# Town Forest Health Check

A Town Forest Steward's Guide to Forest Health Assessment

Words by David Brynn

Photographs by Jonathan Blake, E. Callie Brynn and Louise Kilbourn Brynn

Vermont Family Forest Foundation and UVM's Green Forestry Education Initiative

VERMONT FAMILY FORESTS

UVM Rubenstein School THE GREEN FORESTRY Education Initiative

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DESIGN BY JIM BURNS • BOINZ.COM

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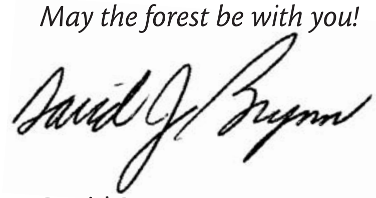
*May the forest be with you!*



David Brynn

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# Town Forest Health Check

## A Town Forest Steward's Guide to Assessing Forest Health

### Why We've Created the Town Forest Health Check

Back in 2005, the Vermont Town Forest Project was initiated to strengthen connections between Vermonters and the forests they live in and around, to encourage citizen stewardship of those forests, and to establish and expand town forests. There are over 150 town forests sprinkled throughout Vermont. Each town forest is unique and all provide rich opportunities to explore community-based forest conservation.

UVM's Green Forestry Education Initiative and Vermont Family Forests created the *Town Forest Health Check* to support the goals of the Vermont Town Forest Project. The purpose of the *Health Check* is to provide a simple, straightforward, and (we hope) enjoyable tool for town forest stewards that will help them assess the health of their community's forests.

### Who This Guide is For

If you're a community member interested in taking an active role in maintaining the health of your community's town forest, this guide is for you. The *Town Forest Health Check* describes key forest management practices that should be in place if working forests are to be healthy forests. It also shows you how to gather information about your town forest that will help you determine if these best management practices are in place in your forest.

## How the Guide Works

Here's an analogy that might help you visualize how this guide works: Let's say you want to optimize your own health. One way to do this would be to go to your doctor and have her conduct a number of tests to check if each of your body parts is in good working order. If one of the tests indicates a lack of health in, say, your heart, you can take the necessary steps your doctor prescribes to improve that condition. This is a pretty costly, technological route.

Or instead, you could look at current medical findings that point to best practices for maintaining health—like eating plenty of vegetables, avoiding smoking, exercising, and so on. Put those practices in place, and you have a very good chance of optimizing your health. It's less direct than the testing method, but also less costly and technological, and it's something you can implement on your own without a medical degree.

In the case of forest health, you could try to directly measure the condition of your town forest—conditions like soil and water chemistry, infiltration capacity, biological diversity of flora and fauna, and the degree of carbon storage and cycling. But these direct measures can be very time-consuming and difficult to gather. And, if indeed you are able to make these measurements, you then need to research the solutions to any unhealthy conditions you discover—not an easy task!

Instead, the *Town Forest Health Check* focuses on a dozen best management practices—derived from highly credible scientific research—that have proven effective in helping forests keep themselves healthy. These best management practices help maintain or enhance soil productivity, water quality, biological diversity, and carbon storage, and increase the forest's resistance to invasion by exotic plant species. With the help of this guide, you'll be measuring forest health indirectly by assessing the degree to which your forest complies with these best management practices.

## Why Focus on Forest Health?

Healthy forests are the foundation of a healthy forest economy and community. Aldo Leopold wrote, "Health is the capacity of the land for self-renewal."[1] A healthy forest is a forest ecosystem that has the long-term capacity to renew its own ecological productivity, diversity, and complexity, particularly following a disturbance, whether human-caused or natural.

A community forest can be retained as an ecological reserve, managed intensively for timber, conserved using light-on-the-land forestry, or some combination of all of these. In any case, forest health is the foundation upon which any and all landowner objectives are achieved. Although "silvi-culture" literally means "forest care," many silvicultural guides focus on managing forests for *sustained yields* of timber.[2] They are very utilitarian. In sustained yield forestry, the goal has been to expand the timber *growing stock* (i.e. the principal) and to harvest only a portion of the *growth* (i.e. the interest). Writing about forests managed for timber or fuel production, Aldo Leopold noted, "Overdrawing the interest on the woodlot bank is perhaps serious, but it is a bagatelle when compared with destroying the capacity of the woodlot to generate interest."[3] More recently Justin Brande put it this way: "Without ecology, there is no economy and no community."

The *Town Forest Health Check* will help you assess and improve your town forest's health, securing its capacity for self-renewal, and thus its capacity to generate interest, from which your community might someday wish to draw. Or not.

## How this Guide is Organized

Part I of the *Town Forest Health Check* outlines the characteristics of forest health, as spelled out in 1992 by the Montreal Process Working Group (MWPG) for the Conservation and Sustainable Management of Temperate and Boreal Forests—an international body of foresters. While the MWPG identified seven **criteria** for sustainable forest management, we only describe four in this guide—the ones that focus on forest health. The MWPG also identified **indicators** for each of those criteria—signs that each criterion is present (or absent) in a given forest. In Part I, we list those indicators, since they form the scientific foundation from which we have developed the *Town Forest Health Check.*

In Part II, we describe the standards for measuring and judging the presence of these indicators of forest health in your forest. We refer to these standards as **benchmarks** . If you achieve significant compliance with all twelve benchmarks in your town forest, you can be reasonably sure that you have a healthy forest on your hands. Part II also details the process of assessing these benchmarks in your forest. Accompanying the *Health Check* guidebook are tally sheets on which you'll record your findings as you carry out the 12 benchmark assessments. On the *Health Check Summary Sheet*, you'll compile your findings, which will give you an overall picture of your town forest's health.

## How To Use This Guide

This guide includes 12 benchmarks and the associated protocols and tools for assessing them in an effort to gain insights into the health of your town's forest. How you use and apply the guide is up to you. You can use it to evaluate the entire forest or an area within the forest. You can randomly sample, or you can focus on problem areas. Although it will work best to have two people work on the data collection, you may elect to gather the data alone or in groups. You can look at one trail or you can look at all of the trails. All of this is up to you.

It strikes us that the TFHC can be a great way to build community. Community members could divide the forest into areas, and teams could take on the assessment of those areas. At the end of the day, the teams could compare notes, celebrate findings, and strategize next steps. But again, that is up to you!


PHOTO: JONATHAN BLAKE

# PART I

## Criteria for Forest Health

> *"Identifying reliable indicators of ecosystem health is one of the highest-priority tasks for ecologists during the coming years."* [4]
>
> —David Perry, et al. *Forest Ecosystems,* 2008

As mentioned earlier, an international body of foresters, known as Montreal Process Working Group, identified seven **criteria** for sustainable forest management.[5] The Montreal Process continues to refine and update these criteria, giving international scientific consensus on the necessary components of sustainable forestry. Four of the criteria specifically relate to forest health (rather than economic or legal issues), and we describe these below. The MWPG also identified **indicators** for each of those criteria—signs that each criterion is present (or absent) in a given forested landscape.

In this guide, we have focused on those indicators that are widely applicable across forest types and sites found in the Northern Forest and that are relatively simple and quick for a non-forester to measure. Many of the Montreal indicators are much more global in nature or quite complex. For example, forest fragmentation (the chopping up of large forested tracts into isolated islands, a result of human activities) is an indicator for conservation of biological diversity. But we didn't include this indicator here because it can't be measured on the level of an individual forest—it's a bioregional/global issue.

### 1. Conservation of Biological Diversity
**(Montreal Process Criterion 1)**

*Montreal Process Indicators:*

*1.1 Ecosystem Diversity*

*1.1a Area and percent of forest by forest ecosystem type, successional stage, age class, and forest ownership or tenure.*

*1.2 Species diversity*

*1.2a Number of native forest associated species.*

When people talk about biological diversity, they're often referring simply to the variety of species that live in a particular area. But biological diversity encompasses more than just species diversity—it includes the genetic diversity within those species and the diversity of the ecosystems and their structures and functions in that given area.

As a general rule, biological diversity helps stabilize forest ecosystems and keep them healthy, as long as that diversity comes from native species, rather than introduced, exotic species. A forest community with high native biological diversity is optimally stable and able to rebound from disturbances. Non-native, introduced species can upset the stability of a native ecosystem, in which species have evolved together for thousands of years. That's why conserving native biological diversity may involve reducing the presence of invasive exotic species.

## 2. Maintenance of forest ecosystem health and vitality

**(Montreal Process Criterion 3)**

*Montreal Process Indicators:*
*3.a Area and percent of forest affected by biotic processes and agents (e.g. disease, insects, invasive species) beyond reference conditions.*

A healthy forest is a lot more than just a collection of healthy trees. When thinking about forest health, we need to consider the whole forest ecosystem—the entire assemblage of living forest organisms (trees, shrubs, herbs, bacteria, fungi, mammals, reptiles, amphibians, insects, and so on) together with their environment (the surrounding air, soil, water, organic debris, and rocks).

## 3. Conservation and maintenance of soil and water resources

**(Montreal Process Criterion 4)**

*Montreal Process Indicators:*
*4.2. Soil*
*4.2.a Proportion of forest management activities that meet best management practices or other relevant legislation to protect soil resources.*
*4.2.b Area and percent of forest land with significant soil degradation.*
*4.3 Water*
*4.3.a Proportion of forest management activities that meet best management practices, or other relevant legislation, to protect water related resources.*

While soil comes in a tremendous array of textures, colors, varieties, and degrees of fertility, healthy forest soils share certain traits—they are optimally stable, structured (i.e. uncompacted), cool, and imbued with organisms and organic matter appropriate to their soil type.

Water flowing from healthy forests is generally clear, clean, cool, and highly oxygenated. These qualities enable it to support diverse aquatic life.

## 4. Maintenance of forest contribution to global carbon cycles (Montreal Process Criterion 5)

*Montreal Process Indicators:*
*5.b Total forest product carbon pools and fluxes.*

Forests play a key role in the global carbon cycle. Simply put, trees sequester (store) carbon, helping to reduce atmospheric carbon levels (greenhouse gases that contribute to global climate change). During photosynthesis, trees and other plants absorb carbon and convert it to sugar—the building block for roots, stems, and leaves. Some of the carbon stored during photosynthesis transfers to the soil when the leaves drop or the plant dies.

Trees also release a small amount of carbon dioxide to the atmosphere through the process of cellular respiration. By keeping forests healthy, we maintain their role in the global carbon cycle.

PHOTO: JONATHAN BLAKE

# PART II

## Twelve Benchmarks of Forest Health

> *"Science can be very useful to those who would be healers, but it cannot substitute for heart, intuition, and hands."*
>
> —David Perry, et al. *Forest Ecosystems*, 2008

So, now it's time to get out into your town forest and assess its health, which you now know hinges upon conserving biological diversity, maintaining forest ecosystem vitality, conserving soil and water resources, and maintaining your forest's contribution to global carbon cycles. The 12 benchmarks below will help you determine whether or not your forest meets the criteria and indicators for forest health listed in Part I.

First, we'll describe the benchmarks below. Then, in the next section, we'll guide you through the process of assessing these benchmarks in your town forest.

## The Trees

In the early days of American forestry, forest managers often removed poorly formed, rotting, slow-growing, old, dead, and dying trees and species incapable of producing high-quality timber, in order to get the forest under "wise use." Today, forest conservation practices maintain and even increase those very trees that were once viewed with such disdain. The following three benchmarks help ensure that your town forest maintains these important forest features.

### Legacy Tree Benchmark:

**There are a minimum of three vigorous and wind-firm legacy trees per acre measuring over 19 inches diameter at breast height (DBH).**

A legacy is defined as "something that had come from a predecessor or the past."[6] Biological legacies are biological elements that persist through disturbances and assist in maintaining a given trajectory for a stand or area.[7] Biological legacies include buried seeds, living roots, soil microbes (such as mycorrhizal fungi), animals, living and dead trees, and even soil organic matter. Ecosystems with excellent supplies of diverse, well-distributed, biological legacies can be expected to recover much more rapidly and completely from disturbance.

In addition to providing seed, shade, and countless other ecological functions, living trees maintain connectivity with the elements of the forest ecosystem that are found below ground. Living trees—especially healthy, large, old ones—therefore maintain elements of mature forest soils in forests that have been disturbed. They also provide structural diversity in a recovering forest ecosystem.

## Tree Species Richness Benchmark:

**Native tree species richness is maintained when pre-and post-treatment levels are compared.**

Species richness can be as simple as the number of different species found in a given area. Every forest is made up of various **natural communities**—distinct assemblages of organisms interacting with each other and with their physical environment. In Vermont, ecologists have identified 25 upland forest and woodland communities and 14 forested wetlands, and each natural community has a particular array of plant and wildlife species associated with it.

> *"Structural diversity of species-rich forests (the variety of sizes, forms and seasonal patterns exhibited by trees) is greater than that of species-simple forests, even when the latter are genetically diverse. Since structure in the tree layer provides living and working space for the other occupants of the forest ecosystem, it is not too surprising that the diversity of animal species varies in the same manner as diversity of trees species."*
>
> –Perry et al, *Forest Ecosystems*, 2008

All things being equal, species richness increases as the size of the sampled area increases. Increases in species richness indicate increased available energy, increased habitat complexity, reduced environmental stress, and increased environmental stability.[8] Trees are a critically important part of the species richness of forests, and their richness gives insights into the richness of other species—plant and animals. And trees stand still when measured!

## Snag & Cavity Trees Benchmark:

**There are a minimum of four large, secure cavity or snag trees per acre with one exceeding 21" diameter at breast height (DBH) and four exceeding 15" DBH.**

Dying, dead, and down trees were once considered a waste of wood fiber and a fire hazard. Snag trees are relatively stable standing trees that are dead or partially dead.[9] They provide habitat for many animal species and also serve as germination sites for many plant species.

> *"Large dead wood plays a keystone role in forests. Snags are essential for cavity-nesting birds, and logs that fall into streams enhance fish diversity by creating pools and hiding places."*
>
> —Perry et al, *Forest Ecosystems*, 2008

Cavities can be found in healthy, dead, or dying trees. Cavity trees provide important habitat for many forest-dwelling wildlife species, and many of these species have very specific minimum size requirements for the cavity trees or snags they utilize.[10] All other things being equal, larger cavity trees provide better thermal insulation, increased protection from predators, higher and more stable perches, and greater longevity than smaller cavity trees. Larger trees also can hold larger cavities, with more room for larger cavity-nesting animals and their young.

PHOTO: JONATHAN BLAKE

## Forest Access

### Access Paths and Trails Benchmark:

**Erosion control structures such as water bars, broad-based dips, and turn-ups are properly installed on all forwarding paths and skid trails at intervals according to Table 1 of the Vermont AMPs.**

*"Steep slopes are particularly vulnerable to water erosion when forest cover is removed.… Removing forest cover increases surface erosion for two reasons: 1) because of loss of tree cover and litter layers, rain impacts soils with much more force, and that extra force is translated into moving soil: and (2) the mechanical holding power of roots is lost."*

—Perry et al, *Forest Ecosystems*, 2008

Properly located, designed, constructed, maintained, and closed forwarder paths and skid trails are essential to maintaining forest health. Done well they become "lines of grace" in working timberlands. Good design minimizes the number and extent of these access roads while greatly improving harvesting efficiency and reducing residual stand damage. After identifying proper locations for log landings and stream crossings, it is important to locate the road network. This is best done without leaves on the trees and snow on the ground. Though access roads with average grades of 7% or less are highly stable and efficient, they do require proper drainage to prevent soil erosion.

> **Old-style forest access:** *"If the old pine passed muster, the next step was to lay out a road on which to balk it, as hauling the log was called in those days, to the nearest waterway, often miles away. First of all, the road had to be straight, for one doesn't turn corners with a log over 100 feet long and a yard or two thick. Swampers cut down trees and underbrush, dug out rocks, cut off projecting roots, filled hollows, bridged streams and gullies, and "wharfed" side-hills with logs."*
>
> —Robert E. Pike, *Tall Trees, Tough Men* (p. 41)

## Log Landing Benchmark:

**Log landings are located on nearly level, stable ground, kept out of protective strips, and graded to prevent soil erosion and stream sedimentation.**

Log landings are the places from which forest products are shipped off to market. Log landings must be readily accessible to trucks. They also need to be large enough to allow the loggers to sort their products. In some cases they need to provide enough space for on-site processing of firewood. In short, log landings are busy and important places. They tend to have significant amounts of bare mineral soil so they need to be relatively flat and well away from streams and other waterbodies. In sum, log landings are control points that must be carefully located, designed, constructed, maintained, and closed.

## Stream Crossing Benchmark:

**Streams are crossed with bridges or culverts that are properly sized according to Table 2 in the Vermont AMPs and carefully installed perpendicular to the stream.**

Stream crossings are where forest access roads and streams intersect. Finding just the right location for steam crossings can significantly reduce their ecological impacts. Ideally, stream crossings are located where the stream and stream banks are straight and well-defined. Ideally the ground is well-drained, and there is enough room to discharge road surface water off the road before crossing the stream.  Stream crossings, like log landings, are key control points. Every effort should be made to minimize their number and to find ideal locations for those crossings that are required. Bridges are often better than culverts because impacts to stream channels are reduced. (Note: Some management guides permit fording streams that have stable bottoms or placing wood debris in them which is later removed. Neither of these management practices could be described as "best.") Whether culvert or bridge is employed, crossings that are perpendicular to the stream can reduce the risk that the stream will jump out of its channel and follow the access road down the hill. This can have devastating impacts!

## Leaving Wood Behind

### Large Downed Wood Benchmark:

**There are a minimum of four downed trees or 16+ foot long logs per acre on average, with one exceeding 21” DBH and four exceeding 15” DBH.**[11]

> *“Decayed logs on the forest floor and within the soil store water and provide habitat for microbes, invertebrates, and some vertebrates. Down logs and other coarse woody debris are also believed to be critical for the survival of martens, fishers, and sables. Coarse woody debris is particularly important to these animals in winter, providing protection from predators, access to spaces below the snow where prey live, and protected sites where (animals) can minimize energetic costs while resting.”*[12]
>
> —Perry et al, *Forest Ecosystems*, 2008

Downed wood provides habitat for many species of plants and animals. It also stabilizes the forest floor, provides sites where positively-charged ions can attach (thereby aiding nutrient retention), and retains moisture for long periods. All other things being equal, large-diameter downed wood is much longer lasting and more effective at achieving these ecological benefits than small-diameter downed wood.

### Small Woody Debris Benchmark:

**All leaves, needles, and tree limbs less than 3 inches in diameter are left in or close to the place where they were felled.**

> *“In the past, German farmers regularly raked litter from pine stands to use as bedding for livestock. To test whether that might affect tree growth, German foresters set up paired plot experiment in which litter was raked annually from one of the pair, while the other was left undisturbed. After several decades, site class of plots from which litter had been removed average more than one to more than two classes lower than plots without litter removal. Similar effects of litter removal have been demonstrated in the United States.*
>
> —Perry et al, *Forest Ecosystems*, 2008

Leaves, needles, and small branches contain a disproportionate amount of a tree’s nutrients. Leaving them to rot where they fall in the forest can dramatically reduce the incidence of nutrient depletion. Small branches can create a woody mat that allows more water to seep into the soil, rather than flowing over the top. Such “overland flow” can dislodge soil particles and transport them long distances. Small branches also trap and cool soil. When tops are left in place and not lopped to the ground, they can discourage herbivores like white-tailed deer from munching on the regeneration.

PHOTO: JONATHAN BLAKE

## Streams & Their Buffers

### Stream Protective Strip Benchmark:

**All streams are bordered by protective strips that exceed the minimum widths listed in Table 4 of the Vermont AMPs, have little or no bare mineral soil or ground disturbance, and have at least 70% crown closure.**

To maintain a healthy forest, it's essential to maintain undisturbed or minimally disturbed protective strips in stream riparian zones. In addition to providing travel corridors and connectivity for wildlife, protective strips can capture significant amounts of sediment before it washes into flowing waters. In addition, protective strips with high amounts of canopy closure can intercept solar radiation before it strikes streams and raises water temperatures.

### Stream Condition Benchmark:

**All streams and other bodies of water are kept free of logging slash, debris, and waste.**

In a self-willed forest, trees and their parts are constantly falling into streams and other waterbodies. Some sediment is deposited as well. The wood serves a wide variety of important ecological functions and values. It creates plunge pools, as well as places for stream macroinvertebrates to deposit their eggs and to attach themselves. Fallen leaves and twigs provide food as well. However, during logging operations, slash, debris, and sediment may be added to streams and other waterbodies in large quantities over a short period of time. This can choke spawning beds, divert streams, block fish migration, and clog culverts.

## The Other Important Stuff

### Ecologically Sensitive Areas Benchmark:

**Sensitive areas such as rare upland forest communities and forest wetlands are properly buffered.**

"*Special habitats and ecosystems are places within a landscape that make unique contributions to biodiversity. They require special consideration during forest management activities.*"[13]

—Carol R. Foss, *Special Habitats and Ecosystems*, 1999.

Certain places in the forest are so fragile and so unique that they ought to receive very special care and attention. These areas serve as mini ecological reserves within working timberlands. Perhaps the best thing to do is to identify them and leave an undisturbed buffer around them.

### Non-native Invasive Tree & Shrub Species Benchmark:

**Invasive tree and shrub species are absent.**

To be labeled as *invasive*, a species must be non-native to the ecosystem under consideration. Moreover, its introduction must cause, or be likely to cause, economic or environmental harm or harm to human health. Invasive species are second only to habit loss and degradation in endangering native species.[14] Ecologists estimate that about one-third of the plant species currently residing in Vermont are non-native.[15] The Vermont state flower, red clover, is one of them! Fortunately only about 8% of these non-native species are considered invasive, with the potential to inflict "ecological or economic harm due to their ability to grow rapidly, profusely, and widely." The Invasive Plant Atlas of New England lists over 100 plants as invasive.

PHOTO: JONATHAN BLAKE

PHOTO: JONATHAN BLAKE

## Assessing the Benchmarks in Your Town Forest

> *"Ultimately, a sustainable future will be achieved only by considering the earth and all of its inhabitants as an integrated, interdependent whole."*[16]
>
> —Perry et al, *Forest Ecosystems*, 2008

**We've organized the 12 benchmark assessments so as to group together assessments that focus on similar landscape features:**

- During the first three assessments—of access paths and trails, stream crossings, and log landings—you'll be walking your town forest's access paths and trails.
- To carry out the next two assessments—of stream protective strips and stream conditions—you'll walk along the streams and/or other surface water features in the forest.
- During the next four assessments—of tree species richness, non-native exotic trees and shrubs, sensitive areas, and small woody debris—you will explore various areas within the forest and identify particular features (tree and shrub species, and the presence or absence of small woody debris) along the way.
- To make the final three assessments—of legacy trees, snag and cavity trees, and large downed wood—you'll be conducting some simple point sampling to determine the abundance of these landscape features in your town forest.

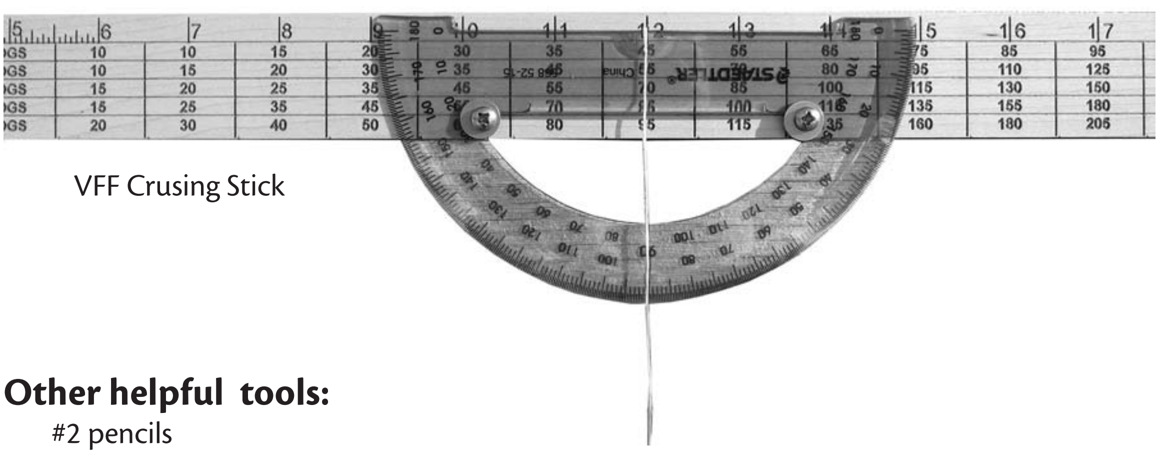
For each assessment, we provide both written and video instructions, as well as tally sheets on which to record your findings. When you complete all 12 benchmark assessments, you'll fill out the *Health Check Summary Sheet*, which will help you compile your findings and determine what steps, if any, you might take to improve your forest's health.

First we'll introduce you to the basic tools you'll need to make your assessments, and teach you how to use them.

## The Vermont Family Forests Health Check Tool Kit

You don't need a lot of expensive equipment to get a good sense of what's going on in your forest. In VFF's *Health Check Tool Kit*, available from Vermont Family Forests, you'll find the following low-tech tools:

| **Tool** | **Purpose of tool for *Health Check*** |
|---|---|
| **VFF cruising stick** | Measures tree diameter |
| **Protractor clinometer** | Measures slope, ruler edge is useful in identifying invasive exotic plants |
| **Penny** | Measures number of trees per acre |
| **Health Check tally sheets** | Record data from benchmark assessments |
| **Roll of bright flagging** | Serves as second person |
| **Point center stick** | Marks sample point centers |
| **Crown densiometer (clear plastic grid)** | Measures how completely the forest canopy covers the stream |



VFF Crusing Stick

## Other helpful  tools:

#2 pencils
Permanent markers (for writing on flagging)
Clip board
AMP booklet (available from your county forester, or on-line at www.vtfpr.org/watershed/documents/Amp2006.pdf
*Wetland, Woodland, Wildland*, by Elizabeth Thompson and Eric Sorenson.
Map of property
USGS 1:24000 topographic map

## How to use your VFF *Health Check* tools

### 1. VFF Cruising Stick: Measuring tree diameter

To see a video demonstration of how to use the VFF Cruising Stick, visit www.familyforests.org/education/TFHC

Foresters measure tree diameter at 4.5 feet up the trunk from the ground (thus, the measurement's known as "diameter breast height," or DBH). If you're of average height, then your breast height should be about 4.5 feet. If not, measure from your feet up your body and make a mental note of where on your body you reach 4.5 feet. That way, you'll be able to easily determine that height while you're in the woods. If the tree is on a hill, measure up 4.5 feet from where the ground is highest. If the tree is forked at or below 4.5 feet, consider the two trunks as separate trees.

To measure tree diameter, you're going to need to hold the VFF cruising stick 25 inches out from your body. The 25-inch distance is important to get a reasonably accurate measure of diameter, so use the cruising stick carefully. One narrow side of the cruising stick has inches laid out on it. Using that side, place one end of the stick against your chest (the zero end of the inch scale) and hold the stick at the 25-inch mark. That's the distance from your body that you need to hold your hand when measuring tree diameter.

To measure tree diameter, use the "Tree Scale" side of the cruising stick. Stand in front of the tree and hold the VFF cruising stick 25 inches away from your body at 4.5 feet above the ground with the diameter scale facing you. Position yourself so that the stick is touching the tree, and look directly at the center of the trunk. Moving only your eyes (don't shift your head), slide the stick to the left or right until the zero-end of the stick coincides with the left edge of the tree trunk.

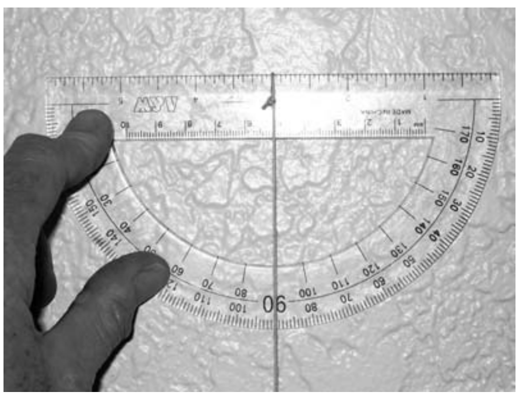
Without moving your head, shift your eyes to the right and read the measurement that coincides with the right edge of the tree trunk. That's the tree's DBH, including bark. Since trees are not perfect cylinders, you can take two measurements at right angles to one another and average them for greatest accuracy.

## 2. Protractor Clinometer: Measuring access road slope

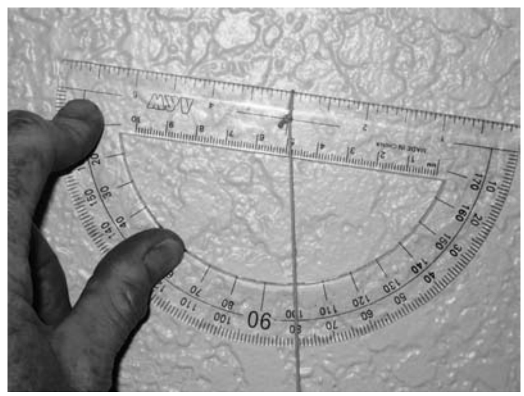
To see a video demonstration of how to use the protractor clinometer, visit www.familyforests.org/education/TFHC

While most foresters have clinometers that they use to measure ground slope, these clinometers work on the same general principle as a simple protractor with a weighted string. When you hold your protractor with the straight edge up and parallel to the ground, the weighted string hangs straight down, crossing the curved part of the protractor at the 90° mark. If you shift the protractor so that the straight edge tilts at an angle to the ground, the string shifts its position along the curved edge of the protractor. The reading at which the sting crosses tells you the number of degrees the straight edge is sloping from horizontal.

### For example:



*The straight edge of this protractor is horizontal (zero slope). The string crosses the curved edge at the 90° mark.*



*The straight edge of this protractor is tilted. To determine the slope of this tilt, look where the string crosses the curved edge. In this example, it crosses at the 80° mark. That means it's 10° off of the horizontal reading in the left photo, so the slope is 10°. You can convert from degrees of slope to percentage using Table 5, below. According to that table, this slope is 18%.*

To measure the slope of a particular stretch of land in your town forest, here's what you'll do: Stand at one end of the slope you wish to measure and have a friend stand at the other end. If you're working on your own, you can hang a bright flag at your eye level at that end spot. The VFF cruising stick anchors your protractor clinometer to the cruising stick, with the straight edge aligned with the narrow edge of the cruising stick. Place the end of the cruising stick below one eye, and sight along it, over the straight edge of the protractor, so that your friend's eye (or flagging) appears at the other end of the stick. Carefully trap the string against the protractor as you sight along the straight edge, so that you can capture the measurement. The difference between that measurement and 90° (which is the measurement when the protractor is horizontal and the slope is zero) is the number of degrees at which your access road slopes. Use the table below to convert degrees to percent slope.

**Table 1. Converting slope in degrees to slope in percentage**[17]

| Slope (degrees) | Slope (%) (rounded to nearest whole number) | | Slope (degrees) | Slope (%) (rounded to nearest whole number) | | Slope (degrees) | Slope (%) (rounded to nearest whole number) |
|---|---|---|---|---|---|---|---|
| 1° | 2 | | 8° | 14 | | 15° | 27 |
| 2° | 4 | | 9° | 16 | | 16° | 29 |
| 3° | 5 | | 10° | 18 | | 17° | 31 |
| 4° | 7 | | 11° | 19 | | 18° | 33 |
| 5° | 9 | | 12° | 21 | | 19° | 34 |
| 6° | 11 | | 13° | 23 | | 20° | 36 |
| 7° | 12 | | 14° | 24 | | 21° | 38 |

## 3. Penny: Measuring number of trees per acre

To see a video demonstration of how to use a penny to measure trees per acre, visit www.familyforests.org/education/TFHC

While foresters use a 10-factor prism to help them calculate the number of trees per acre, you can use a humble penny. In the penny method, you're going to need to hold the penny 25 inches in front of your eye. If you have the VFF cruising stick, then your cruising stick has a slot carved into it at exactly 25 inches into which your penny fits. When you place the zero end of the cruising stick on your cheek under your eye, the penny will be perched at the appropriate distance, ready to use.

With *variable area point sampling*, you randomly choose points in the forest area you are sampling. These will serve as the *point centers* for your sample areas. Push your point center stick (included in the VFF *Health Check Tool Kit*) into the ground at your first randomly selected plot center point. With your eye positioned directly over the plot center stick, hold a penny 25 inches from your eye. You will gradually move in a complete circle around this center point, sighting on the trees you see beyond your penny. If the penny appears to fit inside the tree trunk at breast height, then it's a potential "count" tree. If the penny appears wider in diameter than the tree trunk, don't count that tree. Measure every other tree that appears to exactly match the penny diameter.

Because we're only interested in large trees in this survey, you'll only tally the tree on your tally sheet if it meets the following criteria:

1) If the tree is vigorous and wind-firm and measures more than 19" DBH;
2) If the tree has a cavity in it and measures more than 15" DBH; or
3) If the tree is dead, you will count all standing trees over 15 inches DBH, as well as all downed trees or logs (over 16 feet long) that measure over 15 inches DBH.

**Be sure to verify each tree or log diameter with the VFF cruising stick before counting it and recording it on your Health Check tally sheet.**

Please note that you are tallying trees in 2-inch *diameter classes*. That means that trees 15-17 inches DBH are tallied as 16-inch trees, and so forth.

Through this rather magical process, you'll end up with a tally of trees within a sample area of 1/10 of an acre. Trees that are large enough and close enough to the plot center are "count trees." The diameter of each counted tree will allow you to determine how many trees per acre it represents (You'll be guided through the process of determining trees/acre in the instructions for Benchmarks 10-12.)

In your town forest, you should try to take a minimum of 5 point samples for any given forest area or stand you're interested in learning about. Make sure you select the point sample sites **randomly** so that your results will be as accurate as possible. You will have one tally sheet for each forest stand, and on each tally sheet, you'll have tree data from however many point samples you assess. **Be sure to note on the tally sheet how many point samples you study.**

## 4. How to measure distance by pacing

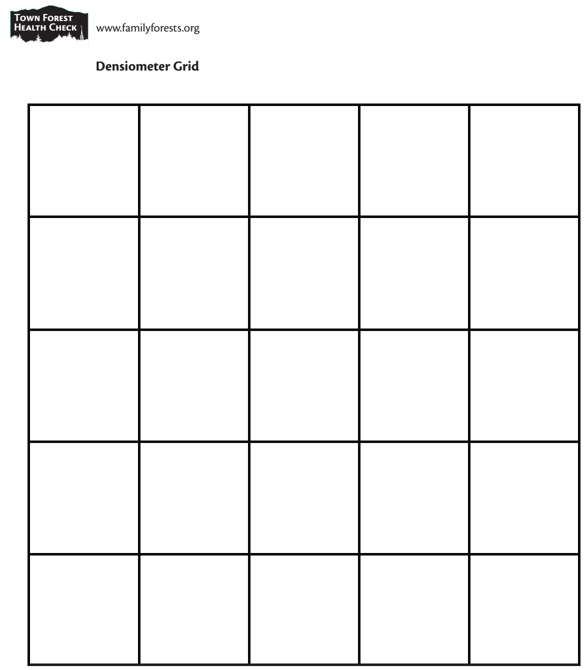
To see a video demonstration of how to calculate your pace, visit www.familyforests.org/education/TFHC

Before you head into the woods, walk 10 strides (a **stride** equals the distance of 2 steps) and measure the distance you cover with a measuring tape. Then divide by 10 to determine the length of one stride. Jot that stride length down on one of your Health Check tally sheets. That is your very own pace! (If you happen to forget, paces are often quite close to the pacer's height.)

When you need to determine a distance in the forest, count the number of strides you take to walk between the two points. Multiply that number by your stride length to determine the distance you covered.

## 5. Crown Densiometer: Measuring % crown closure

To see a video demonstration of how to use a Crown Densiometer, visit www.familyforests.org/education/TFHC




While foresters often use a spherical densitometer to measure the density of the forest overstory, this equipment is relatively expensive and not widely available. A simple transparency with a grid of 25 squares superimposed upon it can give satisfactory results. This transparency is included in the VFF Health Check tool kit, but you can also make your own by drawing a 5 x 5 grid of boxes, each 1.5” square, on an 8.5” x 11” transparency. Hold the sheet in a horizontal position over your head. Count the number of squares in which tree crowns (rather than sky) occupy more than half the square. Multiply that number times 4. That is the percent crown closure for that point. If the crown closure appears to be variable in the area you are examining, take 4 or 5 samples and average them.

PHOTO: LOUISE KILBOURN BRYNN

## Walking the Access Trails (benchmark assessments 1-3)

In Assessments 1-3, you'll be walking your town forest's access trails, examining erosion control structures, log landings, and stream crossings. Before beginning your explorations, read the instructions for Assessments 1-3, so that you know what you'll be looking for and doing along the way.


### Access Paths and Trails Benchmark Assessment

**Access Paths and Trails Benchmark.** Erosion control structures such as water bars, broad-based dips, and turn-ups are properly installed on all forwarding paths and skid trails at intervals according to Table 1 of the Vermont Acceptable Management Practices (AMPs).

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

Trails and paths—usually too many of them—cross most woodlots. Ideally you will look at all of the trails. But if time is limited, focus on those trails that seem to have been most frequently and recently used and that are located near streams or other waterbodies. This is where you will likely encounter the highest potential for negative impacts on water quality and site productivity.

**You can best carry out this assessment by evaluating one trail segment at a time. For each trail segment you study, you'll need to take the following three measurements:**

1. **The slope of the trail or path segment.**
2. **The number of places where water is effectively removed from the road surface.**
3. **The length of the trail segment.**

***Record your findings on the tally sheet for Benchmark Assessment #1.***

**1& 2.** Start by hanging a bright flag at your eye height at the starting point for the assessment. Then walk out the trail as far as you can while still being able to clearly see the flag. As you walk, keep track of the number of paces you take, so you can calculate the length of that segment.

Also, as you walk, keep track of the number of places where water is obviously discharged from the road surface. These can be natural changes in topography, places where logs fell across the trail and divert water, or human-made diversions like waterbars and dips. The bottom line is that, to prevent erosion, these natural and human-made structures need to divert water off the road, even when the trail is heavily used.

When you reach the end of the trail segment (the point at which you nearly lose sight of the first flag you hung), hang another bright flag at eye height.

Now calculate and record on your tally sheet the slope of the trail segment you just walked by sighting with your clinometer back at the flag that marks the beginning on the segment. (For instructions on measuring slope, see page 20).

3. Calculate and record the length of the trail segment you just walked (see page 22 for instructions on calculating distance from pace).

At this point you have the length and average slope of the trail segment and the number of erosion control structures in place along that segment. Using Table 2, you can now determine how your trail segment measures up to Vermont's Acceptible Management Practices (AMPs).

**Table 2. Number of erosion control structures needed per trail segment:**[18]

| Trail grade (%) | Trail grade (degrees) | 50 foot segment | 100 foot segment | 150 foot segment | 200 foot segment | 250 foot segment |
|---|---|---|---|---|---|---|
| **1** | <1 | 0.1 | 0.3 | 0.4 | 0.5 | 0.6 |
| **2** | 1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 |
| **5** | 3 | 0.5 | 0.7 | 1.1 | 1.5 | 1.9 |
| **10** | 6 | 0.6 | 1.2 | 1.9 | 2.5 | 3.1 |
| **15** | 9 | 0.8 | 1.7 | 2.5 | 3.3 | 4.2 |
| **20** | 11 | 1.1 | 2.2 | 3.3 | 4.4 | 5.5 |
| **25** | 14 | 1.2 | 2.5 | 3.7 | 5.0 | 6.2 |
| **30** | 17 | 1.4 | 2.8 | 4.3 | 5.7 | 7.1 |
| **35** | 19 | 1.6 | 3.1 | 4.7 | 6.2 | 7.7 |
| **40** | 21 | 1.7 | 3.3 | 5.0 | 6.7 | 8.3 |

Let's say your trail segment is 200 feet long, has a slope of 25%, and has 3 functioning waterbars in place. Using the table above, you can see that the trail segment needs two more erosion control structures to meet the Access Paths and Trails Benchmark.

Once you finish assessing the segment, you can remove the flag at the starting point of that segment. If time allows, you can flag the locations for additional erosion control. It would be helpful to write "waterbar" or "dip" on the flag in permanent marker. Make a note of the work required on your tally sheet.

**Repeat the above process for each trail segment you'll be assessing.**

**Conclusion:** If a trail segment meets the Vermont AMP recommendations for erosion control, then check "Y" in the "Meets benchmark" column for that trail. If not, check "N". If all trail segments meet the benchmark, check “Healthy” in the box in the lower right corner of the tally sheet. If not, indicate that the trail “needs work” and summarize the work required.


## Log Landing Benchmark Assessment

**Log Landing Benchmark.** Log landings are located on nearly-level, stable ground, kept out of protective strips, and graded to prevent soil erosion and stream sedimentation.

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

**If you have any log landings on your town forest, you will assess them by taking five measurements:**

1. **The slope of the landing.**
2. **The most advanced soil erosion on the landing.**
3. **The existence of drainage swales that intercept and re-direct water before it reaches the landing.**
4. **The distance from the landing to a stream or waterbody.**
5. **The slope of the land between the stream or waterbody and the landing.**

***Record your findings on the tally sheet for Benchmark Assessment #2.***

**1.** Find the lowest elevation point on the landing and hang a flag there at your eye level. Then go to the highest point on the landing and determine the slope from there to the lowest point (see page 20 for instructions on how to measure slope). It should be 5% or less.

**2.** Walk the entire landing and look for evidence of soil erosion. Note the worst case of erosion encountered, and record as follows:

**None to slight**
**Sheet** = minute rills present
**Rill** = erosion up to 6 inches deep
**Initial gully** = 6 -12 inches deep
**Marked gully** = 12 -24 inches deep
**Advanced gully** = +24 inches deep

**3.** Note if surface water is effectively diverted before it encounters the landing.

**4.** If there is a stream or other waterbody within 110 feet of the landing, go to the point on the landing that is closest to it. Hang a flag at eye level. Pace the distance to the stream or waterbody and calculate the length of that distance (see page 22 for instructions on using pace to calculate distance).

**5.** Calculate the slope of the buffer strip between the water body and the closest point on the landing. (see page 20 for instructions on calculating slope).

**Table 3: Protective Strip Width Guide**[19]

| Slope between Landing and Stream or Waterbody (%) | Slope between Landing and Stream or Waterbody (Degrees) | Minimum Width of Protective Strip Between Landing and Stream (in feet along surface of ground) |
|---|---|---|
| 0-10% | 0-6 | 50 |
| 11-20% | 7-11 | 70 |
| 21-30% | 12-17 | 90 |
| 31-40% | 18-23 | 110 |

**Conclusion:** If the landing is 5% or less in slope, has only 'none-slight' erosion, has surface water effectively diverted, and is located outside the protective strip, then check "Y" under the "Meets benchmark" column on the tally sheet. If all landings meet the benchmark, check "healthy" in the box in the lower right corner of the tally sheet. If a landing does not meet the benchmark, check "N" in the "Meets benchmark" column, check "needs work" in the box in the lower right corner of the tally sheet, and summarize the work required.


## Stream Crossing Benchmark Assessment

**Stream Crossing Benchmark.** Streams are crossed with bridges or culverts that are properly sized according to Table 2 in the Vermont AMPs and carefully installed perpendicular to the stream.

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

**To assess stream crossings, you will need to examine:**

1. **The functional size of the existing culvert or bridge.**
2. **The recommended structure size.**
3. **The angle of the crossing.**

***Record your findings on the tally sheet for Benchmark Assessment #3.***

Stream crossings should be made with adequately-sized bridges or culverts, and this size is based upon the acreage and soil drainage of the upstream watershed. They also should be installed at the proper angle.

You can determine the size of culvert or bridge required for drainage sites along your access trails by using topographic maps to assess the drainage area or by using the Hasty Method.

The topographic drainage area approach requires a USGS map of 1:24000 scale or so. First, identify the location of your culvert on the map. Then determine the upstream watershed acreage.

To obtain more information on *Calculating Watershed Area*, refer to *"Outlining a Surface Watershed"* which is included in the VFF Health Check Tool Kit.

In addition, you need to identify the watershed soils as either "well drained" or "shallow to bedrock and/or impermeable." You can use a soil survey if one is available. Otherwise, look at the soils throughout watershed and estimate what % are well-drained sandy or loamy soils and what % are clay or shallow to bedrock.

**Table 4: Guide for determining culvert size for stream crossings using the topographic drainage area method. (Drainage Area = The number of acres that slope toward your culvert site.)**[20]

| Upstream watershed area (acres) | | Recommended pipe diameter (inches) |
|---|---|---|
| Well-drained soils | Shallow soils with frequent rock outcrops or impermeable soil conditions | |
| 16 | 4 | 15 |
| 25 | 7 | 18 |
| 40 | 12 | 21 |
| 55 | 16 | 24 |
| 84 | 27 | 30 |
| 130 | 47 | 36 |
| 190 | 64 | 42 |
| 260 | 90 | 48 |
| 335 | 120 | 54 |
| 400 | 166 | 60 |
| 550 | 205 | 66 |
| 650 | 250 | 72 |

An easier but less accurate way to determine the appropriate bridge or culvert size for your stream crossing is called the **Hasty Method.** Add the widths of the stream (in inches or in feet) along the stream bottom and at the high-water mark and divide this by 2. Then multiply that figure by the depth of the stream when the water is at its high mark. This yields the recommended minimum structure size in square inches or square feet. Then use Table 5 to determine what the minimum diameter of your crossing culvert should be.

$$\frac{\text{Stream bottom width + Stream high-water mark width}}{2} \times \text{stream depth from high-water mark} = \textbf{Functional Structure Size}$$

(in square inches or square feet)

**Table 5. Hasty Method conversion table for determining proper culvert or bridge size from stream cross section assessment.**

| Minimum size of drainage structure (sq. in.) | Minimum size of drainage structure (sq. ft) | Recommended culvert diameter (inches) |
|---|---|---|
| 177 | 1.2 | 15 |
| 254 | 1.8 | 18 |
| 346 | 2.4 | 21 |
| 452 | 3 | 24 |
| 707 | 5 | 30 |
| 1017 | 7 | 36 |
| 1385 | 10 | 42 |
| 1809 | 13 | 48 |
| 2290 | 26 | 54 |
| 2827 | 20 | 60 |
| 3421 | 24 | 66 |
| 4071 | 28 | 72 |

Let's say your stream is 20 inches wide on the bottom, 38 inches wide at the high water mark, and 13 inches deep at the high water mark. {(20 + 30) / 2} * 13 = **325**. The functional structure size is 325 square inches, which meaning (according to Table 5) that you need a 21-inch culvert.

**1.** When you come to a stream crossing on one of your town forest access roads, identify the current stream crossing as bridge, culvert, or ford. Remember that fords are the least sustainable means of crossing and should be upgraded to a culvert or bridge.

**2.** If the crossing utilizes a culvert, measure the functional diameter of the existing culvert. If it is crushed or otherwise blocked, make the appropriate deductions and record that diameter in inches on your tally sheet. If the crossing utilizes a bridge, determine the area under the bridge that is available for water to pass through and record that area in square feet.

**3.** Use Table 4 or 5 above to determine the recommended culvert diameter/bridge size. If your existing culvert/bridge meets or exceeds this recommended diameter/size, then check the box that indicates that the crossing meets the VT AMP standard.

**4.** Trails and paths should be constructed so as to the cross the stream as close to perpendicular as possible. Project a line connecting points marking the center of the stream 15 – 20 feet above and below the stream crossing. Project a line connecting points marking the center of the trail or path 15-20 feet on either side of the stream crossing. Measure the acute angle made by those two lines. It should be 80 degrees or more.

PHOTO: E. CALLIE BRYNN

**Conclusion:** If the stream crossing has an adequately sized crossing structure in place and the access trail crossing is nearly perpendicular to the stream, then check "Y" in the "Meets benchmark" column of the tally sheet. If not, check "N". If all crossings meet the Stream Crossing Benchmark, check "healthy" in the box at the lower right of the tally sheet. If not, check "needs work" and summarize the work required.

## Walking the Streams (benchmark assessments 4 & 5)

In Assessments 4 & 5 you will walk along the banks of any streams that flow through your town forest, looking both at the streams themselves and at the forested land bordering either side of the streams. Read through the instructions for Assessments 4 & 5 before beginning your explorations, so you know what you'll be looking for and doing along the way.


### Stream Protective Strip Benchmark Assessment

**Stream Protective Strip Benchmark.** All streams should be bordered by protective strips that exceed the minimum widths listed in Table 4 of the Vermont AMPs, have little or no bare mineral soil or ground disturbance, and have at least 70% crown closure.

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

**To assess stream protective strips you will need to take three measurements:**

1. **The slope and width of the buffer strip between the stream and logging paths or trails.**
2. **The crown closure over the stream.**
3. **The existence of bare mineral soil on that portion of the protective strip within 25 feet of the stream.**

***Record your findings on the tally sheet for Benchmark Assessment #4.***

If time permits, you should examine all streams or waterbodies. If time is limited, select streams or waterbodies near areas where there has been recent road use and/or timber harvesting activity. (The point is to identify problems, not average conditions.) Establish sampling points at intervals of 100 to 250 feet along the stream or waterbody. It would be good to have at least 5 samples per stream.

**1.** At each sampling point along the stream, hang a flag at eye height. Measure the slope of the land between the stream and trails or paths. (See page 20 for instructions on measuring slope). Measure the width of the forested protective strip between the stream and trail. Using Table 3 on page 28, determine the recommended width of this protective strip. Record both figures on your tally sheet.

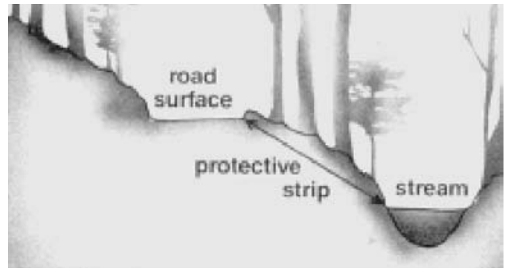



**Figure 1: The protective strip prevents road sediments from washing into surface water sources.**

(From *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs*, http://www.vtfpr.org/watershed/documents/Amp2006.pdf.)

**2.** Crown closure is best calculated when hardwood stands are in full leaf. Calculate the crown closure within the protective strip by using the crown densitometer included in your VFF *Health Check Tool Kit*. This 8.5 x11-inch transparency has been divided into 25 equally sized blocks. (If you need to make one of your own, simply use a fine-point permanent marker to divide a transparency into a 5 x 5 square-block grid, making 25 blocks.) Holding the transparency level and above your head, look through it and count the number of squares in which tree crowns and foliage occupy more than 50% of that square. Multiply that number by 4 to determine the % crown closure. It should be over 70%. If the crown closure appears to be variable in the area you are examining, take 4 or 5 samples and average them. Record the number on your tally sheet.

**3.** Within 25 feet of the stream or waterbody, note any bare mineral soil that exists and record on tally sheet.

**Conclusion:** If the width of the forested protective strip meets or exceeds the recommended width, the canopy is at 70% crown closure or greater, and the 25-foot buffer closest to the stream has little or no bare mineral soil, then check "Y" in the "Meets benchmark" column. If all protective strips meet the Stream Protective Strip Benchmark, check "healthy" in the box at the lower right of the tally sheet. If not, check "needs work" and summarize the work required.


## Stream Condition Benchmark Assessment

**Stream Condition Benchmark.** All streams and other bodies of water are kept free of logging slash, debris, and waste.

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

**To assess stream condition, you will need to take two measurements:**

1. **The dominant condition of the stream segment in terms of sedimentation.**
2. **The instances of the in-stream deposition of logging debris such as tops and logs.**

***Record your findings on the tally sheet for Benchmark Assessment #5.***

PHOTO: JONATHAN BLAKE

If time permits, you should examine all streams. If time is limited, select streams near areas that have experienced recent road use and/or timber harvesting activity. (The point is to identify problems, not average conditions.) Establish sampling points at intervals of 100 to 250 feet along the stream. Try to assess at least 5 samples per stream.

**1.** At each stream sampling point, examine both the water itself and the condition of the stream bed. The water should be clear and free of suspended sediment . The streambed should be free of sediment deposits resulting from adjacent land use. These deposits can blanket the entire stream bottom or be in feather-like plumes. Neither type of deposit resulting from accelerated soil erosion is good, and both should be noted.

**2.** Then examine the stream for evidence of logging debris, such as tops, branches, and logs. Note your findings on the tally sheet.

**Conclusion:** If the stream segment appears to be in natural condition with clean adjacent rocks, little sediment, and no plumes or alluvial fans, and if there are no deposits of logging debris such as tops and logs, then check "Y" in the "Meets benchmark" column. If all stream segments meet the Stream Protective Strip Benchmark, check "healthy" in the box at the lower right of the tally sheet. If not, check "needs work" and summarize the work required.

## Exploring Areas Within the Forest (benchmark assessments 6-9)

In Assessments 6-9, you'll examine several different areas within your forest, preferably ones that are quite different in character (in terms of slope, direction they face, soil type, soil moisture, and so on). Each particular physical environment attracts its own unique assemblage of plants and animals—its own distinct natural community. In Vermont, ecologists have identified 25 upland forest and woodland natural communities and 14 forested wetland natural communities.

During your assessments, you'll want to sample as many different natural communities as possible, so pay attention to changes in the landscape as you explore the forest. For Assessments 6-8, you'll be identifying tree and shrub species within your study area. For Assessment 9, you'll simply be noticing the presence or absence of small woody debris from past harvests in the areas you study. Read through the instructions for Assessments 6-9 before you begin your explorations, so you know what you'll be looking for and doing along the way.


### Tree Species Richness Benchmark

**Tree Species Richness Benchmark.** Native tree species richness is maintained when pre-and post-treatment levels are compared.

**To assess tree species richness, you will need to:**

**1.Tally the native species you find in a particular area within the town forest.** ***Record your findings on the tally sheet for Benchmark Assessment #6.***

**2. See "Extension" shaded box below.**

**1.** Choose a particular area within the forest to study. Walk through the area and record on your Benchmark Assessment #6 tally sheet the number of native tree species you find in that area. Tally only those species that have trees present that are over 4 inches DBH.
**Note: To be most efficient, you should also fill out the tally sheet for Benchmark Assessment #8 (non-native invasive trees and shrubs) at this time. You'll find photos and tips for identifying the non-native exotic plants on page 41.**

The tally sheet lists 54 native tree species, so you'll want to bring along a tree identification guidebook. One option is the excellent guide, *The Tree Identification Book.* Though it's bulky (8.5x11"), it has great illustrations of leaves, buds, twigs, bark, flowers, and fruits, and an easy-to-use key. The *Tree Finder* books are pocket-sized—much more portable than *The Tree Identification Book,* but not as exhaustive. Tree Finder helps you identify trees by their leaves. Its companion, *Winter Tree Finder,* helps with identification by branch pattern, buds, and fruits.

Repeat this process in several other areas of your town forest. Try to find sampling sites that are quite different from one another in character, since each particular physical environment attracts its own unique assemblage of plants and animals. Keep separate tally sheets for each sample area. If you have a map of your town forest, identify the locations of the each of the sample areas on it.

**These tallies provide a baseline of species richness information that your community can refer to should the town plan to harvest the forest in the future. To maintain the forest's health, the harvest plan should maintain the species richness of each area being harvested, giving special attention to under-represented species.**

**Extension:** You can use your tallied species list to help identify the natural community you're exploring. That process takes more work than you may wish to get into for this *Health Check*, but if you're willing to take it on, you can learn a lot about your forest. By identifying the natural community of the area you are sampling, you can then compare the number of species you found during your sampling with the potential tree species richness for that community, as detailed in *Wetland, Woodland, Wildland,* by Elizabeth Thompson and Eric Sorenson, which describes the species mix in all 81 of Vermont's identified natural communities (39 of which are forested). The book is available both in hard copy and on-line at www.vtfishandwildlife.com/books.cfm?libbase_=Wetland, Woodland,Wildland.

The number of species found in an area of known natural community can give some insight into the health of the forest growing there. For example, let's say one finds only sugar maples growing in a particular Rich Northern Hardwood Forest Community. That may be natural. However, across the range of Rich Northern Hardwood Forest Communities, one could—according to *Wetland, Woodland, Wildland*—find up to 10 species growing abundantly or occasionally. Perhaps the encountered monoculture was the result of past sugarbush management. If so, future management might encourage a more diverse array of species.

Eric Sorenson cautions, however, against basing management choices solely on the species composition in your sample area. He notes, "*The natural community types are composite descriptions, not goals for each place where the natural community occurs.*" If there is clearly a human-caused reason that a species does not occur at a particular natural community (for instance, if white oak were all logged out of a clayplain woodlot) then cultivating for this species makes sense. On the other hand, some natural community sites may naturally lack particular species. For example, some dry oak-hickory hophornbeam forests lack shagbark hickory because they are located at the northern edge of that natural community's range. In that instance, cultivating for shagbark hickory at that site does not make sense.

**Conclusion:** The process of determining the tree species richness of an area generally does not yield hard and fast information upon which specific management practices can be based. However, the species richness does give clues about the health of the forest as indicated by its biological diversity. At best, determining tree species richness will raise your awareness of the present conditions and cultivate your intuitions for future management considerations. If three or more native tree species are identified as *abundant* and there are five additional species that are *occasional to locally abundant*, then check "healthy" in the box in the lower right of the tally sheet.  If not, check "may need work" and summarize the work that might be required.


## Ecologically Sensitive Areas Benchmark Assessment

**Ecologically Sensitive Areas Benchmark.** Sensitive areas such as rare upland forest communities and forest wetlands are properly buffered.

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

**To assess the health of ecologically sensitive areas in your town forest, you will first need to identify the presence of ecologically sensitive areas. To do this you will:**

1. **Compare your tree species richness tally sheets (from Assessment #6) with the list of rare community indicator species on page 38.**
2. **Identify any forested wetland areas within your town forest, including seeps and vernal pools.**

**Once you've identified ecologically sensitive areas within your town forest, you will then**

3. **Look for evidence of human activities (access roads, tree cutting) near the sensitive areas and measure the distance of those activities from the sensitive areas.**

***Record your findings on the tally sheet for Benchmark Assessment #7.***

**1.** Take out the tree species richness tally sheets you compiled for Assessment #6. If any of the species you tallied are shaded gray on the tally sheet, they may indicate the presence of an uncommon natural community. Compare your tally list with the list of rare community indicator species on page 38. Use *Wetland, Woodland, Wildland* to clarify the natural community type.

**2.** Look for forested wetland areas within your town forest. Wetlands are saturated with water during the growing season and are dominated by species that are well adapted to living in saturated soils. As you might guess, forested wetlands have common to abundant trees.

Two specific kinds of forested wetlands that you find are seeps and vernal pools. Seeps have abundant groundwater discharging at their margins and usually a lush growth of herbs.

Vernal pools are depressions that fill with water in the spring and fall and typically have little herbaceous cover.

**3.** For any ecologically sensitive areas you identify, check for signs of human activities (bare mineral soil, erosion, or compaction resulting from access trails, logging, etc) within the area and within a 50-foot protective strip around the perimeter of the area.

**Conclusion:** If the ecologically sensitive area is not disrupted by human activities that result in bare mineral soil and/or soil erosion or compaction, and if there is no evidence of vegetation management, then check "Y" under the "Meets benchmark" column of the tally sheet. If all sampled areas meet the Ecologically Sensitive Area Benchmark, check "healthy" in the box in the lower right of the tally sheet.  If not, check "needs work" and summarize the work required.

## Indicator Tree Species for Uncommon Natural Communities

If you see any of the tree species listed below in the forest, there's a good chance that you're in an uncommon or rare natural community. Use *Wetland, Woodland, Wildland*, by Elizabeth H. Thompson and Eric R. Sorenson to help you pinpoint the natural community type (available in hard copy or on line at www.vtfishandwildlife.com/books.cfm?libbase_=Wetland,Woodland,Wildland).

**State Rank:** These ranks indicate the relative rarity of natural community types and are assigned by the Vermont Nongame and Natural Heritage Program.[21]

**S1:** very rare in the state, generally with fewer than five high quality occurrences.
**S2:** rare in the state, occurring at a small number of sites or occupying a small total area in the state.
**S3:** high quality examples are uncommon in the state, but not rare; the community is restricted in distribution for reasons of climate, geology, soils, or other physical factors, or many examples have been severely altered.

**Black gum:** Red Maple-Black Gum Swamp (S2)

**Black oak:** White Pine-Red Oak-Black Oak Forest (S3), Pine Oak-Heath Sandplain Forest (S1)

**Black spruce:** Cold Air Talus Woodland (S1), Black Spruce Swamp (S2), Black Spruce Woodland Bog (S2), Subalpine Krummholz (S1)

**Chestnut oak:** In Vermont, this oak species is found only in two uncommon communities: Dry Oak Forest (S3) and Dry Oak Woodland (S2)


PHOTO: JONATHAN BLAKE

**Eastern red cedar:** Red Cedar Woodland (S2)

**Northern white cedar:** Limestone Bluff  Cedar-Pine Forest (S2), Northern White Cedar Swamp (S3), Red Maple-Northern White Cedar Swamp (S3)

**Pitch pine:** This uncommon tree grows almost exclusively in three rare forest communities in Vermont: Pitch Pine-Oak-Heath Rocky Summits (S1) and Pine-Oak-Heath Sandplain Forest (S1), and  Dry Oak Woodland (S2).

**Red pine:** Red Pine Forest or Woodland (S2)

**Silver maple:** one of the three silver maple-dominated floodplain forest types: Silver Maple-Ostrich Fern Riverine Floodplain Forest (S3), Silver Maple-Sensitive Fern Riverine Floodplain Forest (S3), Silver Maple-Ostrich Fern Riverine Floodplain Forest (S2)

**Swamp white oak,** in conjunction with white oak, white pine, shagbark hickory, white ash, and/or green ash: Valley Clayplain Forest (S2)

**Yellow oak:** Limestone Bluff Cedar-Pine Forest (S2), Temperate Calcareous Outcrop (S3)


## Non-native Invasive Tree & Shrub Species Benchmark Assessment

**Non-native Invasive Tree & Shrub Species Benchmark.** Invasive tree and shrub species are absent.

**To complete the Non-native Invasive Tree & Shrub Species Benchmark Assessment, you will:**

1. **Identify the presence of any of the 11 most common non-native invasive species listed below.**

***Record your findings on the tally sheet for Benchmark Assessment #8.***

The following invasive trees and shrubs are ones you're most likely to encounter in your Vermont town forest. While walking though the forest, note on your tally sheet if you encounter any of these species. You'll find a guide to identifying these species on pages 41.

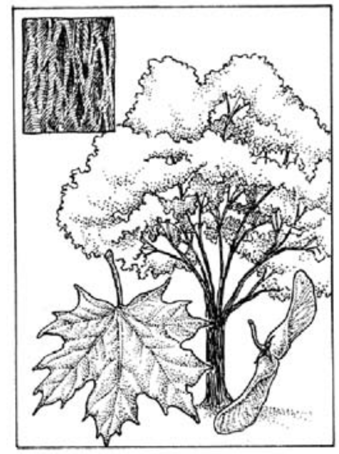
**Table 6. Common Invasive Exotic Plants in Vermont Forests.**

| **Scientific Name** | **Common Name** |
|---|---|
| *Acer platanoides* | Norway maple |
| *Alnus glutinosa* | European black alder |
| *Berberis thunbergii & vulgaris* | Japanese and Common barberry |
| *Euonymus alata* | Winged euonymous/ Burning bush |
| *Elaeagnus angustifolia* | Russian olive |
| *Elaeagnus umbellate* | Autumn olive |
| *Frangula alnus* | Glossy buckthorn |
| *Lonicera spp* | Honeysuckle species |
| *Rhamnus cathartica* | Common buckthorn |
| *Robinia pseudoacacia* | Black locust |
| *Rosa multiflora* | Multiflora rose |

**Conclusion:** If you didn't detect any invasive exotics in a particular area, then check "Y" in the "Meets benchmark" column on the tally sheet. If you did detect invasive species, indicate the species you saw in each area, and check "N" for that area. If all areas meet the benchmark, check "Healthy" in the box in the lower right of the tally sheet. If not, state that the forest 'needs work' to control them, and summarize the work required.

## Common Invasive Exotic Plants in Vermont Forests[22]

One important way to keep forests healthy is to limit the presence of non-native, aggressive plant species. These invasive exotics displace native species and upset the ecological balance of the forest. Below you'll find some of the most common forest invasives, plus information on how to identify them. We encourage mechanical removal of invasive species, rather than herbicide use.



**Norway Maple** *Acer platanoides*
Trees produce large numbers of wind-dispersed seeds that invade forests and forest edges. The dense canopy formed by Norway maple inhibits the regeneration of sugar maple and other tree seedlings, reducing forest diversity.

> **Identification:** Leaves are dark green, simple, opposite, 4"-7" wide with 5 lobes. Bark is grayish-black and furrowed. You can distinguish Norway maple from other maples by the milky fluid that oozes from freshly broken leaf stems. The tree leafs out and produces seeds earlier than other maples.

**European Black Alder** *Alnus glutinosa*
This quick-growing tree escaped cultivation in the late 1800s. A pioneer species, it readily colonizes open ground. Found in wet habitats, it produces abundant seeds that disperse readily in water. Able to form dense monocultures, it threatens native wetland species.

> **Identification:** This tree reaches 30 – 50 feet tall, often with a multi-stemmed trunk. The bark of young trees is smooth and gray-green, but turns grayish brown speckled with short, warty horizontal stripes and irregular, shallow fissures. Leaves are alternate, simple, oval, 2 -5 inches long, with a rounded or slightly notched tip.

Male flowers are slender, red-brown catkins 1 to 1.5 inches long. Female flowers are small, 1/6 inch, reddish-brown, cone-like catkins in clusters of 2–5 near branch tips. In fall, fruits are cone-like woody catkins, initially green, turning brown when ripe, 3/4 inch long, egg-shaped, and contain many small winged nutlets.

**Japanese Barberry** and **Common Barberry** *Berberis thunbergii* and *B. vulgaris*

Since birds often eat the fruits, then distribute the seeds in their droppings, the species has easily naturalized. Barberry suppresses the growth of native herbs.

> **Identification:** Compact, spiny, deciduous shrub, with small oval leaves, yellow flowers in spring, and oblong bright-red fruits in mid-summer through winter. You can distinguish common barberry (*Berberis vulgaris*) from Japanese barberry by its toothed leaves and its flowers, which form a long cluster, or raceme.

Japanese barberry, top
Common barberry, bottom

**Winged Euonymous (Burning Bush)** *Euonymus alata*

Widely planted as an ornamental shrub for its red autumn foliage, winged euonymous can spread by root suckers or by animal-dispersed seeds. It shades out native herbs and crowds out native shrubs.

**Identification:** Can grow 15 to 20 feet tall and equally as wide. Green-to-brown stems have two to four prominent corky wings. Elliptical leaves are simple, opposite or nearly opposite, 1 to 3 inches long and 1/2 to 1 1/4 inches wide, and finely toothed. Leaves turn bright red in autumn.


PHOTO BY JAMES H. MILLER, USFS

**Russian Olive** and **Autumn Olive** *Elaeagnus angustifolia* and *E. umbellate*

Both Russian and autumn olive were introduced from Asia as ornamentals. Birds and other wildlife eat their fruits and spread the seeds in their droppings. They thrive in poor soils and sprout vigorously after cutting or burning.

> **Identification:** Autumn and Russian olives are deciduous, thorny shrubs or small trees, with smooth gray bark. Their most distinctive characteristic is the silvery scales that cover the young stems, leaves, flowers, and fruit.

Russian olive, top
Autumn olive, bottom

**Glossy buckthorn** and **Common buckthorn** *Frangula alnus* and *Rhamnus cathartica*

Once established (often spread in bird droppings), both buckthorn species have the potential to spread aggressively because they thrive in habitats ranging from full sun to shaded understory. Both species cast a dense shade as they mature, inhibiting native herbaceous and low-shrub communities, and preventing the sprouting of tree seedlings.

Common buckthorn, top
Glossy buckthorn, bottom

**Identification:** Common and glossy buckthorns are tall shrubs/ small trees reaching 20 feet in height and 10 inches in diameter. Most often they grow in a large shrub form, with several stems. Common buckthorn leaves are dull green, oval, nearly opposite, finely toothed, and 1 to 2 inches long. Twigs may be tipped with sharp thorns. Small clusters of fragrant four-petaled, greenish-yellow flowers grow among the leaves. Glossy buckthorn has similarly shaped leaves, but they are glossy or shiny and lack teeth on their margins.

**Honeysuckle family** *Lonicera spp.*

Five non-native species of honeysuckle—Tartarian, Morrow, bell, dwarf, and Amur honeysuckles—have invaded Vermont's forests. Honeysuckles can form a dense shrub layer in the forest that competes with native woody and herbaceous plants.

**Identification:** Shrub grows to 16 feet. Leaves are opposite, oval to oblong, 1 to 2.5 inches. Tubular flowers hang in pairs on slender stalks and produce red, orange, or yellow berries in fall. Prefers lime-rich soils.

**Black Locust** *Robinia pseudoacacia*
What's not to like about black locust? Fragrant spring flowers, rot-resistant wood that's good for everything from fence posts to firewood. In fact, it was evidently once customary in Vermont to give newlyweds a black locust tree.

But this native of Southern Appalachia and the Ozarks grows very aggressively, sprouting from root suckers to form dense groves of clones that squeeze out native shrubs and trees.

> **Identification:** Can reach 40 to 100 feet in height. The bark of mature trees is dark brown and deeply furrowed, with flat-topped ridges. Leaves are alternate, compound (with 7-21 oval leaflets). Fragrant white flowers form drooping clusters in spring and have a yellow blotch on the uppermost petal. Fruit pods are smooth, 2 to 4 inches long, and contain 4 to 8 seeds.

**Multiflora Rose** *Rosa multiflora*
Native to Asia, multiflora rose was introduced in the 1860s as a root stock for ornamental roses. It has spread prolifically since then and can form dense thickets that squeeze out native plants.

> **Identification:** A thorny shrub with arching stems (canes). Compound leaves hold 5-11 toothed leaflets. The base of each leaf stalk bears a pair of fringed bracts. Clusters of fragrant, one-inch white to pink flowers appear in late spring, Small red rose hips develop during the summer and remain on the plant through the winter.

PHOTO: JONATHAN BLAKE


## Small Woody Debris Benchmark Assessment

**Small Woody Debris Benchmark.** All leaves, needles, and tree limbs less than 3 inches in diameter are left in or close to the place where they were felled.

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

**To complete the Small Woody Debris Benchmark Assessment, you will:**

1. **Identify areas harvested in the past 5 years or so.**
2. **Check for the presence of harvest-related tree limbs less than three inches in diameter.**

***Record your findings on the tally sheet for Benchmark Assessment #9.***

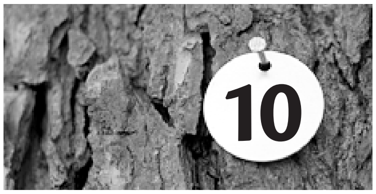
**1.** After about 5 years, most small woody debris associated with harvests has broken down and become difficult to identify. So in this assessment, you should identify areas in which timber harvesting operations have been completed within the past five years or so.

**2.** At each harvest site, note where the stumps are, and then locate the tops of the trees associated with those stumps. Does it appear that most of the limbs measuring less than 3 inches in diameter were left in the forest right where they fell? Record your findings on your tally sheet.

**Conclusion:** If the leaves, twigs, and limbs less than 3 inches in diameter were left where they fell in the forest, then check “Y” under “Meets benchmark” on the Small Woody Debris Benchmark tally sheet. If not, check “N”. If all assessed harvest areas meet the benchmark, check “Healthy” in the box at the lower right corner of the tally sheet. If not, check “Needs Work,” indicating that future harvests should increase retention of small woody debris.

PHOTO: JONATHAN BLAKE

## Conducting Point Sampling (benchmark assessments 10-12)




### Legacy Tree Benchmark

**Legacy Tree Benchmark.** There are a minimum of three vigorous and wind-firm legacy trees measuring over 19 inches diameter at breast height (DBH) per acre.


### Snag & Cavity Trees Benchmark

**Snag & Cavity Trees Benchmark.** There are a minimum of four large, secure cavity or snag trees per acre with one exceeding 21” diameter at breast height (DBH) and four exceeding 15” DBH.


### Large Downed Wood Benchmark

**Large Downed Wood Benchmark .**There are a minimum of four downed trees or 16+ foot long logs per acre on average, with one exceeding 21” DBH and four exceeding 15” DBH.[23]

To see a video demonstration of this assessment process, visit www.familyforests.org/education/TFHC.

**To gather data for assessing benchmarks 10-12, you will use a process known as point sampling. You will then plug this data into the tally sheet, which will help you calculate the number of legacy trees, snag and cavity trees, and large downed trees and logs per acre.**

**The data-gathering process you’ll be using for assessing these three benchmarks is known as *point sampling or variable area sampling.*** In this process, you will randomly choose points in the forest, and these will serve as the center of the samples. You’ll use the Penny Method to tally the trees in your sample. See page __ for detailed instructions on using the Penny Method.

At the point center, you will tally live trees (without den holes) if they are over 19 inches DBH. You will count all standing dead trees over 15 inches DBH, and all live trees with den holes that are over 15 inches DBH. You will also tally all downed trees or logs (over 16 feet long) that measure over 15 inches DBH.

You'll record these trees on the Benchmark Assessment #10-12 tally sheet, under three categories:

**1. Vigorous, wind-firm legacy trees** that dominate the site and that will, barring a major disturbance event, live and thrive for many years.

**2. Standing snags (dead trees) or den trees (either living or dead).** It is possible that a vigorous tree with a cavity could be both a Legacy Tree and a Cavity Tree and therefore could be tallied twice.

**3. Large downed trees or logs.**

Below is a sample of the *Health Check* tally sheet for Benchmarks 9-11, just like what you'll be using to tally your trees. The tally sheet helps you convert your point sample data into number of trees per acre and helps you compare that data with the minimum trees-per-acre specified in the benchmarks. When you use the penny method, you're basically sampling 1/10th of an acre. On the tally sheet, you'll see a column labeled "# per acre." This column tells you how many trees per acre each tree you've tallied represents. On the sample tally sheet below, we've added some sample data so you can see how the sheet works (sample data is in gray).

## 10 – 12 Legacy Trees, Standing Snag & Den Trees, Large Down Trees or Logs

**Sample Crew:** J. Appleseed & Bob White **Date:** 11/3/09 **Town Forest:** Hillville **Location:** Northern Hardwood forest area in southwest corner of property

| | Vigorous & Wind-firm Legacy Trees | | | | | | Standing Snag (dead) or Den Trees (living or dead) | | | | | | Large Down Trees or Logs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter class (in.) | # tallied | # per acre | Total (multiply # tallied by # per acre) | Bench-mark # trees /acre | Meets Bench-mark Y | N | # tallied | # per acre | Total (multiply # tallied by # per acre) | Bench-mark # trees /acre | Meets Bench-mark Y | N | # tallied | # per acre | Total (multiply # tallied by # per acre) | Bench-mark # trees /acre | Meets Bench-mark Y | N | Notes |
| **16** | | | | | | | 1 | **7** | 7 | | | | | **7** | | | | | |
| **18** | | | | | | | 1 | **6** | 6 | | | | 1 | **6** | 6 | | | | |
| **20** | 2 | **5** | 10 | | | | | **5** | | | | | | **5** | | | | | |
| **22** | | **4** | | | | | 2 | **4** | 8 | | | | 1 | **4** | 4 | | | | |
| **24** | 1 | **3** | 3 | | | | | **3** | | | | | | **3** | | | | | |
| **26** | 1 | **3** | 3 | | | | | **3** | | | | | | **3** | | | | | |
| **28** | | **2** | | | | | 1 | **2** | 2 | | | | | **2** | | | | | |
| **30** | | **2** | | | | | | **2** | | | | | | **2** | | | | | |
| **Total trees** (add totals for each size class) | | | 16 | | | | | | Trees > 15" 23<br>Trees > 21" 10 | | | | | | Trees > 15" 10<br>Trees > 21" 4 | | | | |
| **# points sampled** | | | 5 | | | | | | 5 | | | | | | 5 | | | | |
| **Total trees/ac.** (divide total trees by # points sampled) | | | 3.2 | **3** | Y √ | N | | | # trees/ac. > 15" 4.6<br># trees/ac. >21" 2 | **4**<br>**1** | Y √ | N | | | # trees/ac. > 15" 2<br># trees/ac. > 21" .8 | **4**<br>**1** | Y | N √ | *Need more large down trees or logs on this site.* |

**Conclusion**: If your assessment shows that you meet the minimum number of legacy trees, standing snag and den trees, and large down trees or logs, then √ "Y" in the appropriate columns on the tally sheet above and √ the "healthy" box, right. If not, √ "N" in the appropriate columns above, and √ the "needs work" box, right.

Healthy ☐
Needs Work ☐

## Overall Assessment of Your Town Forest's Health

Once you have completed each of the 12 benchmark assessments for your town forest, you're ready to fill in the *Health Check Summary Sheet*. Simply transfer the information from the check box in the lower right-hand corner of each benchmark tally sheet to the Summary Sheet. If you have checked the "Needs Work" column for a particular benchmark, then fill in the "Description of work needed" column for that benchmark. This sheet will provide you with a single-page reference that summarizes the overall health of your forest, as well as specific management opportunities for improving forest health.

## Congratulations on completing the Town Forest Health Check!

# Endnotes

[1] Aldo Leopold. 1949. *A Sand County Almanac.* Ballentine Press: New York. Pg. 258.

[2] John A. Helms, ed. 1998. *The Dictionary of Forestry.* The Society of American Foresters: Bethesda, Maryland. Pg. 167.

[3] Aldo Leopold. 1939. The Farmer as a Conservationist in *Aldo Leopold: For the Health of the Land,* ed. J. Baird Callicott and Eric T. Freyfogle, 1999. Island Press: Washington, D.C. – Covelo, CA. Pg. 163.

[4] Perry, David A., Ram Oren, and Stephan C. Hart. 2008. *Forest Ecosystems.* Johns Hopkins University Press, Baltimore. Pg. 445

[5] The Montreal Process maintains a website, www.rinya.maff.go.jp/mpci/home_e.htm, on which you can view the most up-to-date version of the criteria and indicators of forest health.

[6] Merriam-Webster Dictionary. 1997. Merriam-Webster, Incorporated, Springfield, MA. Pg. 425.

[7] Perry et al. Pg. 125.

[8] Hansen, Andrew; and Jay Rotella. 1999. Abiotic factors. Pp 161-209 *in* Malcolm L. Hunter, Jr. (ed.) *Maintaining Biodiversity in Forest Ecosystems,* Cambridge University Press, Cambridge, UK.

[9] Pelletier, Steven K. 1999. Downed Woody Material, Snags, and Cavity Trees. Pp 27-31 *in* Catherine A. Elliott (ed). *Biodiversity in the Forests of Maine: Guides for Land Management,* University of Maine Cooperative Extension Bulletin #7147.

[10] Ibid.

[11] Bryan, Robert R. 2004 Focus Species Forestry: A Guide to Integrating Timber and Biodiversity Management in Maine. Pg. 64.

[12] Perry et al. Pg. 470.

[13] Foss, Carol R. 1999. Special Habitats and Ecosystems. Pg. 45 *in* Catherine A. Elliott (ed). *Biodiversity in the Forests of Maine: Guides for Land Management,* University of Maine Cooperative Extension Bulletin #7147.

[14] Perry et al. Pg. 112.

[15] Vermont Invasive Exotic Plant Committee. 2005. Invasive Species Watch List for Vermont.

[16] Perry et al.

[17] Adapted from table on www.friendlyrobotics.com/faq/?kb=4&add_node_label=How+to+Calculate+the+Lawn+Slope.

[18] *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont, 2006,* Pg. 12. www.vtfpr.org/watershed/documents/Amp2006.pdf.

[19] *Acceptable Management Practices for Maintaining Water Quality on Logging Job in Vermont, 2006,* Pg. 31.

[20] *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont.* 2006. Pg. 16.

[21] Thompson, Elizabeth H and Eric Sorenson. 2000. *Wetland, Woodland, Wildland: A Guide to the NaturaL Communities of Vermont.* Vermont Department of Fish and Wildlife and The Nature Conservancy, Vermont. Pg. 429.

[22] Unless otherwise noted, descriptions and photos were drawn from the Vermont Invasive Exotic Plant Committee website, www.vtinvasiveplants.org.

[23] Bryan, Robert R. Pg. 64.