the end of the harvest.

2.7 Protecting Your Future Forest

Everyone would like to conduct each harvest without any damage to residual trees and root systems, but some damage is inevitable. The important thing is to minimize the amount of damage to your forest, keeping it as low as possible. A skilled logging contractor with the right equipment can minimize damage and the negative visual impact.

The performance of the contractor and the choice of equipment for the harvest can have a large impact on the condition of the forest after the harvest. It is important that the pole-size and larger trees left standing (residuals) and the seedlings and saplings (regeneration) incur as little damage as possible during the harvest.

Damage to residuals includes broken tops and branches within the crown, scuffed or broken bark, exposed wood along the stem, and exposed or severed roots. Damage may be caused as other trees are felled, by machines bumping or scraping against residual trees during harvesting or skidding/forwarding, and by compaction of soil along trails. Proper felling techniques and equipment operation can minimize this damage.

Mechanical harvesters with skilled logging contractors can minimize damage by directing where harvested trees are placed.

Designate bumper trees along skids trails, especially on corners. Bumper trees serve to protect existing and future sawtimber trees by assuring that the skidding of harvested trees does not damage trees outside the skid trail. Bumper trees can be left standing after the harvest if it is determined that they will survive and fill the same function in the next harvest; if not, they may be harvested or retained as future snags, cavity trees, or down woody material as long as they are located in areas not frequently used by people.

Regeneration can be damaged by harvesting machines as they maneuver from tree to tree to be cut, by felling trees on top of regeneration, or by skidding and forwarding activities on or beside trails. Seedlings and saplings are more vulnerable to equipment damage than tree felling. Properly laid out skid trails, directional felling, and conducting your harvest on snow-covered frozen ground can help minimize damage to regeneration.

2.8 Harvesting Aesthetics

"Beauty is in the eye of the beholder." What is aesthetically acceptable or pleasing to one person may be unattractive to another. If you harvest timber only a few times during your tenure of ownership, you may not be prepared for the visual changes that can occur. Before your harvest, ask your forester or logging contractor about visiting an active or completed harvesting operation elsewhere to get a better sense of what an operation on your property may look like. Alternatively, ask for before-and-after photos. Your contract should specify thresholds of acceptable levels of damage.

Some eyesores are avoidable, while others are not. It is important to know the difference. For instance, exposed earth is generally viewed negatively. Seeding and mulching exposed soil, especially on highly visible roads or landings, can help improve aesthetics and reduce the possibility of erosion. On the other hand, exposed soil can be used as a silvicultural tool to establish a seedbed for some tree species.

All bent, broken, and heavily damaged trees should be cut to make room for healthier trees and regeneration. Keeping stumps of harvested trees low can also minimize negative aesthetics.

The season of operation can affect visual impacts of a harvest. Snow and frozen ground minimize soil disturbance. Harvesting conducted during the period when trees are actively growing (late spring through early summer) can result in more serious tree wounds as a result of the tendency for bark to "slip" more readily during this time. Soils can be extremely fragile during this time of year. The potential for rutting, compaction, and erosion caused by harvesting equipment is greatest in the spring and early summer when soils are often saturated from spring snowmelt and rain.

Some harvesting practices that appear unsightly provide silvicultural or habitat benefits:

- Slash, the dead and down tops of trees, especially if left higher than 3 feet, is nearly always viewed negatively with respect to aesthetics. However, slash and large pieces of dead and down wood can enhance wildlife habitat, as well as

store carbon and enhance soil fertility. Leaving tree tops intact and not lopping them to the ground can help protect regeneration from damage as well as protect seedlings from over-browsing by deer or moose.

- Dense stands of saplings are often viewed negatively because these forests appear impenetrable, while herbaceous ground cover is generally viewed positively. From a forest management standpoint, however, dense stands of saplings are indicative of successful regeneration while herbaceous plants (especially ferns) can lead to unsuccessful regeneration and degraded forests.
- Leaving standing dead (snags) or dying trees provides habitat for birds and mammals.
- Much of the negative visual impact is short-lived and appears more acceptable over time.

Here are a few practices that can improve the look of a harvest:

- Residual slash or unmerchantable woody material left behind can be unsightly. Keeping maximum slash heights low in high-use areas will minimize negative aesthetics.
- Avoid logging during the active growing periods of late spring and early summer, when possible to help reduce tree wounding.
- Consider winter harvesting operations in highly sensitive (especially wet) areas to avoid soil disturbance.
- Suspend operations during extended wet periods to minimize mud on roads and landings.
  Use terrain and reserve patches in heavy cuts to make forest canopy openings appear smaller.
- Remove logging debris from landings after operations are complete. Seed and mulch landings and highly visible roads.

2.9 Managing Equipment, Fuel, and Lubricants

Equipment used in forest management activities burns diesel fuel and uses varied types of oil (e.g., hydraulic oil, motor oil, gear oil) and greases on a daily basis, all of which are considered hazardous materials. Spills of these materials into water, soil, or air are a hazard to the environment and must be avoided.

Some common-sense steps can be taken to minimize the risk:

- Equipment fueling, daily maintenance, and overnight parking areas should be located away from water resources.
- Make sure the logging contractor has a spill response kit on-site to allow for a quick response if a spill occurs.
- The logging contractor should maintain equipment on a regular basis during the harvest, and the forester should inspect equipment on regular site visits.
- The logging contractor should collect waste oil, hydraulic fluid, and other hazardous materials and their containers and transport them off-site for proper disposal either daily or weekly, depending on how much equipment is operating.

If a spill does occur, stop the spill at its source; prevent spills from entering waterways, drainage ditches, etc. Contain spilled material using a barrier, temporary dike, or trench. Petroleum spills or releases of 2 gallons or more must be reported to the Vermont

Department of Environmental Conservation at 1-800-641-5005. Failure to report a spill can result in significant fines and further legal action. Spills that enter waters of the state need immediate attention.

2.10 End of Harvest Close-Out Activities

Once a harvesting operation is completed, the changes made on the ground—such as skid trails, water crossings, and landings—may create conditions that could negatively impact the water and soil resources if not properly closed out. Refer to your contract for the conditions that the logging contractor must meet to complete the job. Complete all close-out work as soon as conditions on the ground allow. Ideally, this work should be completed when soils and skid trails are sufficiently dry.

Any ruts in skid trails should be smoothed to keep channels from forming and to divert runoff directly into vegetated buffer strips. Your consulting forester can help determine which skid trails need to be repaired. Your contractor should install diversions such as waterbars on trails before leaving a site permanently. If a trail is to remain open for use after the harvest, the logging contractor should prepare it for that use. For instance, broad-based dips may be better than deep waterbars for some trail use.

Your consulting forester can determine if any slash needs to be lopped down, removed from water resources, or pulled away from any shared boundary lines or neighboring buildings. Remove slash 50 feet from any abutting landowner boundary line or public highway, and 100 feet from any buildings on adjoining property. This is the time when you should ensure that aesthetic considerations have been met. Your logging contractor should sever leaning trees and smooth, seed, and mulch the landing area. Remove temporary water crossings, install waterbars, and seed and mulch the approaches to water crossings. Seeding and mulching roads and skid trails help to stabilize disturbed soils and minimize erosion.

Keep in mind that landowners are responsible for maintaining erosion-control devices after a logging operation is completed.

Chapter 3: Protecting Water Resources

3.0 Introduction

Water is a public resource, and it is your obligation as a landowner to protect the following water resources.

Vermont's **wetlands** are defined as “those areas of the state that are inundated by surface or ground water with a frequency sufficient to support plants and animals that depend on saturated or seasonally saturated soil conditions for growth and reproduction.” These areas are commonly known as ponds, bogs, fens, marshes, wet meadows, shrub swamps, and wooded swamps.

Wetlands often occur in association with lakes, ponds, rivers, and streams, as the transitional areas between dry land and open water. However, wetlands can also be isolated from any obvious connection to water when they occur where the topography

collects surface water, or where ground water surfaces. Some areas may simply be wet without actually meeting the above definition of a wetland, although they should still factor into your planning. Specific types of wetlands are as follows.

Bog: A peat-accumulating wetland with wet organic soils. It has a complete or near-complete sphagnum cover and a highly acidic pH value ranging from 3.5 to 5.0. It receives water primarily from precipitation.

Fen: A peat-accumulating wetland that receives mineral-rich ground water. Sphagnum may be present but not as a complete layer.

Marsh: A wetland dominated by herbaceous plants.

Swamp: A wetland dominated by woody plants, shrubs, or trees.

Seeps and springs: Small wetlands, usually less than 1/2 acre, often found on slopes or at the base of slopes in upland forests, where ground water discharge is evident.

Vernal pool: A temporary body of freshwater that appears in the spring or fall and provides important spring breeding habitat to many species of amphibians.

Rivers, streams, and brooks: These usually begin in the higher elevations, often from seeps and springs. Seeps and springs are simply places where subterranean water comes to the surface. This ground water is fed by precipitation.

As water comes to the surface it moves downhill and at some point turns into definable channels which, during certain times of the year, may be dry. These smaller feeder streams flow into larger streams and then into rivers, lakes, or ponds. The question is often asked, “When is it actually a stream?” There is no right answer, but the more important point is that any water, especially flowing water, needs to be considered when planning your operation.

Lakes and ponds: Lakes (and ponds) greater than 10 acres in size are subject to regulation under Vermont’s Shoreland Protection Act as well as existing water quality regulations. In addition, there are many smaller ponds in Vermont which also are subject to existing water quality regulations.

3.1 Wetland Protection and Management

Harvesting is allowed in wetlands in Vermont, but landowners must comply with regulations and management practices to minimize adverse impact. The Vermont Wetland Rules may apply not only to the wetland but also the buffer area around a wetland. Excessive rutting in wetlands may change surface water patterns, sever plant roots, and cause erosion. Even though the impact of your individual operation may be minimal, the cumulative activities over time of all landowners throughout a watershed may affect the integrity of wetlands.

Under the Vermont Wetland Rules, wetlands are classified into classes which have different levels of legal protections. Class I and II wetlands in Vermont have the highest

protection under the law. Any landowner with a Class I or II wetland needs to understand what these protections are.

Identifying Wetlands
Understanding what kind of wetlands you have, where they are located, and what you can do in them is critical. The wettest areas are often easy to spot and many landowners will choose to avoid such areas entirely, but other wetlands and their associated buffers may not be as obvious. The presence or absence of water cannot, by itself, always be used to make a determination. Refer to the ANR Wetlands Inventory Maps for general guidance. A link to these maps are located on the Department of Environmental Conservation Wetlands Program website. Not all wetlands are mapped, but in most cases the Vermont Wetland Rules will apply. Seek assistance from the Agency of Natural Resources Wetland Division for locating wetlands on your land. They can tell you what permit(s) you might need.

Seeps
Some seeps meet the statutory definition of a wetland and are subject to state wetlands regulations. Contact the Vermont Fish & Wildlife Department for help when planning forestry activities near seeps to avoid or minimize impacts to rare plants and exemplary natural communities. Harvesting near seeps may alter the natural community.
Lay out roads and skid trails in the spring or summer when seeps are most visible. Harvest near seeps when the ground is frozen to avoid rutting and keep tree tops and slash out of seeps.

Wetland Buffers
A wetland buffer is the vegetated upland area adjacent to a wetland. Wetlands can be surrounded by productive upland forests and may be affected by cutting along the wetland edge. Uplands bordering wetlands filter run-off, capture pollutants before they enter the wetland, and are critical to the survival of wetland-dependent wildlife. Be aware that wetland buffers are regulated under the Vermont Wetland Rules. The regulated buffer is 100 feet for Class I wetlands and 50 feet for Class II wetlands.

Leaving the understory adjacent to wetlands intact will benefit many wildlife species and protect water quality. Wetlands are usually best left unmanaged to allow for natural disturbance. Be aware that some wetland buffers are regulated under the Vermont Wetland Rules.

Consider leaving the area closest to the stream, pond, or wetland undisturbed. This will provide increased protection to aquatic habitats and allow a long-term supply of cavity trees, snags, and down woody material. Larger zones will increase the protection of non-timber values.

A buffer's effectiveness increases with its width. Sensitive wetlands require larger buffers to reduce the risk of disturbance. Consult the Vermont Wetland Rules, vernal pool guidelines located in the Vermont Fish & Wildlife Department's publication *A Landowner's Guide: Wildlife Habitat Management for Lands in Vermont.*

Buffers protect wetlands against rutting, which can change water flows. Tracks on equipment can cause less rutting than wheels. When logging in and near forested wetlands, avoid rutting and other damage by harvesting when the ground is frozen or

sufficiently dry to support the type of equipment used. Keep all logging equipment a minimum of 25 feet from any water. Use of “corduroy” or tree tops on skid trails can be effective in minimizing impact to the ground. Be aware that in wetlands these materials are considered fill and need to follow the Vermont Wetland Rules.

When harvesting, retain trees with cavities, standing dead trees, down logs, and large canopy trees.

3.2 Forest Buffers

A stream is a natural channel with a defined bed and banks, which may have flowing water year-round or only part of the year. Forest buffers are areas that border a stream, wetland, or water body and provide a natural mechanism to protect the water from adjacent land uses and activities. Forest buffers contain a mixture of trees, grasses, shrubs, groundcover plants, and a duff layer over a naturally vegetated and uneven surface. Soils are often more moist and nutrient-rich than surrounding uplands, so these areas often contain very diverse plant communities.

Stream buffer vegetation slows water and filters out sediment and other pollutants. Mature trees shade the water, helping to keep temperatures low by maintaining canopy cover. Large trees that fall naturally into the stream provide beneficial aquatic habitat. Additionally, the root structure of plants and trees within the buffer zone help maintain bank stability and reduce peak flows and the erosive power of streams by adding roughness during major precipitation events like spring snowmelt and flood.

Buffers that benefit aquatic species also provide habitat for many other types of wildlife. The forest provides insects, leaves, and coarse woody material to the food web along the entire stream course. Downed trees and branches are natural components of streams. Trunks and branches retain nutrients within the stream and keep excess nutrients from being flushed downstream. Coarse woody debris may create pools for fish and aquatic animals and may be used as refuges to avoid predators. Aquatic organisms benefit from decreased sedimentation and lower temperatures, while terrestrial species benefit from the landscape connections that these areas provide. Additionally, protection of the streambed allows it to continue its function of removing nutrients from water bodies. Forest buffers are the single best and simplest tool available to protect our waters.

There is no one ideal width of a forest buffer, but 50 feet is the minimum required by Vermont water quality laws. AMPs restrict operating equipment within 25 feet of streams and require continuous forest cover be maintained. If you wish to protect wildlife habitat, a larger buffer than those prescribed in AMPs is better. Wider buffers provide an opportunity for sediment to drop out as it moves across the landscape toward streams or wetlands. Forest canopy is critical in moderating stream temperature, particularly over narrower streams, because it can shade a large portion of the water surface. This is doubly important because these small streams feed cool water into larger streams and rivers, some of which are so wide a forest canopy only shades them minimally.

Water flows faster and is more concentrated on steeper slopes, so wider buffers are more important there. Wider buffers are also important in places with active stream channels, shallow soils, or higher elevations that get more precipitation. If you have

rare, threatened, endangered, or sensitive species, or sensitive significant natural communities, keep your forest buffer wide.

Always attempt to locate truck roads, skid trails, and log landings outside of buffers. Flag or paint the boundaries of the buffer area before timber harvesting occurs. Avoid or minimize the number of stream crossings for truck roads and skid trails that pass through a buffer. Keep the roads and trails as narrow as possible. Operate ground-based equipment when the ground is dry or frozen to minimize soil disturbance.

Consider using a two-tier buffer on all streams: an area of no cut and no machinery adjacent to the stream, bordered by an area of partial harvest.

3.3 Stream Crossings

Chances are good that you have a stream on your property, which means that your logging contractor will probably need to cross it. Stream crossing structures such as bridges, culverts, or pole fords are installed across intermittent and perennial streams to provide temporary access for logging equipment. When properly located, constructed, and maintained, stream-crossing structures can prevent damage to the bed and banks of streams and control the movement of sediment into the water.

Aquatic organisms move upstream and downstream at different times in their life cycles. The survival of a population depends on access to spawning habitat, feeding areas, and shelter as well as the dispersal and colonization of available habitat. Many species of amphibians, reptiles, and mammals use riparian zones as travel corridors. Their movement may be impeded by poorly constructed stream crossings.

Sediment and ice are also integral parts of stream systems. Movement of coarse woody debris and ice can block stream crossings causing sediment backup and erosion.

Streams are inherently dynamic. Natural processes in altering stream location and rate of flow over time can have dramatic impacts on stream crossings. Undersized crossings can become plugged with debris and sediment, leading to increased maintenance costs.

Watershed size and topography affect the flood potential. Consult with your forester or the Department of Environmental Conservation to make sure your crossing follows state and federal regulations.

Design, construct, and maintain stream crossings to avoid disrupting the migration or movement of fish and other aquatic organisms. Continuing the natural substrate of the stream through the culvert ensures aquatic organism passage. Open-bottom culverts and bridges maximize aquatic organism passage by maintaining a natural streambed.

Stream crossings ensure that the stream can flow normally while allowing access across them. Resist the temptation to undersize or to make do with the cheapest stream crossing. You can save money by planning the trail and road network to limit the number of stream crossings while not increasing the contractor’s skidding and hauling distances.

In building stream crossings, keep the following in mind:

- Install stream crossings using materials that are clean, non-erodible, and non-toxic to aquatic life.
- Minimize channel changes and the amount of excavation or fill needed at the crossing by selecting locations where the water channel is straight and unobstructed.
- Construct stream crossings during periods of no or low flow.
- Stream crossings should be perpendicular to the channel.
- Turn-ups, broad-based dips, or waterbars should be used to divert water off the truck road or skid trail on the approach to a stream crossing so that sediment does not directly enter the stream. Steeper approaches require more waterbars and more buffer area to filter out any sediment.
- Keep stream crossings clear and free of debris so that water can pass unimpeded at all times.

Common types of stream crossings are

Bridges may be permanent or temporary depending on whether you need access for long-term forest management and whether recreational or other uses are an objective. Bridges may be made of wood, metal, or a combination. Permanent bridges are often used on truck roads, while temporary bridges may be used on skid trails. When sited properly, bridges will not affect water flow and will reduce bank erosion. Build bridges high enough to allow high water flow beneath them.

The installation of a permanent bridge may cost more than that of a culvert upfront, but over the course of the life of a bridge the savings associated with the reduced need for maintenance and the potential cost for bridge replacement of failed culverts make it well worth it. Portable bridges on skid trails are an option to be used for the duration of a harvest.

Culverts are pipes or tubes usually made of corrugated metal or plastic installed in an intermittent or permanent stream to allow a truck or skid road to cross over. Improperly designed or sized culverts can block fish, other animals, and natural materials from moving downstream or upstream. Install culverts that are large enough to carry high water flow.

You can find culvert size guidelines in *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*.

Select pipe culverts that will extend at least a foot beyond any fill that is placed over the culvert. Size culverts so they can provide an uninterrupted flow of water, sediment, and down wood and ice. Protect the upstream end of the culvert from erosion by using rocks to armor the culvert inlet.

Poled fords are temporary stream-crossing structures made by placing logs side by side parallel to the stream channel. They are typically used on smaller streams. Avoid installing pole fords on soft-bottom streams. Poles will become embedded into the streambed when travelling across them with equipment, making them difficult to remove. Pole fords can significantly reduce the stream channel's capacity to carry

water so it is important to use larger-sized poles, 10 inches diameter or larger, to allow for water flow. Metal or plastic pipes can be used in conjunction with poles to provide for water flow.

Brushed-in crossings are another alternative but only allowed under AMPs when frozen ground conditions prevail. Install brushed-in crossings only on intermittent streams by placing poles in the bottom of the stream channel and then placing topwood (tree limbs and branches) over the poles. To avoid the use of brush, intermittent streams may also be frozen-in with snow during the winter creating an ice ford crossing. Inspect poled fords and brushed-in crossings regularly to ensure they are not obstructing stream flow.

3.4 Maintaining Water Quality

Sediment is the most common pollutant associated with harvesting. Sedimentation occurs when soil particles from runoff enter streams and other water. Sources of sediment include truck roads, skid trails, and log landings. Discharges of sediment, petroleum products, hazardous materials, and logging slash into state waters constitute violations of Vermont water quality laws and regulations.

Logging slash left in streams may block the flow of water in the stream channel and alter the natural course of a stream which can result in soil erosion and damage to infrastructure downstream. If trees are felled into or across streams or other bodies of water when harvesting, they should be immediately removed from the stream channel before being lopped and limbed.

Studies have shown that forest roads, skid trails, and log landings can account for as much as 90% of the erosion and sedimentation during a harvest. Anytime soil is exposed, there is a potential for soil movement from runoff and snowmelt.

Maintaining adequate forest cover on hillsides feeding into lowland streams can prevent costly erosion and flood damage by reducing the amount and velocity of water movement.

Do not operate logging equipment within 25 feet of streams to avoid soil disturbance and the potential for sedimentation. Remove timber within this zone by directionally felling trees away from streams or other bodies of water. Use a cable or reach into this zone with a mechanical felling arm or a forwarder/loader to remove trees. The steeper the slope near a stream, the wider the buffer and the lighter the cut should be to prevent erosion.

Truck roads, skid trails, and log landings comprise the transportation network that is necessary for conducting timber harvesting operations. To avoid excessive soil disturbance, keep the number of truck roads, skid trails, and log landings to a minimum. between 10% and 15%. This goal may be attainable on your parcel through good access planning. Eliminating unnecessary or duplicate skid trails, landings, and roads can reduce the surface area disturbed by logging, thereby decreasing the potential for erosion and sedimentation.

A well-timed harvest during frozen or drier times of the year can also reduce the surface area disturbed by logging, thus decreasing the potential for erosion and sedimentation.

Monitor and suspend operations during extreme wet weather events or whenever conditions are not suitable.

Brush-in wet areas to elevate equipment and minimize ground disturbance as a temporary measure to avoid further impacts to soils.

Immediately stabilize exposed soil on steep slopes and adjacent to streams by seeding and mulching.

3.5 Shoreland Protection

Vermont has more than 550 lakes and ponds greater than 10 acres in size. The Shoreland Protection Act regulates activities within 250 feet of the mean water level of these lakes. Its intent is to allow reasonable development of shorelands of lakes and ponds while protecting aquatic habitat and water quality, and maintaining the natural stability of shorelines.

Silvicultural (harvest) activities are allowed in a protected shoreland area if the activities comply with a forest management plan approved by the Commissioner of Forests, Parks and Recreation and follow AMPs. If you do not have an approved plan, you must comply with the Vegetation Protective Standards under the Shoreland Protection Act for tree removal within the 250-foot zone. Under these standards, existing vegetation must be measured using a plot system to determine how many trees must remain. Before harvesting near a lake or pond, review your plan to make sure water quality protection measures are in place throughout your job so that erosion and runoff do not reach the lake. More information is available at the Agency of Natural Resources Division of Watershed Management.

Because streams can deliver sediment to a lake, identify streams and other sources of runoff that will need to be protected and managed to prevent erosion from reaching a lake or pond. Studies have shown that adjacent tree canopy is critical in maintaining water quality in lakes and ponds, in preserving habitat in the water and on land, and in maintaining natural stability of shorelines.

Chapter 4: Protecting Soil Health and Productivity

4.0 Introduction

It is easy to see the different types of trees in your forestland, but not always so easy to see the foundation of that forest: the forest floor and the forest soil. Understanding the importance of the forest floor will form a basis for all the recommended practices in this chapter. Protecting and maintaining your forest soil during harvesting operations is vital for both your current and future forest. The forest floor is susceptible to disturbance during harvest operations, and careless or poorly planned harvesting operations may disturb the structure and, subsequently, the function of forest soils.

Compaction is most severe in truck roads, landings, and major skid roads, and can take large areas of land out of production for many years unless appropriate measures are taken during site preparation. New developments in equipment, such as feller bunchers with wide tracks, can reduce soil compaction; however, equipment choice alone cannot eliminate site disturbances, especially if harvesting is conducted when soils are wet.

Forest soils are dynamic and complex. Their physical, chemical, and biological attributes all play key roles in plant germination, regeneration, and overall stand composition. Soils are the basis of our forest and farm economies. Forest soils took years to build but can be damaged quickly through carelessness. Do not let that happen on your land. It is preventable.

4.1 Forest Floor

The forest floor provides habitat for many plants and animals, while it recycles nutrients, tree leaves, down wood, and plant materials to replenish and build the forest soil.

Soils are a mixture of organic and inorganic materials. The bedrock geology contributes much of the inorganic material, essentially pulverized rock. Much of this material was pushed down from Canada by the last glacier. As these glaciers melted, they formed a wide variety of water features, which moved material around in vast quantities and formed the basis of our very complex soils. Organic matter includes all of the parts of plants and animals, living and dead, in the top layer of the soil.

The forest floor provides soil structure, which helps minimize erosion. Buried within it is a bank of seeds vital for regeneration. It also provides habitat for vascular plants, lichens, bryophytes, and fungi, each of which are important to the diversity of your forest. Ecological processes that occur on and within the forest floor also depend on the overhead tree canopy. Changes to the canopy from harvesting or natural disturbances can affect the forest floor, but this can be mitigated through good planning.

The forest soils on your land are affected by biological activity and climatic conditions. Forest soils include the undecomposed litter of leaves, twigs, and small branches found on the forest floor. The structural characteristics of the forest floor—including litter composition, depth and density, and topography—also affect productivity and biodiversity. The forest floor is a major source of nutrients, especially for many shallow-rooted seedlings. Protecting the organic layer and minimizing exposure of the mineral soil can reduce adverse effects on soil health and productivity.

This is especially important because research indicates that years of acid deposition (emissions and oxidation of sulfur and nitrogen that are deposited on leaves or reach the soil through precipitation) have changed soil chemistry in some forests, most notably in high-elevation spruce-fir forests. The long-term effects of changes in soil nutrients are not well understood, but acid deposition strips soils of calcium and magnesium, which are essential for plant growth. It can shift the balance of soil elements toward aluminum, which is toxic to plants and trees.

Retaining organic material during a harvest mitigates the loss of the trees. It is also important to minimize soil disturbance from log extraction, and reduce erosion on roads and landings. Use longer intervals between harvests on sites known to be deficient in nutrients and organic matter. Although the growth of vegetation immediately following clear-cutting is usually rapid, you can still lose some nutrients in runoff.

Scraping to bare soil may be beneficial for the regeneration of certain species, but in other cases may be detrimental. Compaction should always be avoided. Track-mounted feller bunchers with low centers of gravity operate efficiently on slopes up to 20% and

usually cause less soil disturbance than rubber-tired equipment. It is important to avoid operations on wet soils. Research indicates that long-term harvest effects on drier soils are less and may be minimal in some cases.

Minimize skid-trail width by careful layout and using other trees as bumper or pivot trees which act to straighten out the hitch (bunch) of trees being skidded.

Establish skid trails that zig and zag to follow land contours for short distances, while limiting straight uphill stretches. On straight uphill sections, use waterbars and drainage dips to eliminate or reduce erosion. Recommended guidelines for the number and construction of these can be found in AMPs. Dropping slash in these steep roadways is another effective means of reducing the effects of compaction and erosion.

Suspend harvesting operations if deep ruts (especially those greater than 12 inches deep) develop on wet soils, or move equipment until drier or frozen ground conditions prevail.

4.2 Maintaining Soil Productivity

Forest growth depends on soil productivity, defined as the capacity of your soil to support plant, animal, fungal, microbial, and other forms of life. As rocks, minerals, and organic material break down, nutrients are released into the soils. Maintaining soil nutrients is essential to the health of both your current and future forest. One characteristic of a healthy forest is that it has more nutrients coming in than going out. Some loss of nutrients is unavoidable during harvesting because harvesting removes nutrients though the removal of biomass. Further losses of nutrients from soils by leaching and runoff from a poorly executed harvesting operation can and should be avoided.

Proper planning and execution of your harvest can help minimize short-term impacts associated with nutrient loss and limit long-term effects on soil productivity. Nutrient depletion directly affects forest productivity by reducing soil fertility and limiting the growth of trees and other plants.

The reduction in tree cover that occurs in a harvest results in less evapotranspiration (the process of water being absorbed by the roots of trees and released from the leaves) and causes increased water flows that could lead to erosion. Soil compaction also increases runoff. Erosion and runoff from a harvesting operation can accelerate the depletion of nutrient reserves and degrade stream water quality.

There is widespread agreement that the productivity of your forestland will be enhanced if woody material and organic matter are left to recycle nutrients back into the soil. Determining how many trees to harvest, how much of a tree to remove, and how much slash or woody material to leave are all important considerations to help reduce nutrient depletion and maintain soil productivity, wildlife habitat, and water quality. When harvesting, minimize nutrient and organic matter depletion. Leave the site in a condition to sustain and replenish long-term soil productivity. Minimize ground disturbance as much as possible.

Take precautions to avoid soil erosion, compaction, and nutrient depletion by harvesting during the winter months, when the ground is snow covered and frozen, or in the driest months of late summer.

Your local office of the Natural Resources Conservation Service (NRCS) has maps and information on soils throughout Vermont. They have a web-based internet tool at NRCS, the Web Soil Survey, that provides up-to-date information, complete with soil mapping, types, and descriptions. This will be helpful as you prepare your plans with your consulting forester and logging contractor as it provides information on slope and susceptibility to erosion.

There are three harvesting methods: whole-tree, cut-to-length, and tree-length. Whole-tree harvesting requires careful consideration before using it. This harvesting is a method of harvesting that severs the above-ground tree, including the main stem and branches, but not the stump and roots, and removes it to a landing. Because it removes all of the above-ground biomass, it could lead to a decline in forest health in some situations. Most researchers have found that significantly greater short-term (3 years) nutrient loss occurs from whole-tree harvesting than other methods, but there is less agreement about the long-term nutrient loss (the longest studies are up to 35 years following whole-tree harvest). The effects of multiple whole-tree harvests over time on the same site have not been adequately studied.

Although foliage (leaves) comprise only a small portion of the total above-ground biomass of a tree, they—along with branches and twigs—contain the most nutrients. Fallen leaves recycled back into the soil return important nutrients to the site and help to to maintain long-term productivity. Whole-tree harvests conducted when leaves are off remove less nutrients from the site.

The potential impacts of whole-tree harvesting on site productivity are variable and site-specific, which is why you need a well-thought-out plan when using this method. Nutrient concentrations of soils and distribution in trees vary by species, age, climatic conditions, stand density, season, and site quality. All of these can influence the amount of nutrients removed by harvesting.

Ground disturbance from dragging whole trees out to the landing can be greater than other harvesting methods, especially if not done on frozen ground. Whole-tree harvesting also can decrease biodiversity by reducing structural complexity. Sites that had been whole-tree harvested demonstrated significant decreases in density of snags and large live trees, and reduced volumes of well-decayed down woody material.

Whole-tree harvesting can in many circumstances be the best option. Where there is little economic value because of poorly formed trees, a whole-tree harvest can provide a fresh start to a forest. It can be beneficial if your objective is to provide a mineral soil seedbed that some tree species need for germination. It can make a harvest area more visually pleasing by removing slash, which also makes the area easier to access for recreational use.

Given this, here are some things to consider when deciding whether to use a whole-tree harvest:

- The amount of nutrient loss from the harvest area when whole-tree harvesting is employed to conduct a thinning or non-clear-cut harvest is less than when clear-cutting.
- Utilize alternatives to whole-tree harvesting if shorter harvest intervals are prescribed in your management plan, or if you plan to harvest on low-fertility or other sensitive sites. No matter which harvest method you use, minimize the removal of tops, branches, and twigs on such sites. Leaving some amount of severed stems and tops on the site can reduce impacts associated with nutrient loss.
- Utilize alternatives to whole-tree harvesting on sites that have recently been harvested and are being re-harvested.

There are ways to reduce the potential nutrient loss:

- When utilizing whole-tree harvesting, return and distribute an appropriate amount of tree tops to the harvest site.
- If you choose to use the whole-tree harvest method, manage the effects by working with your consulting forester to cut fewer trees per entry or lengthen the time periods between harvests on sites that have previously been whole-tree harvested.

4.3 Retaining Down Woody Material for Sustaining Soil Health and Productivity

One of the best ways to avoid nutrient depletion and promote long-term soil productivity during a harvest is to focus on retaining down woody material. In addition to enhancing soil productivity, down woody material provides a number of other important benefits, including shelter from browse for regenerating trees, stability for slopes and stream banks, heightened site moisture during dry periods, and habitat for a wide range of wildlife species.

Down woody material includes fallen trees, dead branches and twigs, and large fragments of wood and bark on or near the forest floor. Although woody material occurs naturally, you should consider strategies to retain and augment it. Woody material resulting from the harvest operation can be left on site by severing it in place. You can increase the future supply of dead trees that will fall over and become down woody material by identifying and leaving those trees standing.

Nutrient concentrations are highest in the leaves, branches, and twigs of trees. The tree's stem contains the lowest concentration of nutrients but the largest amount of organic matter. Organic matter is an important contributor to forest processes. Decaying wood cycles nutrients that are essential for the regeneration of small trees, provides a substrate in which insects are active and available as food for wildlife, and creates cavities to shelter wildlife.

The stump and root system contribute to nutrient retention and increase soil stability. Like other parts of the tree, they hold soil on site, reduce erosion potential, and enhance soil structure.

Forested sites naturally contain a combination of live trees, dead snags and down coarse woody material (3 inches in diameter or larger) and fine woody material (less than 3 inches in diameter). Amounts of down woody material vary by site, age of the forest, and tree species composition. Large dead trees left standing or cut on the forest floor can help build soil organic matter and are essential wildlife habitat for insects, birds, and mammals.

Ways to enhance the down woody material in your forest:

- Plan to leave a variety of sizes of down woody material and leaves in the forest during and following harvesting operations.
- Monitor cutting practices during the harvest to ensure that the amount of woody material being removed is not more than your plan calls for. Retain leaves and down woody material of all sizes, evenly distributed across the site. If you are harvesting one third or less of your trees you should try to retain at least one fifth of the harvested tree tops. If removing more, retain one third of the harvested tops. Retain more material on poor quality sites if it is practical.
- Minimize disturbance to the leaf layer, and keep stumps and roots of harvested trees as intact as possible, except where scraping to bare soil is needed for regeneration.
- If woody material is lacking, consider leaving newly cut logs scattered across the site. Leave trees with the least economic value. An ideal target would be to leave three to five stems at least 18 inches in diameter and 10 stems at least 14 inches in diameter per acre. All of them should be at least 16 feet long.
- Recycle woody material (bark, twigs, tops) that accumulates on the landing by returning it to the harvest site on return skidder trips.
  Plan to retain standing dead and decaying trees (having obvious decay cavities or holes) in the harvest areas. Targets should be a minimum of four trees per acre that are greater than 14 inches in diameter and two per acre that are greater than 24 inches.

4.4 Soil Compaction and Rutting

Soil compaction and rutting can reduce soil productivity and alter surface water movement. This can affect tree growth, quality, health, and the biodiversity of the forest floor.

Some skid trails are used repeatedly during the course of a timber harvest and others only a few times. Repeated passes of heavy equipment over certain types of soil or during wet conditions can lead to soil compaction and rutting. Compaction is the compression of soil caused by a load (or by pressure) that exceeds the strength of the soil to resist it. Soil compaction is usually not visible from the surface. Ruts are trenches or furrows created by machine tires or tracks. Rutting displaces soil and damages soil structure by impeding root development and soil drainage. Rutting can sever or damage roots, which can lead to decay, stain, reduced growth, and mortality.

Two factors contribute to the likelihood of compaction and rutting on skid trails. The first is soil texture and the second is the amount of water present. Soils that are less prone to compaction when ground conditions are dry or frozen may be very susceptible when the soil is saturated.

The amount of water in soil varies with the season, the weather, topography, and soil type. In general, soil moisture is greatest in the spring as trees begin the year's growth and in fall as trees go into dormancy. Work in areas that are most susceptible to erosion or compaction during the best conditions: dry, snow-covered, or frozen ground.

While activities of soil organisms and natural soil processes such as freeze–thaw cycles help restore compacted soils to near pre-harvest conditions, the rate of recovery often takes many years and depends on soil type, soil depth, and degree of compaction. It is better to avoid compaction as much as possible.

Avoid making deep ruts (12 inches or greater), which are usually detrimental to regeneration and frequently present a severe erosion threat because they can divert and channelize surface and subsurface water flows.

4.5 Erosion Prevention

Many parts of Vermont have steep slopes. Whenever soil on steep slopes is exposed or disturbed, especially from harvesting equipment, it has the potential to run off when it rains. Soil on steep slopes, especially at higher elevations that are shallow on top of bedrock, is especially fragile and prone to erosion. Your consulting forester can determine your soil type and average depth of soil and plan your equipment and skid road layout accordingly. Some soil types are more prone to erosion than others. Coarse-textured soils, such as sand or gravel, are less prone to erosion than fine-textured soils that contain portions of clay and silt. Deeper soils will be better drained than shallow soils, thus less prone to rutting. Steep slopes, fragile soils, or wet areas can be protected from erosion by maintaining adequate numbers of trees and canopy cover.

Compaction on steep slopes will greatly increase runoff. Avoiding soil compaction on steep hills and mountainsides is critical. The best practice is to avoid operating on such slopes.

It is also a safety issue. According the Natural Resources Conservation Service (NRCS), operators may begin to experience equipment limitations on slopes between 25% and 35% grade. They may be unable to operate equipment safely on slopes greater than 35%.

Waterbars on steep slopes and unfrozen ground are difficult to maintain because skidder tires are more likely to lose traction when travelling over them, damaging the waterbars and loosening the soil. The loose soil will then be carried farther down slope when hitches of wood are dragged over them. In time, an inverted trail profile or "dug-way" may develop making it difficult to divert runoff from the skid trail during the current or future logging operations. Forwarders may not be practical on steeper, uneven slopes.

We recommend the following steps to control soil erosion:

- Avoid steeper road grades that will require more erosion control measures and maintenance.
- Avoid or minimize locating truck roads and skid trails on steep slopes when possible.

- Grades on truck roads should be kept under 10% or to the minimum grade practical. Sections greater than 10% grade should not exceed 300 feet in length. On those portions of truck roads with steep grades, apply a surface coat of gravel or crushed stone to avoid erosion and rutting.
- Keep skid trail grades as gradual as the topography will allow. Short, steep sections of skid trails up to 25% grade should not exceed 300 feet in length.
- Incorporate grade-breaks on steep sections of skid trails by turning the road slightly downhill for a short distance before continuing upslope. This will allow surface runoff to be diverted into a vegetated area by creating a dip in the trail. On skid trails, install log-reinforced waterbars on downhill approaches to steep slopes. Install them at a 10-degree downhill angle to the skid trail to divert runoff and for ease of getting over them with equipment.
- Stabilize steep sections of skid trails during logging by armoring with logging slash and lopping tops.

Chapter 5: Biodiversity and Wildlife Habitat

5.0 Introduction

Conserving your forest's native biodiversity is challenging, but it is vital to overall forest health and sustainability. A forest with diverse plants, animals, and forest conditions enhances forest health and productivity and increases its value within the larger forest landscape. Harvesting can degrade habitat features, but it can also enhance them. Knowing what habitat features and conditions you have is the first step in the process.

Extensive information is available on how to manage for individual wildlife species. The best source is the Vermont Fish & Wildlife Department, which offers a reference for managing wildlife habitat: *A Landowner's Guide: Wildlife Habitat Management for Lands in Vermont.* Often these techniques benefitting single species can be integrated into an overall plan that can enhance biodiversity and benefit a wider variety of species.

Contact the Vermont Fish & Wildlife Department for more information on any of the habitat considerations or recommendations in this chapter.

5.1 Natural Communities

A natural community is an interacting assemblage of plants and animals, their physical environment, and the natural processes that affect them. These assemblages of plants and animals repeat across the landscape wherever similar environmental conditions exist, and can be described as natural community types. The community is the actual place on the ground; the community type is the recognizable, repeating pattern. The Vermont Fish & Wildlife Department recognizes over 90 upland and wetland natural community types in our state. Natural community typing is a powerful tool for describing the landscape, developing sound management plans for land, determining conservation priorities, and increasing our understanding of the natural world.

As your forest grows over time, it goes through stages of succession. Natural community types are based on the vegetation that will be growing in your forest in the mid- to late stage of succession, not necessarily what is there now. In other words, natural community types are what your forest will become. For a property in an early

stage, such as old-field pine (pine that grew in after a field was no longer farmed), understanding the future natural community type provides insight into the potential vegetation of the site. This can be very helpful in making forest management decisions that work effectively with natural succession and the physical realities of each site.

Some community types are common, others rare. Based on the rarity of the natural community type and the quality of each natural community example, the Vermont Fish & Wildlife Department considers a subset of the best examples of each natural community type to be state-significant. Significant natural communities are mapped in the Department's Natural Heritage Database.

The six largest, most common forest types that dominate the Vermont landscape are known as matrix forests. Northern hardwoods is an example, along with montane spruce-fir. Smaller communities are found in patches within these larger types. Most of the broad matrix forests are conducive to responsible harvesting. Smaller and rare natural communities are generally much more sensitive to disturbance from logging.

Some communities are very dependent on specific conditions such as quantity and quality of water. Even small changes to these conditions such as harvesting or ground disturbance can alter their species composition and overall quality. Other communities are more resilient. Some geographic areas of Vermont, such as the Champlain Valley, have more rare and small-patch natural communities than other regions.

If your land contains a rare and uncommon natural community determined to be state-significant by the Vermont Fish & Wildlife Department, you could enroll it as an "ecologically significant treatment area" (ESTA) under the Current Use program. An ESTA does not require harvesting. Contact your county forester or the Vermont Fish & Wildlife Department's state ecologist.

Ask your consulting forester to list or map the natural communities that occur on your property as part of your forest management plan. Identify any state-significant natural communities and plan for their conservation in developing the management plan. Contact the Vermont Fish & Wildlife Department for assistance in identifying and planning for any state-significant natural communities.

Most rare and small-patch natural communities produce little valuable wood and are easily disturbed by harvesting activities. Design harvests to avoid and buffer these areas. For common and widespread forested natural communities that are in poor condition, responsible harvesting can improve ecological conditions by enhancing forest structure and restoring native species composition.

Maintain or enhance the native species composition of trees, shrubs, and herbs that are appropriate to the site and natural community type.

5.2 Forest Stand Complexity

A variety of trees—in terms of species, density, diameters, and heights—supports biological diversity. Some landowners own enough land to manage for diversity within their property. Most landowners with smaller holdings can still manage for diversity by

paying attention to surrounding properties and seeing how your property fits into the larger landscape. Maintain a full complement of native tree and shrub species in a forest stand or natural community.

Inclusions (groups of trees dissimilar to the surrounding forest) are an important means of enhancing diversity. You can create a forest with different sizes and heights of trees by maintaining or creating inclusions of overstory trees that are different from the surrounding forest.

For example, you can retain a patch of hemlock in a pure hardwood stand or patches of oak in a pine stand. Inclusions of different forest types and trees of different sizes and heights provide feeding, nesting, and shelter that may not occur in continuous stands of a single forest age and type. Softwood inclusions within hardwood stands (spruce or fir within a maple stand, for example) often attract deer, moose, and some furbearers. Look for native species not commonly found in the stand and unique stand features, such as a group or patch of larger diameter stems or of different ages that may be part of a different stage of a natural community type.

Look at your woods with an eye for any existing inclusions by searching for patches of unique stand features. Where inclusions exist, maintain or regenerate them. Leave an inclusion unharvested if it is small (1/4 acre or less) and the volume of wood generated from its harvest would be limited. Be conservative when harvesting on sensitive sites such as wet areas or shallow soils over ledge.

Create new inclusions in large uniform stands if site conditions allow, and if appropriate to the site/natural community. If you are thinning a uniform stand, cut the groups of trees rather than single trees to create patches of young growth.

To maintain some age diversity when conducting a regeneration cut, consider leaving uncut patches within the harvest area. Patch size should start at a minimum of 1/4 acre. Use cavity trees (live trees with existing holes or hollowed out sections) exceeding 18-inch diameter at breast height or active den trees as nuclei for uncut patches, aiming for at least one cavity tree per minimum patch size, or four per acre-sized patch. Incorporate inclusions with other desired habitat features such as buffers, seeps, vernal pools, or a large legacy trees.

Removing the trees surrounding an inclusion may put it at risk of blowdown, sunscald, and other damage that would reduce its value. Leaving too small a group or just one inclusion on unstable soils could defeat the purpose of having them.

Buffer softwood inclusions to provide wind protection. Plan to leave an edge of standing trees 80 to 200 feet wide on the sides exposed to prevailing winds.

Inclusions can often be located in areas where they do not take away from your economic return. These are areas you might not harvest for other reasons, such as an area of difficult terrain or in a buffer area.

5.3 Snags, Cavity Trees, and Legacy Trees

Retaining snags and cavity trees provides essential habitat for a wide range of wildlife in Vermont, including woodpeckers, owls, squirrels, fisher, bats, and many other species.

Maintaining an abundance of snags and cavity trees in a diversity of diameters offers a range of habitat characteristics important for roosting, nesting, and feeding. Legacy trees are large diameter (often 24 inches or greater) living trees that are extremely limited on the landscape and provide unique habitats for those wildlife species that require larger trees.

These forest features are important, and many acres do not have enough of them. Planning for an appropriate number of standing snags or cavity trees per acre will result in a more diverse and biologically rich forest.

All of them, large or small, have value. More than 30 Vermont bird and mammal species use natural or excavated cavities in forests for nesting, roosting, or denning. Meeting the needs of these many species requires a variety of cavity-tree sizes. While cavity trees of any size have value for smaller wildlife such as the black-capped chickadee and tufted titmouse, trees larger than 18 inches in diameter accommodate larger animals and are used by a wider range of species. Cavity trees larger than 24 inches in diameter are uncommon. Retaining snags in a variety of size classes should be a primary focus when harvesting. Snags provide various substrates on which woodpeckers and other gleaners forage for insects. Snags also grow lichens, mosses, liverworts, and fungi upon which many small mammals forage and where other life forms live.

Many of Vermont's now rare species of bats require dead and dying trees as roosting habitat, as well as places to rear their young. In fact, roosting habitat is absolutely essential for the survival of these bats, and given their recent population decline, landowners are strongly encouraged to identify and maintain these critical habitat features.

Snags and cavity trees are created in forest stands of all ages when natural disturbances such as wind and ice break tree branches or damage entire trees. Cavity trees are generally less than 10% of the standing trees in most forests. Retain as many as possible during harvests. Avoid disturbing cavity trees and snags. Keep in mind that many birds and mammals are nesting or in dens with young from April to July, so take extra care during the breeding period. Bats, including the northern long-eared bat, may be roosting and rearing their pups in snags and cavity trees from May through August.

Retain and recruit a minimum of four secure snags or cavity trees per acre. These should include a diversity of diameters and sizes ranging from 5 to 6 inches to over 24 inches. Ideally, on each acre one snag over 24 inches should be retained or developed.

Where cavity trees are lacking, and to recruit future cavity trees, retain live trees that have damage or defects likely to lead to future cavities. Prior to harvesting, identify and plan to retain future snags and cavity trees including some greater than 24 inches in diameter. These legacy trees are providing roosts and perches now and will become cavity trees in the future.

Large snags (greater than 18 inches) remain standing longer than small diameter snags. Hardwood snags tend to last longer than softwood snags, which are more susceptible to blow down.

Compliance with Occupational Safety and Health Administration regulations regarding the removal of dangerous trees may conflict with recommendations in this section. If retaining snags is a goal, it is imperative that you contract with a logging professional who is fully insured and understands all elements of regulatory compliance.

5.4 Retaining Down Woody Material for Habitat

Retaining down woody material is addressed in Section 4.3 of these guidelines in terms of mitigating nutrient depletion. In addition, dead and down woody material is extremely important for habitat. Many species of birds, mammals, amphibians, and reptiles rely on coarse woody materials for shelter, nesting, denning, foraging, perching, displaying, and basking sites.

The American marten is an endangered species whose survival depends on a mixture of large and small dead and down material. It hunts under the snow and uses dead and down material for access to small mammals.

Harvests provide opportunities to enhance levels of down woody material. Avoid damaging or removing existing coarse woody material, especially large (18 inches in diameter), hollow, or rotten logs and rotten stumps during logging and cleanup operations. These have value for a variety of plants and animals, including as display or ground denning sites.

Consider leaving newly cut logs scattered across the site. An ideal target would be to leave three to five stems at least 18 inches in diameter and 10 stems at least 14 inches in diameter per acre. All should be at least 16 feet long.

Brush piles provide cover for small mammals and song birds that nest on the ground or in low, shrubby cover. They also serve as feeding areas for predators who feed on these other animals. For instance, rabbits and squirrels use brush piles created by fallen trees and tree crowns as escape cover from predators. Tree tops and brush left 3 to 4 feet high protect regenerating hardwood species that can be heavily browsed by deer and moose. By the time the tops have decayed to the point deer can reach in, saplings will be above browse level.

5.5 Old Forests

The forests present when settlers first arrived exist today only in scattered remnants. Known as old growth, virgin, primeval, or old forests, they escaped harvesting or other human modification over the last 350 years.

Vermont's old forests are unique and valuable natural resources. True old forest conditions are extremely rare in Vermont. Late successional habitats are less rare but still uncommon.

Old forests are biologically mature forests that have escaped stand-replacing disturbance for more than 100 years and have little evidence of human disturbance such as logging or farming. These forests also exhibit many of the associated characteristics such as:

- hardwood trees exceeding 150 years old for most forest types (100 years for balsam fir, 150 for Eastern hemlock);

- native tree species in multiple ages;
  complex stand structures that include a broad distribution of tree diameters, multiple vertical vegetative layers, natural canopy gaps, abundant down wood that reflects the size of the standing trees (and are in all stages of decay), and numerous large standing dead trees.

The forest floor may exhibit pits and mounds where trees have been tipped over and decomposed, and the soils will have a relatively thick humus layer with few signs of human activity, such as stumps, stone walls, roads, or fences.

Spruce, hemlock, yellow birch, beech, and sugar maple are typical species in old and late successional forests. In the Northeast, it takes a century or more to develop old-forest structure. However, under certain conditions and management, old-growth traits and characteristics can be promoted.

It is good to preserve the integrity of existing old-forest stands and encourage development of future old-forest conditions. If your forest has old-growth conditions or characteristics, consider not harvesting at all.

Restoring older forest conditions in previously harvested stands requires long-term planning and commitment. During a harvest, refrain from salvaging previously downed trees. Establishing small reserves or extending harvest rotations helps develop old-growth characteristics. The enhancement of old-forest characteristics can be tied to other objectives such as the establishment and maintenance of riparian buffers; the avoidance of operations on steep, sensitive, and high elevation terrain; the maintenance of a unique habitat condition; and carbon sequestration.

Consider retaining some large-diameter trees in stands of at least 5 to 10 acres to ensure old-growth structure and function.

If you would like to promote old growth, but your forest is relatively young, retain some component of the forest that remains unmanaged or is planned for harvesting in intervals of more than 100 years. Leave large-diameter living and dead standing trees and large-diameter trees, logs, or branches on the ground.

5.6 High-Elevation Forests

Three percent of Vermont's forestland lies above 2,500 feet of elevation. Vermont's land use planning law, Act 250, requires a permit for harvesting and other activities above 2,500 feet in elevation. Soils in higher-elevation areas are often thin and fragile, and slopes tend to be steep, which challenges equipment operability and increases erosion potential. Trees are likely to have less height growth and log quality.

Higher-elevation forests are at risk of forest health decline from stressors such as atmospheric deposition and late frosts. While overall forest diversity is less, high-elevation forests provide critical habitats for species not found in other habitats, including Bicknell's thrush and blackpoll warblers.

High-elevation forests represent potential refugia (an area where a species or community of species can survive) as the climate warms for species that may today live at lower-elevation forests.

Harvests at high elevations are often more visible than those at lower elevations. Consider the visual impact of your harvest. There may be modifications you can make in the harvest design to make a visually pleasing layout.

In any higher-elevation harvest, you should pay close attention to the soil and weather conditions as well as wildlife habitat. Adjust the timing of your operation and consider the type of equipment you are using as well as the layout of truck roads and skid trails to minimize soil disturbance. Harvesting in winter can protect thinner soils, but may present operability problems on steep ground.

5.7 Specific Wildlife Habitat Considerations

A healthy and diverse forest provides habitat for a variety of wildlife, but you may have unique habitats that provide food, cover, and travel for specific species of wildlife. These include deer wintering areas, mast stands, habitat for nesting birds, and wetlands, including vernal pools. Harvesting operations can directly impact (positively and negatively) these habitats.

Here are brief discussions of some of these habitat features. For more details contact the Vermont Fish & Wildlife Department.

Deer Wintering Areas

These are areas of softwood cover (spruce, fir, hemlock, cedar, and white pine) that deer depend on during periods of deep winter snow and cold temperatures. Deer have adapted to survive in Vermont by using these important habitats. In southern portions of Vermont, deer also use some areas of hardwood forest on south-facing slopes as wintering areas. Although deer do not feed as much in the winter as they do during other times of the year, they need access to natural food in the form of woody browse (twigs and buds of shrubs and young trees). Deer wintering areas offer shelter and food to wildlife species other than deer. These areas can benefit from forest management to regenerate and enhance softwood cover, and create accessible browse where appropriate.

Contact the Vermont Fish & Wildlife Department to see if your harvest area is in or near mapped deer wintering area.

Winter is the best time to harvest near deer wintering areas since deer can forage on fallen tree tops. Limit disturbance inside core (softwood) shelter areas. Route all roads, side trails, and recreation trails around the core shelter areas. However, if the objective is to regenerate the core softwood stand, summer logging is preferred because bare ground disturbance creates a more receptive seedbed.

Mast Stands

“Mast” refers to the fruit and seeds of shrubs and trees that are eaten by wildlife. “Hard mast” refers to nuts (especially those of beech and oaks) and “soft mast” is berries and apples. Both hard and soft mast are important food sources for many species of mammals and birds and are often found as separate stands or patches on the landscape that can be delineated on a map.

Individual oak, beech, and black cherry trees may be of poor quality for wood products but an invaluable source of mast. This is especially true where beech bark disease is present. Consider retaining these trees.

Many berry producers as well as apple trees can be improved by removing overtopping trees. Protect wild apple trees during harvests where possible. Retain some healthy black cherry trees, too.

If you have multiple mast-producing tree or shrub species, maintain the diversity of mast sources. Retain beech trees with bear claw marks on the trunk because the claws indicate a past or current use of the mast tree. Another sign of bear use is clumps of broken branches in the crown.

Retain softwood that extends into mast stands and dense, brushy growth of native shrubs like hobblebush or beaked hazelnut (NOT invasive shrubs like honeysuckle or barberry). This provides animals with protective cover for feeding.

Habitat for Nesting Birds

Vermont's forests are among the world's most diverse and productive for breeding birds. Forest birds need specific forest conditions and structure to reproduce successfully that include nesting sites, food and foraging areas, singing perches, and cover from predators. Structurally complex forests (those with varied heights and diameters of trees and shrubs) provide the highest-quality habitat for the greatest number of bird species.

Forest management activities during the breeding season may disrupt some bird species and lead to decreased nesting success.

If you find hawk, owl, or eagle nests within the harvest area, leave a partially closed canopy and a small uncut buffer of at least 66 feet around the nest trees. Temporarily limit forest management activities within 660 feet of active raptor nests from mid-February to late July. Avoid human activity within 330 feet of active eagle nests from February 1 to August 31. Report eagle nests to the Vermont Fish & Wildlife Department.

Contact Audubon Vermont to conduct a Forest Bird Habitat Assessment if you have an interest in providing song bird habitat.

Wetlands and Vernal Pools

Wetlands are some of the most important biologically rich and unique habitats in Vermont. Ranging from forested swamps and cattail marshes to seeps and fens, these areas are fragile, generally limited on the landscape and provide invaluable habitat for many of Vermont's fish and wildlife. For instance, vernal pools provide critical breeding habitat for a variety of forest amphibians and reptiles and their prey organisms. These water features are typically temporary in nature, do not have a flowing water source, and dry up by mid-summer, making them difficult to identify in some seasons. These areas are at risk from rutting and compaction from harvesting activities. Vernal pools can meet the statutory definition of a regulated wetland, so identifying them is crucial to maintain regulatory compliance.

Vernal pools contain the most water from March to June, so that's the best time for locating them. Vernal pools vary in size and use annually but this does not diminish their importance.

Ruts caused by harvesting equipment within the breeding zone of vernal pools can confuse breeding animals, leading to reproduction failures. It can also disrupt the seasonal hydrology of a vernal pool.

Do not disturb a vernal pool itself. Avoid placing debris, slash, or tops into a vernal pool, regardless of the season. If slash enters a pool when water is present leave it there until the pool has dried to avoid disturbing breeding animals and their eggs/young etc.

Limit harvesting to very light thinning (maintain 80% crown cover if possible) in the core breeding zone (100 feet around the pool) to maintain shade and avoid altering the microclimate. Keep heavy equipment out of this zone and harvest only under completely frozen or dry soil conditions to avoid ruts.

Keep the forest floor as undisturbed as possible within 500 or 600 feet of the pool. Retain woody material, stumps, stones, and natural leaf litter and avoid compacting soils.

5.8 Rare, Threatened, and Endangered Plants and Animals

Plant diversity is an important part of forest biodiversity. Most plant species occur widely enough on the landscape that human activities of limited scope will not put them at risk. Rare plants, however, may require specialized habitats and occur in relatively few locations. The same is true for most of our wildlife; that is, many of our wild animals are common within the forest landscape. Forest management will not harm them, and in some cases will benefit them. Some species of wildlife, such as the northern long-eared bat and the Canada lynx, are extremely rare in Vermont forests.

Rare, threatened, and endangered species include plants, animals and fungi whose populations are low or are at risk of becoming extirpated or extinct. Species listed as threatened or endangered are legally protected under Vermont's Endangered Species Law or the Federal Endangered Species Act. In both cases, the laws prohibit the harm or disturbance of the listed species.

Some species are rare because availability of their habitats has always been limited or because they are at the edge of their range in Vermont. Others have recently become rare as human land uses have affected much of their traditional habitat. Rare species require special attention to ensure their continued survival in a working landscape.

Vermont has about 2,100 species of native and naturalized vascular plants. Just over 600 are on the list of Rare and Uncommon Native Vascular Plants of Vermont. The list includes several tree species, such as pignut hickory, black gum, cork elm, and butternut. About 25% of the plants on the Rare and Uncommon list are state-listed, meaning they are protected by Vermont's Endangered Species Law; three of these species are also protected by the Federal Endangered Species Act.

Vermont has about 600 species of nonvascular plants (mosses and liverworts), of which close to 400 are on the list of Rare and Uncommon Bryophytes of Vermont. Two of

these are state-listed. Information available on the Vermont Natural Heritage Inventory website includes lists of rare and uncommon species, an explanation of how the lists were generated and are maintained, and definitions pertaining to rarity and legal status.

Vermont has 249 species of animals that are known to be rare and 115 species known to be uncommon. Of those, 32 species of animals are listed as endangered in Vermont and 14 species listed as threatened. Some these also appear on Vermont's list of Species of Greatest Conservation Need. A complete list of these species is available on the Vermont Fish & Wildlife Department's website.

You can harvest timber on land with rare plants and animals, but you need to comply with the state and federal laws protecting them. Many rare species are not listed as threatened or endangered, but require careful consideration to ensure they are not impacted by a timber harvest. Avoid harvesting or otherwise harming trees on Vermont's Rare and Uncommon Vascular Plant List. For some rare and uncommon plant species, the best management approach is to avoid harvesting, road building, and other alterations in the vicinity. For others, harvesting or natural disturbance may be necessary to perpetuate suitable habitat. Some rare plants are adapted to successional forests and may tolerate some selective canopy removal. Management needs to be species-specific, so learn about the plants' needs to protect them.

A survey of your land for rare plants and animals should be part of your harvest planning. Become familiar with the natural community types on your land and learn which rare or uncommon plants are likely to occur there. A good reference is *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont* (Thompson and Sorenson, 2000). Contact the Vermont Fish & Wildlife Department early in your planning for help determining the presence or absence of rare and uncommon plants and communities in a harvest area and appropriate management strategies. A map of known locations can be found online in the *Vermont ANR Natural Resources Atlas*, within the fish and wildlife layer of information. Identifying rare and uncommon plants sometimes requires specialized training. The *Go Botany* website helps with identification, including photographs. Rare and uncommon nonvascular plants (e.g., liverworts and mosses) are easily overlooked because they are small and difficult to identify. Contact the Vermont Fish & Wildlife Department before harvesting if you know or suspect you have these plants.

Some geographic areas harbor greater numbers of rare species than others because of soils or underlying rocks (limestone regions) and other regional factors. The Lake Champlain basin and Taconic Mountains in southern Vermont are good examples. Protecting rare and uncommon plants can often be accomplished through simple planning with minimal impact on your harvest. Most are localized and occur in small patches that are easily avoided.

Look for areas with distinct vegetation or extreme site conditions (e.g., very dry, wet, or nutrient-rich) when surveying or working in a harvest area. Examples include riparian areas, forest seeps, and rock outcrops. Protecting these sites often protects rare and uncommon plants that may occur there.

Harvest in winter on frozen or snow-covered ground to minimize damage to the understory, including rare and uncommon plants. With winter harvesting, you also avoid disturbing or harming other rare and listed species such as bats and some birds.

Chapter 6: Planning for Uncertainty

6.0 Introduction

We face many uncertainties about how and when climate changes will affect forests, and even greater uncertainties about how forests will respond. The best risk management may be to manage forests to be more adaptable to a variety of weather conditions. At some point in the future, climate change impacts will require new approaches to sustain tree species at risk. In a gradual transition to new forests, we will want our novel forests to include species native to Vermont that may be suited for future climates, but are not currently well distributed. In the short term, we need to develop forest harvest plans that ensure operational flexibility in the face of the greater likelihood of extreme weather events.

6.1 Climate Change

Researchers continue to warn society about climate change. In Vermont, we have recently witnessed warmer winters, drier summers, and more intense storm events.

Foresters observe forest response to different forest management techniques, and make harvesting recommendations based on our current understanding of those responses. But climate change makes our planning for future forest conditions less certain. The best risk management may be to manage forests and infrastructures assuming a continuation of extreme weather influences.

Higher temperatures, heavy precipitation events, mild winters with less snow cover, and extreme wind and ice storms are all predicted to increase. By incorporating these predictions into forest management planning you will improve your chances of attaining your management goals. When you or your consulting forester revisit your woods after a harvest (always a good practice) and see that unpredicted events have impacted your management objectives, you may need to implement corrective measures. This is what we call “adaptive management,” i.e., the monitoring results of a harvest, understanding outcomes, and providing alternative strategies if your original goal is no longer attainable. Forests, however, are dynamic and sometimes unplanned results still contribute to a successful outcome. For more information on adaptive management, see the forest adaptive resources in *Appendix 1: Additional Information and Resource Guide*.

Given the adverse effects that extreme weather can have, you can plan for uncertainty by improving forest resiliency over the long term. Resilient forests—those with a diversity of tree species, diameters, and heights—are able to accommodate some degree of change and return to prior conditions after a disturbance. Increase the diversity of forest ages and types across your forest. Greater tree species diversity and forest structure can reduce damage from insect pests and minimize storm damage to stands. If you have a larger ownership, you can vary stand ages in different parts of your forestland to build a more resilient landscape.

Excess water is perhaps the largest issue with extreme weather, and you should assess the vulnerability of your woods to excess water. Soil types and the presence of water features such as streams, seeps, and wet areas can influence the sensitivity of a forest area to soil loss or structural failure leading to discharges.
If your existing roads, landings, and skid trails are on soil types known to be erosive or wet, you may need to construct new ones on drier ground. Plan harvest areas for flexibility in ground conditions, so equipment can move to drier areas if conditions become unfavorable. Avoid using or building roads, landings, and trails near seeps, vernal pools, wetlands, and intermittent and perennial streams.

Many harvests have historically been conducted during winter months to reduce soil disturbance and protect naturally wet areas. Milder winters mean it is less certain the ground is frozen. Winter harvest operations may need more flexible timing to start and stop depending on weather and soil conditions. In summer harvests, you may need to maintain flexibility to operate around heavy precipitation events, allowing ample time between storms to allow water absorption.

Some forest stands serve as corridors for plant and animal movements to other forest blocks and promote landscape connectivity. Maintain these corridors.

6.2 Natural Disturbances and Restoration Harvesting

Forests are constantly changing as they are exposed and respond to a multitude of different organisms and environmental conditions. The insect pests, diseases, animal feeding, and weather events that kill trees individually or in larger areas are known as natural disturbances. These natural events are a normal part of forest ecology, and they influence forest composition, structure, and functions. Vermont's forests have been shaped by these natural processes, which can make small gaps in the forest canopy (up to 2 acres). These disturbance-created gaps serve a valuable function in allowing for a diversity of plants and animals to populate a forest. Larger disturbances that kill entire stands of trees are more infrequent.

When faced with serious risk from insect, disease, or weather disturbances, or when a catastrophic event has already occurred, you should focus on the long term. Step back and appraise the situation before taking action because the outcome may be long lasting. After an event that has caused a dramatic change to your forest, intervening with a salvage harvest may be the best option to avoid significant economic loss. But before proceeding you should learn more about your options. Natural disturbances detract from the commercial value but not the overall biological integrity of the forest. Many natural disturbances may be beneficial and are best left to take their course.

Many natural disturbances have short-term impacts, and forests will rebound on their own. Ask your forester to assess the value of the damaged trees to help you decide if it is worth the trouble and expense to salvage them. If you decide on salvage, make sure that you file an amendment to your Current Use forest management plan.

Multiple stresses can have detrimental effects on long-term forest health. For example, conducting a harvest is a major disturbance that, when combined with a pest outbreak, can have a lasting negative impact. Root damage and basal wounding from logging

equipment compounds this stress and may cause growth reductions, branch dieback, and degrade the value of wood products.

Avoid partial harvests during defoliator outbreaks, as this may concentrate insects on remaining trees, exacerbating stress and tree decline. Avoid partial harvests in a stand

until at least 3 years after the last major year of defoliation. A defoliated stand is highly susceptible to residual logging damage as the trees have less nutrition stored in the root systems.

Insect defoliators periodically reach outbreak levels. This usually reduces tree vigor, but most trees recover. These are natural disturbances caused by native insects. They rarely require salvage harvests, and a poorly timed harvest could adversely affect remaining trees.

On the other hand, a number of non-native insects require special management considerations (for example, the emerald ash borer and hemlock woolly adelgid). Section 6.3 below deals specifically with these threats.

Damage from ice storms and wind can create hazardous conditions. Take precautions when entering a disturbance area with downed trees or broken limbs.

Storm damage should be assessed with safety in mind. Where only limbs have broken, most trees will recover. In extreme cases where entire stands have been affected, there may be economic value in salvaging some of the wood, but you do not need to be hasty. Contact your consulting forester to help determine the window of opportunity to salvage valuable timber before it is degraded by stain and rot.

6.3 Invasive Pests

Native insects and diseases are natural parts of healthy forest ecosystems. However, devastating damage may occur when pests from other parts of the world are introduced into new locations. They have few natural enemies, and the genetic resistance of their host trees is limited.

Some invasive pests are recent arrivals in our region and pose a serious threat, including the emerald ash borer, hemlock woolly adelgid, and Asian longhorned beetle. Many others are well established in Vermont and occur throughout the state. These include Dutch elm disease, they gypsy moth, chestnut blight, butternut canker, beech bark disease, and white pine blister rust.

Slowing the spread of non-native pests reduces the rate of damage and buys time to implement management options. Quarantines in Vermont and nearby states regulate the movement of ash, hemlock and pine forest products; nursery planting stock; and firewood. Most allow wood products and planting stock to be moved by shippers who agree to use safe practices. Other strategies overseen by state and federal agencies aim to restore the balance with native tree species by developing genetic resistance in host trees or by introducing natural enemies. Pesticides are rarely practical in forested landscapes.

The impact of invasive insects and diseases varies widely. Information about forest pests is constantly changing, and research on management strategies is ongoing. Given Vermont's cold climate, it is unclear how extensive the impact of some warmer-climate pest impacts will be. Base your management decisions on the latest information about pests of concern. Visit www.vtinvasives.org. Look for signs of invaders and report possible sightings.

Do not preemptively eliminate ash or hemlock from your forest mix. If the emerald ash borer or hemlock woolly adelgid is not yet present in your area, your trees will increase in volume, and may improve in quality while you wait. Timber prices can become depressed if preemptive salvage is widespread. Retain at least some of the healthier trees as long as possible, so they can continue replenishing seeds in the soil.

During scheduled harvests, reduce the percentage of ash, or other threatened species, if it exceeds 20% of the trees present. To keep the property in good condition, retain vigorous trees of a variety of species. Because unhealthy trees are often the first to die from pest invasions, ensure that harvests minimize tree wounding.

Preserve genes of trees that show resistance. Retain healthier butternuts and large surviving chestnuts and elms. If you have smooth-barked beech trees, discuss with your consulting forester strategies for preserving individual trees or their sprouts. Report locations of superior trees, which may be candidates for tree-breeding projects.

Monitor the known location of pests that are not yet present in your area to avoid salvaging standing timber prematurely. In the case of the emerald ash borer, reconsider your option to harvest high value, large sawtimber if it is detected within 10 miles. Discuss the potential impacts with your consulting forester. Consider how management plans will change if the pest is detected nearby, and how the forest will recover if trees are salvaged or die.

Learn about invasive pest quarantines before harvesting. Hemlock and firewood from Vermont are among the products that may be covered. Forest pests may be unwittingly transported on wood products, live trees and nursery planting stock. Movement of firewood is of particular concern because it is more likely to be produced from unhealthy (and possibly infested) trees and then left unburned for a year or more in its new location. Local utilization of firewood and other products reduces opportunities for spreading pests.

6.4 Non-Native Invasive Plants (NNIPs)

NNIPs are species that originated elsewhere, have been introduced here (intentionally or unintentionally), and have developed self-sustaining populations and invaded natural communities. They out-compete native plants and have caused, or are likely to cause, harm to the economy, the environment, or human health.

As a group, these plants tolerate a wide variety of environmental conditions, allowing them to thrive in diverse sites. NNIPs compete with native species for space, nutrients, and water, and displace or alter natural communities. As a result, they can reduce the abundance, density, and diversity of tree seedlings. Their abundance can disrupt the food chain and degrade the quality of wildlife habitat. NNIP can act as hosts for other damaging organisms and alter soil structure and chemistry, affecting the soil's ability to retain or shed water, which may increase soil erosion. Vermont's Quarantine Rule regulates the importation, movement, sale, possession, cultivation, and distribution of NNIPs.

It is important to prevent the dispersal and establishment of NNIPs and mitigate their impacts on the forests, while also minimizing the effects of their control measures on the environment.

NNIPs are dispersed in many ways including by wildlife, horticulture, personal and recreational vehicles, mowers, and forestry activities (by associated equipment, mulch, and contaminated seed, etc.). These plants can thrive on disturbed sites, benefitting from the combination of disturbance and seed sources or plant pieces that root and sprout. Once established, they can spread beyond the introduction site even in the absence of continued disturbance. At this point, control can be costly.

Deer overpopulation and browsing pressure, when combined with NNIP infestations, can make it difficult to regenerate native plants including tree seedlings and saplings. Deer prefer to browse on native species, thereby giving NNIPs the advantage. Failure to account for and/or address NNIPs when planning a harvest can also compromise regeneration success.

Conduct a pre-harvest survey to determine invasive plant levels. This can be integrated into regular stand inventory and monitoring. Map any infestations and use the mapped locations in planning harvest areas and skid trails, truck roads, and landing locations. Avoid placing transportation infrastructure and landings in infested areas, or pre-treat them. Limit new ground disturbance by reusing lands and roads, if they are NNIP-free.

Avoid or minimize the movement of equipment and machinery from infested into invasive-free areas, unless you clean the equipment before moving it. Start in areas free of invasives. Move from areas of lesser to greater infestation. When operating at a site with invasive plants, inspect equipment to ensure that seeds, berries, roots, or branches are not transported to an uninfested location. Clean equipment using a broom, compressed air, or pressure-washing before moving to a new location.

Dispose of invasive debris in a manner that avoids further spread. Burning collected debris in a pile is one disposal method. (Obtain necessary open burning permits from the Town Fire Warden.)

If soil disturbance is needed to achieve a silvicultural objective in an infested stand, limit the disturbance to the target area.

To rehabilitate skid trails, truck roads, and landings, use a seed mix containing winter rye and both short- and long-lived native grasses and forbs. The traditional conservation

mix often contains several undesirable, weedy species. Minimize the time between close of operations and seeding to reduce the chance of invasive establishment.

Use sand, gravel, fill, and mulch that are NNIP-free, if available. Straw is more likely to be free of weed seeds than hay, although hay from a field that has been inspected and determined to be NNIP-free is also an option.

Closely monitor sites where seed, mulch, or fill materials were used. Focus your follow-up monitoring efforts on high-traffic areas or where invasive control was conducted. These are some of the most likely locations of new infestations.

Control

Use an integrated pest management (IPM) strategy for controlling NNIPs. Consider the species, its invasiveness, and size of infestation; ease of control; potential effects of control; effective timing; and possible sources of infestation.

Determine whether control is practical and ecologically feasible. Control may be impractical and costly for invasives present in large numbers.

Determine if control should take place before, during, or after the harvest. Eradicate small to moderate infestations of species known to cause severe economic or ecological damage as soon as practical.

Three to 5 years of active control and monitoring are typically required to ensure effective depletion of seed reserves in the soil seed bank. Without effective follow up, initial treatments may only make the problem worse.

Mechanical control includes hand pulling, digging, mowing, blading, and tilling. Due to its labor-intensive nature and the soil disturbance it causes, manual control is best applied only to small numbers of plants in limited infestations. Manual/mechanical control does not work on all species. Japanese knotweed, for example, can be made worse by this type of disturbance.

Chemical control is also an option. The technique and herbicide used depend on the size of the infestation and species, as well as the timing of the application. Chemical control typically requires follow-up monitoring and treatment. Chemical regulations and applicator licensing information are available from the Vermont Agency of Agriculture, Food and Markets.

Biological control is most suitable for large infestations after harvest operations because it would not control any invasive plant quickly enough to prevent their spread during harvest.

6.5 Forest Monitoring

In your forest management plan, you delineated your goals. After a harvest, you can evaluate whether it succeeded in furthering your goals. Post-harvest monitoring should gauge how the forest responded to the harvest, specifically looking at the health and growth of residual trees, and the establishment and release of regeneration. You will also want to watch for unexpected changes, such as increases in forest pest

occurrence, invasive plant species development, and impacts from severe weather events such as ice and wind storms.

Accomplishment of longer-term goals such as altering the species composition cannot be assessed immediately. Over time, you can monitor numbers of residual trees and regeneration of climate-adapted species. How you monitor the outcomes of your harvest operation will vary depending on your goals for your forest.

It also depends on the accessibility of your forest. The owner of a 50-acre woodlot who regularly spends time in their forest will have different opportunities for monitoring than the absentee owner of a 2,000-acre parcel. Work with your consulting forester to develop an appropriate monitoring plan for your property. This will enable your management responses to be as efficient as possible.

Adapt your management strategies based on information from monitoring results. If you have some unsuccessful outcomes, you can modify plans through adaptive management. If a management strategy did not work, understand why and change your approach accordingly.

Forest management plan updates require periodic re-inventories of the forest, usually at 10-year intervals. While this time interval will not be sufficient to adequately monitor some important elements, it will be suitable for others such as residual basal area growth.

Appendix 1: Additional Information and Resource Guide

Chapter 1: Preparing for Your Harvest

Long S (2012) *More than a Woodlot: Getting the Most from Your Family Forest* (Northern Woodlands, Corinth, VT).

Beattie M, Thompson C, Levine L (1993) *Working with Your Woodland: A Landowners Guide* (University Press of New England, Hannover, NH), Revised Edition.

American Forest Foundation (2014) *My Land Plan: The Woodland Owner's Resource*. Available at http://mylandplan.org/.

Adams D, Adler M, Alexander C, Alfieri A, Austin J, Blodgett D, Buck J, Cox K, Crenshaw B, Darling S, Ferguson M, Hamelin P, Hammond F, Haskell S, Gobeille J, Kirn R, Marshall E, Morin D, Parren S, Richardson L, Royar K, Sausville D, Sorensen E, Zaino R (2015) *A Landowner's Guide: Wildlife Habitat Management for Lands in Vermont* (RavenMark, Inc., Montpelier, VT). Vermont Fish & Wildlife Department, Vermont Department of Forests, Parks and Recreation, and US Department of Agriculture Natural Resources Conservation Service.

Vermont Department of Forests, Parks and Recreation (March 2014) County Foresters. [Brochure.] Available at http://vtfpr.org/resource/documents/CountyForesters2014.pdf.

Long S (Autumn 2008) Consulting foresters: What they do and why you need one. *The Place You Call Home: A Guide to Caring for Your Land in Vermont*. *Northern Woodlands*. Available at http://northernwoodlands.org/pdf/PYCHVT_09.pdf.

Vermont Woodlands Association (2014) Vermont Woodlands Accredited Consulting Foresters. Available at http://www.vermontwoodlands.org/certified-foresters.asp.

Vermont Woodlands Association (June 2011) Call Before You Cut: A Guide to Public Resources for Woodland Owners in Vermont. Available at http://www.vermontwoodlands.org/documents/CallBeforeYouCut2011.pdf.

Clark CW, Bennett KP (2008) The Timber Sale Contract (University of New Hampshire Cooperative Extension, Durham, NH). Available at http://extension.unh.edu/resources/files/Resource000994_Rep1143.pdf. Last accessed March 5, 2010.

Vermont Department of Forests, Parks and Recreation (2009) *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*. Tenth Printing. Available at http://www.vtfpr.org/watershed/documents/AMP2009pdf.pdf.

Vermont Department of Forests, Parks and Recreation (2011) *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*. Eleventh Printing. [In press]

Bennett KP, ed. (2010) *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* (University of New Hampshire Cooperative Extension, Durham, NH), Second Edition. Available at http://extension.unh.edu/goodforestry/assets/docs/GoodForestry2010FINALreducedsizeSECURE.pdf.

Logger Education to Advance Professionalism (2010) Vermont Professional Loggers. Available at http://www.vtleap.com/index.php.

For information about AMPs and Vermont's Heavy Cut Law violations, see:

Vermont Department of Environmental Conservation, Compliance and Enforcement Division (2004) Homepage. Available at http://www.anr.state.vt.us/dec/co/enf/index.htm.

Vermont Department of Forests, Parks and Recreation (2001). Homepage. Available at http://vtfpr.org/.

Vermont Office of the Attorney General William H. Sorrell (Undated) Press Releases. Available at http://ago.vermont.gov/focus/news.php.

For information about the Vermont Stumpage Report, see:

Vermont Department of Forests, Parks and Recreation (2001) Forest Resource Harvest Summary. Available at http://vtfpr.org/util/for_utilize_harvsumm.cfm.

University of New Hampshire Cooperative Extension (2013) Selecting a Professional Logger (University of New Hampshire Cooperative Extension, Durham, NH). Available at http://extension.unh.edu/Selecting-Professional-Logger.

McAvoy D (Summer 2001) Insurance coverage for your logger. *Utah Forest News* (Utah State University Extension, Forest Landowner Education Program, Logan, UT), Volume 5, Issue 3. Available at https://forestry.usu.edu/files/uploads/UFN/Summer01.pdf.

Anonymous (2014) Forester Woodland Owner Sample Contract (Cornell Cooperative Extension, Ithaca, NY). Available at http://www2.dnr.cornell.edu/ext/info/pubs/misc/Forester_Woodland%20Owner%20Contract%20Sample.pdf.

Vermont Department of Forests, Parks and Recreation (April 2012) Timber Harvesting in Vermont: Summary of Laws and Regulations. Resource Guide. Available at http://www.vtfpr.org/regulate/documents/Timber_Harvest_2012Web.pdf.

Leak WB, Solomon DS, DeBald PS (1987) *Silvicultural Guide for Northern Hardwood Types in the Northeast* (US Department of Agriculture Forest Service, Northeastern Forest Experiment Station, Broomall, PA), Revised Edition, Research Paper No. NE-603.

Horton J, Langlais M, Morton T, Paganelli D, Patch N, Wilmot S, Briggs J (2015) *Creating and Maintaining Resilient Forests in Vermont: Adapting Forests to Climate Change* (Vermont Department of Forests, Parks and Recreation, Montpelier, VT). [In press]

Chapter 2: Conducting a Harvest

Vermont Agency of Natural Resources (April 23, 2012) ANR River Management Engineer Districts. [Contact Information]. Available at http://www.watershedmanagement.vt.gov/rivers/docs/rv_contact.pdf.

Vermont Department of Forests, Parks and Recreation (2001) Forest Watershed Program: Portable Skidder Bridge Program. Available at http://www.vtfpr.org/watershed/initiative.cfm.

Wiest RL (July 1998) *A Landowner's Guide to Building Forest Access Roads* (US Department of Agriculture Forest Service, Radnor, PA), Publication No. NA-TP-06-98. Available at http://www.na.fs.fed.us/spfo/pubs/stewardship/accessroads/accessroads.htm.

Vermont Agency of Natural Resources (June 9, 2014) Vermont ANR Natural Resources Atlas. Available at http://anrmaps.vermont.gov/websites/anra/.

Vermont Fish & Wildlife Department (May 2010) *Vermont Stream Crossing Handbook*. Available at http://www.vtfishandwildlife.com/library/Reports_and_Documents/Aquatic%20Organism%20Passage%20at%20Stream%20Crossings/__AOP_%20Handbook.pdf.

Ochterski J (2004) *Forest Land Best Management Practices in the Finger Lakes Region of New York State* (Cornell Cooperative Extension, Ithaca, NY). Available at http://www2.dnr.cornell.edu/ext/bmp/index.html.

Wisconsin Department of Natural Resources (2011) Forest road construction and maintenance. *Wisconsin Forest Management Guidelines*. Chapter 12. Available at http://dnr.wi.gov/topic/ForestManagement/documents/guidelines/chapter12.pdf

Ontario Woodlot Association (2009) Selecting the right equipment. *Careful Logging Practices: Selecting the Right Harvesting Equipment*. Extension Notes. Available at http://www.ontariowoodlot.com/pages_pdf_new/CL%20Sel.%20the%20Right%20Har.%20Equio%20ExNote%20(Web%20Ver).pdf.

Jones GT (1993) *A Guide to Logging Aesthetics: Practical Tips for Loggers, Foresters, and Landowners* (Natural Resource, Agriculture, and Engineering Service Cooperative Extension, Ithaca, NY). Available at http://www.scafbook.com/read/a-guide-to-logging-aesthetics-society-for-the-protection-of-new-7488944/.

Bennett KP, ed (2010) Logging aesthetics. *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* (University of New Hampshire Cooperative Extension, Durham, NH), Second Edition, Section 3.2. Available at http://extension.unh.edu/goodforestry/assets/docs/3-2.pdf.

Vermont Department of Environmental Conservation (November 2013) Environmental Fact Sheet: Hazardous Material Spill Response. Available at http://www.anr.state.vt.us/dec/ead/sbcap/pdf/fs_spills_wm.pdf.

Vermont Environmental Assistance Office (2003) Small Business Compliance Assistance Program. Available at http://www.eaovt.org/sbcap/index.htm.

Vermont Department of Environmental Conservation, Waste Management Division (2003) Hazardous Waste Management Program. Available at http://www.anr.state.vt.us/dec/wastediv/rcra/rcrahome.htm.

Vermont Department of Environmental Conservation, Waste Manage Division (2005) *Conditionally Exempt Generators Handbook: A Hazardous Waste Management Guide for Smaller Vermont Businesses* (Vermont Agency of Natural Resources, Waterbury, VT). Available at http://www.anr.state.vt.us/dec/wastediv/rcra/pubs/ceg_hndbk.pdf.

Vermont Department of Environmental Conservation (September 12, 2008) Vermont DEC: Cleanup Contractors. Available at http://www.anr.state.vt.us/dec/wastediv/spills/pubs/VT.Spill.Contractors.Map.pdf.

Moesswilde M (2004) *Best Management Practices for Forestry: Protecting Maine's Water Quality* (Maine Department of Conservation, Maine Forest Service, Forest Policy and Management Division, Augusta, ME). Available at http://www.maine.gov/dacf/mfs/publications/handbooks_guides/bmp_manual/bmp_manual.pdf.

Chapter 3: Protecting Water Resources

For a complete version of Vermont Wetland rules, see:

Vermont Department of Environmental Conservation, Watershed Management Division (2003) VT Wetlands Guidance Table. Available at http://www.watershedmanagement.vt.gov/wetlands.htm.

Vermont Department of Environmental Conservation, Watershed Management Division (2003) Wetlands - Surface and Ground Protection. Available at http://www.vtwaterquality.org/wetlands/htm/wl_func-protection.htm.

Vermont Agency of Natural Resources (December 9, 2009) Guidance for Agency Act 250 and Section 248 Comments Regarding Riparian Buffers. Available at http://www.anr.state.vt.us/site/html/buff/BufferGuidanceFINAL-120905.pdf.

Vermont Agency of Natural Resources (2005) Riparian Buffers and Corridors: Technical Papers. Available at http://www.anr.state.vt.us/site/html/buff/buffer-tech-final.pdf.

Natural Resources Board (2010) Vermont Wetland Rules, VT Code R 12 004 056. [Ammendments adopted July 16, 2010, Effective August 1, 2010.] Available at http://www.nrb.state.vt.us/wrp/rulemaking/wetlands2010/filedruledocs/VWR%207-16-10.pdf.

Watershed Agricultural Council, Forestry Program (2011) New York State Forestry: Best Management Practices for Water Quality. *BMP Field Guide*. Available at http://www.dec.ny.gov/docs/lands_forests_pdf/dlfbmpguide.pdf.

Germain RH, Munsell JF (2005) How Much Land Is Needed for the Harvest Access System on Nonindustrial Private Forestlands Dominated by Northern Hardwoods? *Northern Journal of Applied Forestry* 22(4):243–247. Available at http://www.esf.edu/for/germain/NJAF%20Harvest%20Access%20System.pdf.

Vermont Department of Environmental Conservation (June 2014) *The Vermont Shoreland Protection Act: A Handbook for Shoreland Development*. Version 1.1. Available at http://www.watershedmanagement.vt.gov/lakes/docs/shoreland/lp_ShorelandHandbook.pdf.

Chapter 4: Protecting Soil Health and Productivity

Nova Scotia Department of Natural Resources Forestry Division (July 2013) Establishing rules for whole-tree harvesting in Nova Scotia - Discussion paper. Available at http://novascotia.ca/natr/strategy/forests/whole-tree-discussion.asp.

Benjamin JG, ed (January 2010) Considerations and recommendations for retaining woody biomass on timber harvest sites in Maine. Maine Agricultural and Forest Experiment Station Miscellaneous Publication 761. Available at http://www.forest.umaine.edu/files/2009/07/Woody-Biomass-Retention-Guidelines-2010.pdf.

North East State Foresters Association (July 2012) A review of biomass harvesting best management practices guidelines. Available at http://www.nefainfo.org/NEFA%20Biomass%20BMP%20comparison%20Report%20FINAL%209.2012.pdf.

Keeton W, Tobi D, Mika A, Littlefield C, Buchholz T (2009) Bioenergy fuel harvesting Impacts on forest habitat and carbon emissions. Northeastern States Research Cooperative. Available at http://nsrcforest.org/project/bioenergy-fuel-harvesting-impacts-forest-habitat-and-carbon-emissions.

Turcotte DE, Smith CT, Jr (1991) Soil disturbance following whole-tree harvesting in north-central Maine. *Northern Journal of Applied Forestry* 8(2):68–72. Available at http://www.ingentaconnect.com/content/saf/njaf/1991/00000008/00000002/art00007.

Minnesota Forest Resources Council (2005) *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers* (Minnesota Forest Resources Council, St. Paul, MN). Available at http://mn.gov/frc/documents/council/site-level/MFRC_FMG&Biomass_2007-12-17.pdf.

Vermont Energy Development Working Group (January 17, 2012) Biomass Energy Development Working Group: Final Report January 2012. Available at http://www.leg.state.vt.us/REPORTS/2012LegislativeReports/272678.pdf.

Evans AM, Perschel RT, Kittler BA (April 2010) *Revised Assessment of Biomass Harvesting and Retention Guidelines*. Forest Guild. Available at http://www.forestguild.org/publications/research/2009/biomass_guidelines.pdf.

Evans AM, Kelty M (May 2010) *Ecology of Dead Wood in the Northeast*. Forest Guild. Available at http://www.forestguild.org/publications/research/2010/ecology_of_dead_wood.pdf.

Bennett KP, ed (2010). Soil productivity. *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* (University of New Hampshire Cooperative Extension, Durham, NH), Second Edition, Section 3.5. Available at http://extension.unh.edu/goodforestry/assets/docs/3-5.pdf.

Sutherland BJ (March 2003) *Preventing Soil Compaction and Rutting in the Boreal Forest of Western Canada: A Practical Guide to Operating Timber-Harvesting Equipment*. Volume 4, No. 7. Available at http://www.swanvalleyforest.ca/pdfs/final_plan_appendices/APPENDIX%2017/Preventing%20Soil%20Compaction%20and%20Rutting%20in%20the%20Boreal%20Forest%20of%20Western%20Manitoba.pdf.

Chapter 5: Biodiversity and Wildlife Habitat

Thompson EH, Sorenson ER (2005) *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont* (University Press of New England, Lebanon, NH), The Nature Conservancy and Vermont Fish & Wildlife Department.

DeGraaf R, Yamasaki M, Leak WB, Lester AM (2006) *Technical Guide to Forest and Wildlife Habitat Management in New England* (University of Vermont Press and University Press of New England, Burlington, VT).

Hunter ML, Jr (1990) *Wildlife, Forests and Forestry: Principles of Managing Forests for Biological Diversity* (Prentice-Hall, New York, NY).

Elliott CA (1988) *A Forester's Guide to Managing Wildlife Habitats in Maine* (University of Maine Cooperative Extension, Orono, ME).

US Department of Labor, Occupational Safety and Health Administration (2014) Logging eTool: Develop a Site Safety and Health Plan. Available at https://www.osha.gov/SLTC/etools/logging/safety_health.html.

Flatebo G, Foss C, Pelletier S (1999*) Biodiversity in the Forests of Maine: Guidelines for Land Management* (University of Maine Cooperative Extension, Orono, ME), UMCE Bulletin No. 7147.

Bennett KP (2005) Moving toward sustainable forestry: Lessons from old growth forests. *Natural Resource Network Report* (University of New Hampshire Cooperative Extension, Durham, NH). Available at http://extension.unh.edu/resources/resource/406/Moving_Toward_Sustainable_Forestry:_Lessons_From_Old_Growth.

Carbonneau L (1986) *Old-Growth Forest Stands in New Hampshire: A Preliminary Investigation*. MSc thesis (University of New Hampshire, Durham, NH).

D'Amato A, Catanzaro P (Undated) *Restoring Old-Growth Characteristics* (University of Massachusetts Extension, Amherst, MA).

D'Amato A, Catanzaro P (Undated) *A Forest Manager's Guide to Restoring Late-Successional Forest Structure* (University of Massachusetts Extension, Amherst, MA).

Keeton W (2006) Managing for late successional/old growth characteristics in northern hardwood-conifer forests. *Forest Ecology and Management* 235:129–142.

Lapin M (2002) *Old-Growth Forests: A Literature Review of the Characteristics of Eastern North American Forests* (Vermont Natural Resources Council, Montpelier, VT).

Luyssaert S, Schulze D, Börner A, Knohl A, Hessenmöller D, Law BE, Ciais P, Grace J (2008) Old-growth forests as global carbon sinks. *Nature* 455:213–215 [Letter].

Whitman AA, Hagan JM (2009) A Revised Rapid Assessment Late-Successional Index for common northeastern forest types. FMSN-2009-1.

VT Monitoring Cooperative (2009) Key findings on the health of forested ecosystems from the VT Monitoring Cooperative (VMC, Burlington, VT).

Osbourne J (2014) Forest project prospecting: Developing a GIS model to identify conservation priorities (Vermont Land Trust, Montpelier, VT).

Reay RS, Blodgett DW, Burns BS, Weber SJ, Frey T (1990) *Management Guide for Deer Wintering Areas in Vermont*. Vermont Fish & Wildlife Department and Department of Forests, Parks and Recreation. Available at http://www.vtfishandwildlife.com/library/Reports_and_Documents/Fish_and_Wildlife/Management%20Guide%20for%20Deer%20Wintering%20Areas%20in%20Vermont.pdf.

Hagenbuch S, Manaras K, Shallow J, Sharpless K, Snyder M (2011) *Forest Bird Habitat Assessment: A Guide to Integrating Bird Habitat Data into a Vermont Forest Inventory*. Audubon Vermont and Vermont Department of Forests, Parks and Recreation. Available at http://vt.audubon.org/sites/default/files/documents/assessment-guide.pdf.

Hagenbuch S, Manaras K, Shallow J, Sharpless K, Snyder M (2011) *Silviculture with Birds in Mind: Options for Integrating Timber and Songbird Habitat Management in Northern Hardwood Stands in Vermont*. Audubon Vermont and Vermont Department of Forests, Parks and Recreation. Available at http://vt.audubon.org/sites/default/files/documents/silviculture-options_0.pdf.

Vermont Fish & Wildlife Department (2015) Vernal pools: Accepted management practices for maintaining water quality in Vermont. *Vernal Pool Management Guide*. [In press]

For Vermont rare and endangered species, see:

Vermont Fish & Wildlife Department (2014) Natural Heritage Invetory. Available at http://www.vtfishandwildlife.com/nnhp_inventory.cfm.

The Nature Conservancy (Undated). *Managing Rich Northern Hardwood Forests for Ecological Values and Timber Production: Recommendations for Landowners in the Taconic Mountains.* (The Nature Conservancy, Montpelier, VT). Available at http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/vermont/placesweprotect/managing-rich-northern-hardwood-forest.pdf.

Roe JH, Ruesink A (2001) *Natural Dynamics Silviculture*: *A Discussion of Natural Community-Based Forestry Practices*. (The Nature Conservancy, Montpelier, VT). Available at http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/vermont/newsroom/pub-nds-doc-3.pdf.

The New England Wildflower Society (2014) Go Botany Project. Available at https://gobotany.newenglandwild.org/.

Chapter 6: Planning for Uncertainty

For forest adaptation resources, climate change tools, and approaches for land managers, see:

US Forest Service, Research and Development (2014) Research & Development Treesearch. US Forest Service Research Publications. Available at http://www.treesearch.fs.fed.us/.

Agency of Natural Resources (May 31, 2013) Vermont Agency of Natural Resources: Climate Change Adaptation Framework. Available at http://www.anr.state.vt.us/anr/climatechange/Pubs/2013.0610.vtanr.NR_CC_Adaptation_Framework_Report.pdf.

Rustad L, Campbell J, Dukes JS, Huntington T, Fallon Lambert K, Mohan J, Rodenhouse N (2012) Changing climate, changing forests: The impacts of climate change on forests of the northeastern United States and eastern Canada. (US Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA), General Technical Report NRS-99. Available at http://www.nrs.fs.fed.us/pubs/41165.

Alan Betts, Atmospheric Research (2015) Research Papers and Talks by Dr. Alan K. Betts. Available at http://alanbetts.com/research/.

US Department of Agriculture, Forest Service, Northern Research Station (November 7, 2014) Northern Institute of Applied Climate Science. Available at http://www.nrs.fs.fed.us/niacs/.

Northern Institute of Applied Climate Science (2015) Climate Change Response Framework. Available at http://www.forestadaptation.org/.

Vermont Department of Forests, Parks and Recreation (2001) Forest Health, Insects, & Diseases. Available at http://www.vtfpr.org/protection/idfrontpage.cfm.

Vermont Invasives (Undated). Vermont Invasives: Actively Conserving Our Environment. Available at http://vtinvasives.org/.

US Department of Agriculture Forest Service, Michigan State University, Purdue University, Ohio State University (Undated) Emerald ash borer. Available at http://www.emeraldashborer.info/.

Vermont Department of Environmental Conservation, Vermont Fish & Wildlife Department, Vermont Department of Forests, Parks and Recreation, The Nature Conservancy (Winter 2003) Vermont Invasive Exotic Plant Fact Sheet Series. Revised. Available at http://www.vtfishandwildlife.com/library/Factsheets/NonGame_and_Natural_Heritage/Invasive_Exotic_Plant_FactSheet.pdf.

Ewing B, Mattrick C (2006) *Field Manual of Invasive Plant Species for the Northeast*. (New England Wild Flower Society, Framingham, MA).

US Department of Agriculture, Forest Service (July 5, 2001) *USDA - Forest Service Guide to Noxious Weed Prevention Practices*. Version 1.0. Available at http://www.fs.fed.us/database/feis/pdfs/weeds/GuidetoNoxWeedPrevPractices.pdf. Last accessed January 21, 2010.

For more information on invasive species management, chemical selection and concentrations, and control strategies, see:

Vermont Invasives (2014) Herbicide Use: Safe, Legal and Effective Chemical Application. Available at http://www.vtinvasives.org/plants/prevention-and-management/herbicide-use.