ASSESSMENT OF TIMBER HARVESTING AND FOREST RESOURCE MANAGEMENT IN VERMONT: 2012

VERMONT AGENCY OF NATURAL RESOURCES

DEPARTMENT OF FORESTS, PARKS AND RECREATION

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The project advisory committee, made up of representatives from the forest products industry, environmental groups, academia, and state and Federal government worked cooperatively to guide the project. The technical committee was made up of experts in various forest resource areas and spent countless hours designing the assessment methodology, analyzing the results and writing the report. The field crew made up of VT FPR foresters, made numerous calls requesting sale information, obtaining landowner permission, and spent the summer of 2012 collecting data from over eighty timber harvesting operations in every corner of the state, regardless of the weather. The field staff also assisted with data analysis and assisted in preparation of the final report. The data analysis team at RJ Turner Company was invaluable in developing the data collection tools, database, and in analyzing the data. The patient cooperation of all of the individuals involved made the project possible.

Our thanks also goes out to the foresters and loggers that helped in compiling the list of timber harvesting operations, and in many cases providing timber harvest information and maps. Finally, we are especially grateful to the cooperating landowners who graciously allowed us to conduct assessments on their property.

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EXECUTIVE SUMMARY

In 1988 the VT State Legislature charged the Commissioner of the Department of Forests, Parks and Recreation with recommending "specific initiatives deemed necessary to mitigate undue adverse effects of timber harvesting in the state." That legislation led to a study of timber harvesting in Vermont conducted by researchers at the University of Vermont. *The Impact Assessment of Timber Harvesting Activity in Vermont*, which was published in March of 1990, provided a detailed look at the characteristics of timber harvesting operations and the associated impacts on a number of forest resources.

The 2012 Timber Harvesting Assessment did not have the same purpose as the 1990 Assessment. Many changes in timber harvesting practices, as well as the introduction of new concerns, such as climate change and invasive plants and pests, have occurred in the years since the last field assessment was completed in 1990. Recognizing these changes, the VT Department of Forests, Parks and Recreation (VT FPR) applied for and received a grant through the USDA Forest Service, Northeastern Area State and Private Forestry (NA S&PF), Competitive Allocation Request for Proposals (CARP) process, to conduct an updated Assessment of Timber Harvesting Activity in Vermont. It was the goal of this project to evaluate a sample of timber harvests for potential impacts (positive and negative) to a number of forest attributes and to compare this snapshot with results from the previous assessment where possible.

The assessment project was overseen by an advisory committee that included representatives from the forest industry, landowner associations, conservation groups, and other partner organizations. This committee was charged with guiding the assessment process and recommending resources to be evaluated. A technical committee was formed to design the ecological assessments, analyze the data, present findings and recommendations to the advisory committee, and to draft the final report. The technical committee included resource professionals with expertise in water quality, timber productivity, forest health, forest soils, aesthetics, archeology, and wildlife. Field assessments were conducted by VT FPR staff.

As in the 1990 report, this document provides basic descriptive information about the number, size, and characteristics of timber harvesting operations around the state. It further provides a snapshot of harvesting practices as they relate to specific forest attributes including: aesthetic values; archeological and historic resources; rare, threatened, and endangered species; timber quality and forest health; forest soils; water quality and wildlife habitat. Where possible and appropriate, the report also provides comparisons between the 1990 results and those of the 2012 assessment.

Understanding and Interpreting These Results

The following report presents a brief summary of the results of the field assessment completed in 2012. Readers are encouraged to refer to the full report of the assessment for supporting data and more detailed explanations and analyses of the results.

Since pre-harvest conditions were not assessed as part of this project, it was not possible to evaluate some attributes that might have been affected by the harvest (e.g., growth rate, tree health, or wildlife habitat quality and use).

Readers should recognize the following limitations of this assessment:

- The results reported are based solely on the harvests assessed, represent a single point in time, and cannot be representative of every timber harvesting operation in Vermont.
- Assessments were conducted after harvest operations had been completed and were intended to evaluate potentially ongoing effects of timber harvesting. Impacts (positive or negative) that might have occurred during the active period of the harvest may not have been captured.
- For the purpose of comparing results with the 1990 assessment, every effort was made to replicate the methods and measurements during 2012. However, this was not always possible, and in some cases improved methods were used making comparisons impossible.

A master list of over 450 commercial timber[1] sales "closed out" between May 1, 2010 and April 30, 2011 was compiled from all over the state, and after removal of duplicates, the final list included 420 distinct sales from 13 counties. A stratified random sample of timber harvesting operations (THOs) was drawn from the master list, with a goal of completing 80 field assessments. Each county was sampled[2] and the number of sites selected per county was proportional to the number of operations listed by county in the master list.

Operations on state, federal, municipal, private, and corporate ownerships were included in the population of sales from which the sample was drawn. Participation in the assessment was completely voluntary and some individuals chose not to provide sale information or to allow field visits. While every attempt was made to ensure that the master list of sales was as comprehensive as possible, some eligible sales were not reported. Eighty-one THO assessments were completed during the summer of 2012.

This summary is intended to present only some highlights and key recommendations of the assessment report. The key recommendations are a compilation from the technical committees, as well as observations provided by the advisory committee.

Changes in Timber Harvesting Characteristics

Based on the THOs sampled during the two assessments, the mean operation size in 2012 was 2/3 the acreage of the mean operation size in 1990. When the average harvested acreage from the sampled THOs was expanded to a statewide-basis, commercial harvesting activity was estimated to have occurred on 70,122 acres annually in 1990 and on at least 26,040 acres annually during 2012. While both of these

[1] Commercial operations were defined as those that resulted in the sale of forest products.

[2] All counties were sampled with the exception of Grand Isle. As was the case in 1990, no information on sales was received from Grand Isle County, so Grand Isle and Franklin counties were combined.

figures represent estimates, Vermont's Annual Forest Resource Harvest Summaries indicate a reduction in volumes harvested over the same period, helping to support the finding of reduced harvesting activity. However, less accurate and potentially inflationary mapping techniques used during the 1990 assessment and under-reporting of operations in 2012 are also likely to have contributed to the magnitude of the difference.

Parcels enrolled in the Use Value Appraisal (UVA) or Current Use program accounted for 40% of the sampled operations in 1990, compared to 73% of operations in 2012. This substantial increase in the proportion of the sample enrolled in UVA is explained, in part, by the fact that in 2012 considerably more forestland parcels and acres were enrolled in UVA than in 1990. In 1987, an estimated 669,353 acres of forestland, 18% of the potentially eligible forestland in Vermont, was enrolled in UVA; in 2011 a reported 1,734,012 acres was enrolled, an increase of roughly 225%.

Forester involvement in harvesting operations increased from the 1990 assessment, from 77% in 1990 to 86% in 2012, with more responsibility and participation in several aspects of timber harvests than was reported in the 1990 assessment.

The use of mechanical harvesters in timber harvesting is an area of significant change in the forest products industry since 1990. Hand felling with chainsaws was the dominant tree harvesting method in 1990 and mechanical felling was not even mentioned in the 1990 report. Hand felling was still the dominant felling method in the 2012 assessment, but mechanical harvesters were used on 49% of operations.

Use of whole-tree skidding (transporting the entire tree with branches attached from stump to landing) has also become much more common and is linked to the use of mechanical harvesters. The earlier assessment found that only 10% of operations used whole-tree skidding, entirely or in part. However, by 2012, 41% of the operations sampled were using at least some whole-tree skidding. Log- and tree-length "skidding" techniques (without branches attached) were used on the majority of operations, but the trend toward increased mechanization is clear.

The production of wood chips is often associated with mechanical harvesting and whole-tree skidding, but this was found to not always be the case on sampled operations. While 34 operations assessed in 2012 used at least some whole-tree skidding, only 30 operations actually produced chips. On those operations not producing chips, tops were removed at the landing and returned to and deposited within the harvest area.

Key Recommendations:

- Continue to conduct periodic assessments of timber harvesting activity on a ten-year cycle.
- Monitoring the positive and negative effects of timber harvests should be incorporated into the forest health monitoring efforts carried out by the Department of Forests, Parks and Recreation and the University of Vermont. Future monitoring efforts related to timber harvesting should consider not only

assessments such as those conducted in 1990 and 2012, but should also incorporate studies to compare pre- and post-harvest site conditions.

- A timber sale contract fact sheet should be prepared and distributed to foresters for use with landowners, suggesting possible contract conditions and language designed to help better manage potential negative impacts to a variety of forest attributes such as aesthetics, archaeologic and historic sites, water quality, and wildlife habitat.

Aesthetic Values

While poorly executed timber harvest operations can loom large in the public eye, this assessment does not indicate any serious aesthetic impacts to public viewing areas resulting from timber harvests in this assessment. The number of occurrences of factors contributing to negative visual impacts was lower than the results reported for the 1990 assessment. The vast majority of THOs sampled (80%) were not visible from visually sensitive vantage points (paved roads, recreation areas, and trails) and therefore had no readily visible aesthetic impacts. There were a number of THOs for which significant visual impacts could have resulted if they had been located along hillsides facing public viewing areas rather than away from them. Whether this was by design or coincidence is not known.

A number of characteristics of harvested stands can be viewed as aesthetically undesirable by the public. For instance, slash and dead or down wood is nearly always viewed negatively from an aesthetic perspective, as are scattered trees silhouetted along a ridgeline. Bare soil and debris left on landing areas are also viewed as negative.

One significant improvement noted during the 2012 assessment was the lack of heavily cut areas along visible hillsides and ridgelines. Another was the lack of highly visible landing areas in which remaining wood chips or other debris were highly evident. Slash described as "left where it falls, large trunks and limbs dominate the scene” was notable on only one THO. Vegetative screens along roadsides, used to reduce any negative aesthetic impact, appeared to be a common practice.

Some of these improvements may be attributable, in part, to laws such as the 1997 Heavy Cutting Law, as well as an increased sensitivity to public concerns and desires by the forest products industry as a whole. Sustainable forest management practices and treatments are sometimes at odds with the public’s perception of what is aesthetically acceptable. For example, the retention of snags, tops, and logging residues to meet wildlife and other biodiversity goals, such as ensuring long-term site productivity, maintaining hydrologic functions, and sequestering carbon, are often viewed as negative by casual observers. The public needs to be educated to the ecological benefits of these practices to better understand and accept them.

Key Recommendations:

- Ensure that recommended practices, guidelines, statutes and other directives related to timber harvesting adequately address visual impacts. Provide foresters and timber harvesting professionals with tools and training on public perceptions of the visual results of forest management practices to allow aesthetic concerns to be better addressed.

- Provide demonstration areas designed to educate foresters, loggers, landowners, and the general public about a variety of timber harvest practices, their benefits, and how they can be managed to reduce aesthetic impacts.
- Provide incentives and educational programs for loggers and landowners that help foster appropriate forest management practices including considerations for reducing aesthetic impacts.

Archaeological Resources

Archaeological resources are particularly vulnerable to negative impacts from timber harvesting because impacts to archeological sites are irreparable and permanent. The values of archeological resources are codified in protections mandated by federal and state law, as well as numerous state program policies and procedures.

The 2012 assessment evaluated potential impacts to archaeological resources in two general categories: historic period sites (ca. A.D. 1609-1950's) and “pre-contact” sites of Native American settlement and/or resource exploitation that date to before the arrival of Europeans, between approximately 9,000 B.C. and A.D. 1600. Sampling methods to assess actual impacts to subsurface artifacts would require substantial excavation at numerous sites, an effort beyond the scope of this assessment. As in 1990, in lieu of confirming presence or absence of actual archeological sites, methods were applied to identify areas with relatively high potential for sites and document observed impacts to these “high risk” areas. It was assumed that artifacts would have been compromised if the high-risk site was impacted by timber harvesting.

The most striking contrast between the 1990 assessment and this assessment is that for nearly every metric, the 2012 assessment produced fewer negative impacts or results of a more moderate scale. This is likely due to smaller mean acreage of THOs in the 2012 sample, refinement in estimates of the percentage of pre-contact sites that actually contain resources, and perhaps a much greater proportion of 2012 THOs being conducted in more remote areas with a lower density of archeological sites, rather than a change in timber harvesting practices. Although more information exists for identifying “high potential” areas for pre-contact sites than was available in 1990, the information could be better communicated to landowners, foresters, and logging contractors.

Data for historic sites, based on actual impacts, indicate that the rate of impacts (percentage of observed historic foundations impacted) has increased substantially, suggesting less protection for historic resources in 2012 than in 1990. Two decades ago impacts to foundations due to various causes (rutting, erosion, skid trails, etc.) ranged from 0-36% of foundations, while in 2012, 50% of foundations were impacted, even though the number of THOs with timber sale contracts reported to have included protections for resources is comparable.

In 1990, two types of landscape features – glacial terraces and quarry sites for stone tool material – were considered to have high potential for containing pre-contact Native American sites. In 2012, a Geographic Information System (GIS) model was used to expand the criteria for potential pre-contact Native American sites to areas beyond glacial terraces and quarry sites. Although the GIS model applied more liberal criteria for identifying areas with high potential to contain pre-contact sites, high probability areas were mapped on only 12% of the THOs, compared to 22% of THOs identified by the more exclusive criteria in 1990. Previous testing of the model, using actual excavation data, indicates that only a portion of the potential sites identified will actually contain artifacts. When these assumptions are applied to the results from the assessment, the data indicate pre-contact Native American sites were likely impacted on 1 to 2% of the 2012 timber harvests statewide.

Key Recommendations:

- Produce an updated guide to the stewardship of historical and archaeological resources including recommended best management practices applicable to private land owners, land managers, and loggers.
- Develop and implement educational materials, programs and workshops for presentation to a wide range of audiences, particularly landowners, loggers, and foresters on recognizing potential archaeological sites and avoiding or mitigating impacts to them. Educational materials should include a listing of timber harvest regulations affecting private lands relative to cultural resources.
- Conduct focused training for ANR staff and other resource professionals on recognition of less obvious sites and how to avoid them during harvesting operations on state and private lands.
- Integrate data from the Vermont Archeological Inventory (VAI) and the predictive model GIS layer developed for the VT Map Tool (currently not publicly accessible) into the new ANR Natural Resource Locator.
- Encourage consulting foresters to prepare Forest Stewardship Program eligible management plans, which include consideration of cultural resources, when preparing plans for enrollment in the Use Value Appraisal (UVA) Program.

Rare, Threatened, and Endangered Species

Rare native plants and animals, those species that have few populations in the state or that face threats to their continued existence, are an important part of Vermont's natural landscape. Timber harvesting operations have the potential to benefit or harm populations of rare species. If the operation is guided by special considerations aimed at improving the habitat or conditions for a particular rare species, the overall effect may be positive. In contrast, an operation that alters suitable habitat for a rare species, or that causes physical damage to individual rare plants or animals, is likely to have a negative effect on the long-term persistence of that population.

The 2012 assessment followed the methodology used in 1990 of comparing the location of sampled THOs with the mapped locations of rare, threatened, or endangered (RTE) species as recorded in the VT Fish and Wildlife Department's Natural Heritage Database. Of the 81 THOs evaluated in this assessment, three overlapped with these mapped locations. This overlap does not in itself demonstrate impact (positive or negative), but was used during the 1990 assessment as a broad indicator of the degree to which timber harvesting operations are potentially impacting RTE species.

All three sites of overlap were on land managed by the State of Vermont, and a wildlife biologist and ecologist were involved in each of the operations. No additional assessment was possible to determine whether the THOs resulted in positive or negative impacts to RTE species.

In contrast to the 2012 assessment results, the timber harvest impact assessment conducted in 1990 identified no overlaps between the THOs and the locations of threatened or endangered species. (The previous assessment only considered species listed in Vermont's Endangered Species Act.) However, in 1990 there was substantially less information available on the locations of RTE species. If anything, this suggests that timber harvests in 1990 had a much greater chance of having unintended negative impacts on an RTE species simply because many sites with RTE species had yet to be identified.

Key Recommendations:

- Continue statewide efforts to find, record, and monitor the locations of rare, threatened and endangered species, and continue to use the Vermont Fish and Wildlife Department's Natural Heritage Database as the primary archive of this information.
- Continue to widely distribute information on the locations of RTE species using tools such as the Vermont Agency of Natural Resources Natural Resources Atlas.
- Encourage greater involvement from ecologists or biologists in pre-harvest inventories or forest management planning to identify whether RTE species are present, particularly where observations or pre-screening tools suggest a possibility of their presence.
- Educate landowners and managers to the full suite of options and programs available to them to identify and address RTE species when managing forests. A few examples of these include:
    - The Natural Heritage Inventory of the Vermont Department of Fish and Wildlife can provide information on known occurrences of rare, threatened, and endangered plant and animal species.
    - The Wildlife Habitat Improvement Program (WHIP) may be able to provide financial incentives and cost-sharing for management and conservation of rare species.
    - Sites with rare species can also be enrolled as Ecologically Significant Treatment Areas under the Use Value Appraisal (UVA) program.

Timber Quality, Regeneration, and Forest Health

Harvesting effects on timber quality and forest health were assessed using measures of damage to residual trees, changes in species composition, adequacy of residual stocking, abundance and species composition of regeneration, the health of residual trees (crown dieback), deer and moose browsing impacts, invasive plant competition, and the presence or absence of residual down woody material sufficient to replenish site productivity. Each of these factors influences future forest diversity, structure, and functions.

Residual tree damage[3] was limited, with 88% of trees sampled having no damage and 92% of operations having less than 20% of the residual basal area damaged. A direct comparison to 1990 assessment data was not possible due to changes in data collection methods. Sites in northern Vermont tended to have a higher incidence of residual tree damage, but the cause of this difference was not assessed.

Crown health is a good indicator of tree survival. Eighty-six percent of trees sampled were rated as having limited crown dieback (<15%), and only 2% had significant[4] dieback. Without knowledge of the health characteristics of the trees on the sampled THOs prior to treatment, it is not possible to speculate on the reasons behind the dieback observed.

The most common forest type, northern hardwoods (sugar maple, beech, yellow birch), was dominant both before and after harvests. The notable change in composition was from softwood to hardwood types. Close to a third of softwood cover types were converted to hardwood or mixed wood types, similar to results reported in the 1990 assessment. Furthermore, understory composition trends suggest a further shift from softwood or mixed types to hardwood. Changes in composition may be attributable to a number of factors including silvicultural practices, land management history, beech bark disease, accumulated browsing impacts and natural succession.

Forester involvement and enrollment in UVA both had a positive effect on anticipated silvicultural outcomes. In general, operations with forester involvement led to results that more closely followed established guidelines for post-harvest conditions. Forester involvement and UVA participation resulted in better stocked stands of sawtimber quality[5] trees in partial cuts, and clearcuts that were silviculturally correct and effective with respect to ensuring regeneration success.

Less than half of all plots were projected to have an understory dominated by tree seedlings and/or saplings (3 to 5 years following harvest). On nearly one third of plots, ferns and herbaceous plants were the expected dominant understory vegetation. In regenerating plots, 48% of plots were expected to have a dominant understory of seedling/sapling/coppice (in 3 to 5 years), compared to 89% in 1990.

When looking at a subset of harvests specifically intended to regenerate stands (plots on which the overstory had been removed), in 1990 the forest floor was occupied

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[3] Residual tree damage included open wounds (sapwood exposed), broken tops (crown), damaged and/or exposed roots, and bent over trees.

[4] "Significant" was defined as having a dieback rating of greater than 50%.

[5] High quality trees were defined as meeting the standards for AGS (Acceptable growing stock) – a commercial species less than rotation age with relatively good vigor, containing no pathogens that may result in the death or serious deterioration of the tree before rotation age, and which contains or has the potential of producing merchantable sawtimber of USFS grade 3 quality or better (see Appendix F of the full report for USFS grading standards).

primarily by seedlings or coppice 68% of the time, and ferns/herbs/Rubus 8% of the time. In 2012 seedling/sapling/coppice stems were the dominant understory vegetation in 49% of this harvest type, and 45% were occupied by ferns/herbs and Rubus spp. Combined with the presence of competing vegetation and/or deer and moose browse pressure, there are concerns for the successful establishment of regeneration of adequate density and desirable species composition in some areas. Results of this assessment suggest that regenerating native tree species will be a challenge on a number of the THOs assessed that will require attention to silvicultural practice, control of competing vegetation, and continued population management of whitetail deer and moose.

In addition to providing wildlife habitat and soil enrichment, down woody material serves many other ecological functions. Leaving tree tops, some large diameter downed trees, and foliage on site after a timber harvest helps to replenish organic matter content, moisture holding capacity, increase rooting depth, and enhance soil nutrition. The average volume of coarse woody material (CWM) on sampled THOs was considerably higher than the statewide average reported by USDA Forest Inventory and Analysis, but much less than volumes considered desirable when practicing silviculture. The majority of CWM was less than 8 inches in diameter and the new down woody material, some from current harvest operations, represented about half the total CWM.

Whole-tree harvests (WTH) left measurably less down woody material than tree-length harvests, though the average volumes were slightly higher than the statewide average.[6] These results indicate relatively lower volumes of residual material left to conserve soil productivity where this harvesting system is utilized.

Key Recommendations:

- The lack of regeneration and the presence of established competing vegetation and/or mid-level shade in many stands suggest a need to carefully apply silvicultural guidelines to ensure more effective regeneration treatments in the future. Current conditions in some stands may require aggressive pre-harvest treatments (mechanical, herbicides, or in combination) to control competing vegetation, and/or site preparation to ensure the establishment of desired regeneration. Silvicultural systems may need to be adjusted to adequately address the increased potential for interfering vegetation.
- Longer term monitoring should be conducted to determine the ultimate success or failure of obtaining desirable regeneration under a variety of conditions.
- More focused assessment of softwood and mixed wood stands, managed to perpetuate these forest types, should be conducted to determine the most successful techniques for insuring successful establishment of softwood regeneration on suitable sites.

[6] On average, tree-length skidding left 975 cubic feet/acre of CWM compared to 611 cubic feet/acre left from whole-tree skidding. FIA data put the statewide average for CWM at 550 cubic feet/acre.

- The browse sensitivity method of assessing deer and moose browse intensity should be further evaluated and, if needed, refined to better reflect observed and recorded forest and regeneration condition.
- Regional differences in regeneration success or potential were significant in some instances and should be used to inform deer and moose population management and silvicultural practice and climate change adaptation.
- Develop a single standard for an Acceptable Growing Stock tree, and provide training regarding what constitutes a high quality stem at the regeneration, pole, and sawtimber size class.
- Develop guidelines for down woody material retention to ensure adequate amounts and sizes of down material are left on site following harvests.
- Future assessments should consider measurement of both recent and pre-existing wounds as well as noting whether or not the wounded tree was retained to serve as a bumper tree along a skid trail.
- Investigate the possibility of aggregating existing data from a variety of sources (public and private) to help provide a statewide data set as a basis of comparison with pre-harvest conditions in future assessments. A subset of basic and consistently defined data on stand density, composition, and quality, as well as regeneration condition, could yield ongoing information to guide practice and policy.

Timber Quality and Productivity – Forest Soil Assessment

Soil is a fundamental ecosystem component and a foundation of maintaining healthy forests. Five physical soil disturbance parameters were selected for measurement for the 2012 assessment based on the Forest Soil Disturbance Monitoring Protocol developed by the USDA Forest Service. The parameters chosen were the extent of bare soil, erosion, compaction, rutting, and the Soil Disturbance Class.[7] Soil data points were located throughout harvested stands and were not targeted to disturbed areas such as roads in order to broadly characterize soil disturbance and impacts, in general, across the THO.

Based on the sampled harvest operations, the observed impacts to forest soils within harvested stands from timber harvesting operations were minimal. Measurable impacts were generally limited to skid trails and truck roads.

- Ninety-five percent of points exhibited no bare soil.
- No erosion was observed on 96% of soil observations.
- Ninety percent of points exhibited no identifiable compaction.
- Ninety-six percent of points had no rutting.
- Eighty-five percent of soil data points were rated as exhibiting natural, undisturbed soil conditions.

[7] Soil Disturbance Class is used to group the type, degree and extent of soil disturbance into an overall rating of soil disturbance.

Overall, 15% of soil data points fell on skid trails. For the purposes of this assessment, a skid trail was defined as an identifiable trail made by two or more passes of a piece of heavy skidding or forwarding equipment and included both permanent infrastructure designed to be used in subsequent harvests and “single use” trails.

Key Recommendations:

- Limit the construction of new skid trails as much as possible and re-use existing skid trails, if they meet AMPs guidelines and are otherwise properly designed and located. Existing skid trails typically have soils that are already compacted. Re-use limits the creation of new areas of compaction.
- Insure proper installation of AMPs to keep erosion to a minimum. This also protects soil productivity.
- On sensitive or wet sites, conduct harvest operations in winter, when skid roads and landings are frozen, and/or covered with a thick layer of snow. This minimizes rutting, compaction, creation of bare soil, and erosion.

Water Quality

The major objectives of the water quality portion of the assessment were to perform an evaluation of direct and indirect water quality impacts associated with timber harvesting operations in Vermont, to evaluate compliance[8] with the Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont (AMPs), and to evaluate compliance of silvicultural activities allowed under the Vermont Wetland Rules.

Analyses were also performed on permanent stream crossing structures to assess flood resiliency and conditions favorable to fish passage. Post-logging impacts to water quality with observable lingering effects, including sedimentation, logging slash, and petroleum product residue, were also evaluated. Operations were evaluated for compliance with 17 of the 24 Acceptable Management Practices. Six of the AMPs apply only to the active phase of a timber harvesting operation and were not evaluated during this assessment. AMP compliance was determined by both frequency of observation and by frequency of operation for purposes of comparison.

Results of this assessment suggest a lower incidence of negative impacts to water quality, as compared to the 1990 report findings. Practices were observed to have been implemented on all timber harvesting operations for protection of water resources. AMP compliance was high for practices related to streamside protective strips, truck roads, and log landings.

Findings from this assessment indicate that 22% of stream crossings showed evidence of sedimentation and represented the principal source of sediment associated with the timber harvesting operations observed. Of the 147 stream crossings evaluated, 32

[8] “Compliance” with a particular AMP was defined as implementation of the recommended practice as described in the Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont (VTFPR 1987). Failure to comply with the AMPs may not result in reduced water quality.

showed evidence of sedimentation as a result of logging. This is less than reported in the 1990 assessment (28% of crossings in 2012 vs. 42% of crossings in 1990).

The number of waterbars observed on skid trails was below levels recommended by the AMPs. The number of waterbars and other drainage structures installed on skid trails according to spacing requirements in Table 1 of the AMPs averaged 42% of the required number by observation (segment) and 39% of required number by operation. Seventy-four percent of observations were rated as having “none to sheet” erosion as the most severe surface erosion type encountered on skid trails. There was a high level of compliance with the Vermont Wetlands Rules on timber harvesting operations. Twenty-three wetlands and their associated buffers were evaluated for timber harvesting impacts on 21 operations. Timber harvesting impacts to wetlands occurred on 2 of the 21 operations evaluated.

Permanent stream crossing structures (bridges and culverts left in place following logging) were evaluated to determine if they were adequately sized to meet hydrologic capacity requirements for the 1 to 3-year, 10-year and 25-year flood events. Structure size openings indicated that 61% of those structures were adequately sized to accommodate a 1 to 3-year flood event; 16% were adequately sized to accommodate a 10-year flood event, and 8% were adequately sized to accommodate a 25-year flood event.

Key Recommendations:

- Direct and enhance efforts to reduce sedimentation associated with temporary stream crossings on logging operations by:
    - promoting and increasing the use of portable skidder bridges through education, outreach and program delivery.
    - providing guidance and training for choosing the appropriate type of temporary stream crossing structure, as allowed in the AMPs, based upon stream characteristics.
    - providing guidance and training on specific techniques for stabilizing approaches to temporary stream crossings within the stream buffer on skid trails.
- Provide technical guidance and training for installing and sizing permanent bridges and culverts on perennial streams to improve flood resiliency and reduce sedimentation.
- Continue efforts to develop the second edition of the AMP manual. The next edition will provide enhanced guidance to help attain a higher level of AMP compliance and protection of water resources.
- Explore potential funding opportunities for conducting AMP effectiveness and evaluation monitoring of logging operations using the USDA Forest Service State & Private Forestry Northeastern Area protocol – Best Management Practices (BMPs) Implementation and Effectiveness for Protection of Water Resources.

- Explore the feasibility of starting a program in Vermont that provides incentive financing to loggers to reduce non-point source pollution risk on timber harvests, using the Maine Forestry Direct Link Loan Program as a model.

Wildlife Habitat

Wildlife species vary in their habitat requirements and sensitivity to disturbances, and timber harvesting can have positive, negative, or neutral impacts on wildlife habitat. A harvest operation may improve habitat for some species while reducing habitat for others. This assessment focused on impacts to a variety of habitat features at multiple scales, with the understanding that they are broad indicators and not the only measures of habitat quality. Examples of these features include: snags, coarse woody material, deer wintering areas, vernal pools, rare natural communities, and forest habitat block size. Many other factors are commonly used to provide a more complete picture of the relative quality of wildlife habitat, but were beyond the scope of this assessment.

The indicators used in this assessment showed no conclusive evidence that the sampled THOs caused substantial negative or positive impacts to the wildlife habitat features that were studied. This does not mean that impacts did not occur, but rather that any impacts to these features could not be detected in a single, post-harvest assessment.

None of the locations of the timber harvesting operations overlapped with a known occurrence of a rare natural community.

Many types of forest harvesting practices were used on the THOs assessed, resulting in a wide variety of residual stand structures, providing habitat for a variety of species.

One area of concern identified in this report is the possible loss of deer wintering habitat. Several plots with softwood cover, which were within or adjacent to mapped deer wintering areas, transitioned to hardwood post-harvest. However, this assessment was not at a fine enough scale to determine if these specific plots were in fact, functional deer wintering areas.

Some aspects of post-harvest wildlife habitat may be the result of pre-harvest forest condition, rather than harvest operations.

- For example, while snags are generally not present in adequate numbers for wildlife, this is not necessarily interpreted as a direct negative impact of the most recent harvesting activity. It may be a result of a combination of the average age of Vermont’s forests and previous harvesting activities that has resulted in a low abundance of snags overall. In these cases, harvesting practices such as leaving trees for future snags, could improve the post-harvest conditions for wildlife over time.
- The abundance of large coarse woody material on the sampled plots is similar to statewide estimates from the FIA program across nearly all diameter classes greater than 12 inches, but lack of pre-harvest data makes definitive conclusions on harvest operation impacts impossible.

On the landscape scale, this assessment found that sampled timber harvests typically occurred in larger-than-average areas of unfragmented forest. The mean size of forest habitat blocks that included one or more timber harvest operation is significantly larger than the mean size of all habitat blocks that are greater than 25 acres in size. Timber harvesting is generally not considered to fragment a landscape if the harvested area is allowed to regenerate as forest and is not maintained as a permanent opening.

Key Recommendations:

- Conduct additional study on the relationship between timber harvesting and the following wildlife habitat features: mast trees, snag and den trees, coarse woody debris, vernal pools, invasive species, and forest habitat blocks. Increase outreach to encourage retention and creation of snag trees, cavity trees, coarse woody material and the retention of trees for recruitment as future snags or coarse woody debris.
- Encourage foresters, loggers, and other natural resource professionals to take advantage of all available information to assist in identifying important wildlife habitat features when planning timber harvesting operations.
- Continue outreach efforts to educate foresters, loggers, landowners, and the public about possibilities for incorporating wildlife habitat considerations into timber harvest operations.
- Encourage enrollment in programs such as the Use Value Appraisal “Ecologically Significant Treatment Areas” (ESTAs) or USDA Farm Bill programs, where appropriate, to provide financial incentives for private landowners to manage significant natural communities or wildlife habitats, respectively.

CHAPTER 1: INTRODUCTION

INTRODUCTION

A recent report issued by the Council on the Future of Vermont indicated that over 97% of Vermonters polled endorse the concept of “the working landscape” as key to the future of Vermont (Moser et al. 2008). With forest land making up roughly 75% and agricultural land 20% of the state’s land area, it is logical to conclude that Vermonter’s have a special interest in farming and forestry as the activities most connected with, and dependent on, our working lands.

The last statewide assessment of timber harvesting in Vermont was initiated in 1988 when the VT State Legislature charged the Commissioner of the Department of Forests, Parks and Recreation (VT FPR) with recommending to that body “specific initiatives deemed necessary to mitigate undue adverse effects of timber harvesting in the state.” In turn, the Commissioner contracted the University of Vermont, School of Natural Resources to conduct an interdisciplinary study designed to “characterize the types and significance of impacts from timber harvesting operations in the state.” The Impact Assessment of Timber Harvesting Activity in Vermont was published in March of 1990. Many changes in timber harvesting practices, as well as the introduction of new variables, such as climate change, increased development and parcelization, invasive plants and pests, mechanized harvesting and increased demand for biomass, have occurred in the years since the last field assessment was completed in 1990. Recognizing this fact, VT FPR applied for and received a grant through the USDA Forest Service, Northeastern Area State and Private Forestry (NA S&PF), Competitive Allocation Request for Proposals (CARP) process, to conduct an updated assessment of timber harvesting activity in Vermont.

The report that follows contains the results of the field assessment completed in 2012. Many of the field procedures and metrics replicated those that were used for the 1990 Assessment. In addition, new or revised metrics were included to either address emerging resource issues or where our understanding of the science related to particular resource values has improved. As in the 1990 report, this document provides basic descriptive information about the number, sizes, and characteristics of timber harvesting operations around the state. It further provides a snapshot of harvesting practices as they relate to specific forest attributes including: aesthetic values; archeological and historic resources; rare, threatened, and endangered species; timber quality, productivity and health; water quality, and wildlife habitat. Where possible and appropriate, this report also provides comparisons between the 1990 report’s results and those of the current assessment.

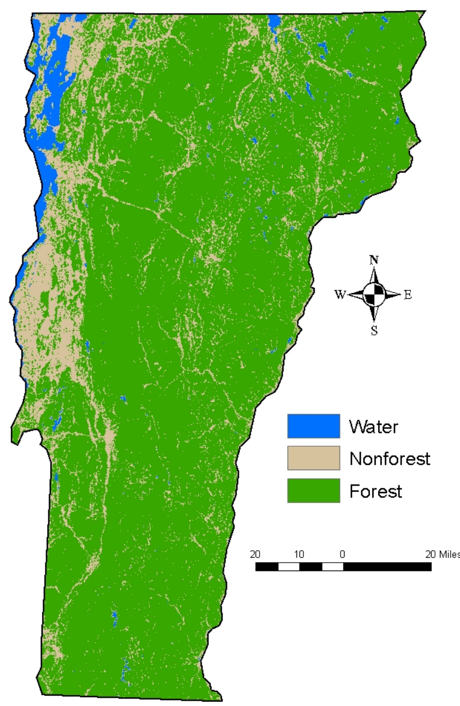
This document constitutes the final report of the **Assessment of Timber Harvesting Activity in Vermont, 2013**.

The Forest

In order to put the importance of forests, forestry, and timber harvesting in Vermont into context, it is helpful to provide some background information and statistics. *Vermont's Forests 2007*, completed by the USDA Forest Service, Northern Research Station, Forest Inventory and Analysis (FIA) notes that, "75% of Vermont's total land area is forested, making it the fourth most forested state in the United States" (Morin et al. 2011) (Figure 1-1). Over 6,000 workers are employed in the state's forest products industry and their efforts generate over $800 million in annual sales. Payroll in the forestry and logging sectors alone amount to more than $34 million annually (NEFA 2014).

Vermont's Forests 2007 also provides some important insights into who owns Vermont's forest and why. Much of the FIA data related to ownership is collected through the National Woodland Owner Survey and includes information on forest holding characteristics, ownership history, ownership objectives, forest uses, and forest management practices (Butler 2008).

Figure 1-1 Distribution of forest land in Vermont (Morin et al., 2011)

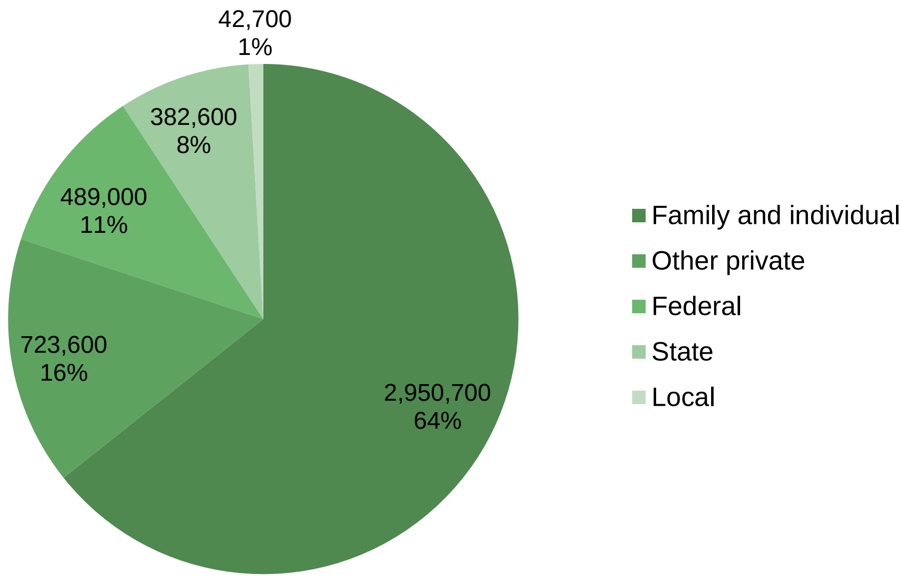


Eighty percent of forest land in Vermont is held by private landowners: a total of over 3.6 million acres. Nearly 3 million of those acres are owned by 87,000 individuals and families (Butler 2008). The number of family forest land owners has increased by over 20,000 in just twenty years, with a corresponding decrease in average land holding size from 65 acres (Widmann and Birch 1988) to 37 acres (Butler 2008). Fifty-three percent of family forest owners hold less than 10 acres of forest land, but represent only 6% of all family forest land acreage.

Corporations, non-family partnerships, nongovernmental organizations, clubs and other non-family groups own another 723,600 acres of forest land (Figure 1-2) (Morin et al. 2011).

Twenty percent of Vermont's forest land is publicly owned, with the Federal Government owning 489,000 acres, most of which is administered by the Green Mountain National Forest. The State of Vermont owns an additional 382,600 acres spread across a variety of state agencies and departments, with local governments holding 42,700 acres of forest land. Public land ownership increased by roughly 160,000 acres between 1997 and 2007 (Morin et al. 2011).

Figure 1-2. Forest land area (acres) by major ownership category, Vermont, 2007.



Family forestland owners' most frequently given reason for owning land in Vermont was because the land was part of a residential property. While only 8% of individual or family owners indicated that timber production was an important reason for owning their land, many also indicated that they had harvested forest products. Fifty-three percent of family forest owners in Vermont (representing 81% of the family forest area) reported having harvested trees from their property, and 32% (67% of the family forest acres) had harvested saw logs. In addition, when asked about their harvesting plans for the next five years, roughly 40% of the family forest ownership responded that they expected to harvest saw logs or pulpwood during that period (Morin et al. 2011).

For those landowners with at least 25 acres of forest land, the Use Value Appraisal Program (UVA) is an important program. The program allows eligible landowners to apply for a reduction in the assessed value of their eligible acreage from an assessment based on fair market value, to an assessment based on the "use value" (a value based on what the land could produce for timber or agriculture). Forest landowners that enroll in the program agree not to develop their land and to follow an approved forest management plan.

The UVA program has proven to be very popular and there are currently over 14,000 owners of more than 1.8 million acres of forestland enrolled. As a result, approximately 39% of the state's privately owned forest land is managed and periodically harvested, contributing to the forest product economy (NEFA 2014). In light of Vermonters' interest in our working forest, and the potential influence timber harvesting has on both forest health and the financial viability of forest land ownership, this assessment provides important information on the current state of timber harvesting in Vermont.

CHAPTER 2: STUDY DESIGN

INTRODUCTION

The 2012 Timber Harvest Assessment was intended to evaluate a sample of timber harvests for potential impacts (both positive and negative) to a number of forest attributes. The study design was based primarily on methods reported in the Impact Assessment of Timber Harvesting Activity in Vermont, March 1990, completed by the University of Vermont, in cooperation with the Vermont Department of Forests, Parks and Recreation, and Associated Industries of Vermont. In addition, the 2012 assessment was intended to allow the comparison of results with the 1990 study and identify any potential trends.

Project Organization

The project was guided by an Advisory Committee made up of representatives from the forest industry, landowner associations, conservation groups, and other partner organizations. The Advisory Committee was charged with guiding the assessment process and recommending resources to be evaluated. A Technical Committee, comprising resource professionals with expertise in water quality, timber productivity, forest soils, aesthetics, archeology, and wildlife, was charged with designing the ecological assessments, analyzing the data, presenting findings and recommendations, and drafting the final report. Vermont Department of Forests, Parks and Recreation staff conducted the field assessments and a contract biometrician was employed to construct the project database, electronic data collection forms, queries, and reports.

Information Needs Assessment

For both the 1990 and 2012 assessments, a carefully structured process was used to determine what data would be measured or observed, and how these data would be collected. The Advisory Committee was charged with outlining the desired data set for the 2012 study. The 1990 study was reviewed by the Advisory Committee and most measures were duplicated in the 2012 assessment. Stream turbidity and temperature assessments were dropped due to evidence that both turbidity and temperature were predictable based on other measures, and that the collection of this information was not likely to provide additional insights into water quality.[9]

The Technical Committee was charged with determining the parameters of data collection and analysis necessary to address the questions posed by the Advisory Committee. The Technical Committee members also modified some of the 1990 measures to reflect the latest science in their respective fields. This ultimately resulted in the inclusion of a number of additional metrics and procedures.

Substantial changes and additions to the data collected during the 1990 Assessment were made for several resource attributes in 2012. In addition to collecting much of the

[9] A complete listing of data collection procedures and data sheets can be found in the appendices.

same data taken during the 1990 assessment on vegetation plots, trees were also inspected for damage incurred during harvesting (on all sides), and dieback in tree crowns was rated. The live crown ratio was determined and trees were graded to classify them as Acceptable Growing Stock (AGS)[10] or Unacceptable Growing Stock (UGS).[11] Data were also collected on standing snags at each plot, as were regeneration data and severity ratings of deer and/or moose browse. The presence of invasive species was also noted.

Soils data during the 2012 Assessment were collected using the US Forest Service "Forest Soil Disturbance Monitoring Protocol - Rapid Assessment" method.

The presence, size, and quantity of coarse woody material (CWM) were also evaluated in 2012.

Population Definition and Sample Selection

In order to allow the comparison of 2012 data with select data from the 1990 assessment, it was necessary to collect data from a sample of all timber harvesting operations (THOs) throughout the state. A qualifying THO was defined as a "commercial" harvest that was "closed out" between May 1, 2010 and April 30, 2011. A "commercial" timber harvesting operation was defined as any operation where forest products were harvested and commercially removed from the site. This definition was designed to include traditional timber harvests as well as land clearing for agricultural conversion or development, as long as products were removed from the site commercially. The term "closed out" is an industry term indicating that the harvesting operation has been completed and work has been performed to stabilize stream crossings, skid trails, landings, and truck roads, preparing the site to lay dormant for an extended period of time.

Timber harvest operations under state, federal, municipal, private, and corporate ownership were included in the population from which the sample was drawn. All landowner information was voluntary and anonymous, as was true in the 1990 assessment, and no information has been reported on individual THOs.

Vermont Department of Forests, Parks and Recreation foresters assigned to the assessment project were responsible for conducting a census of THOs that met the criteria above for field assessments. During the 1990 assessment this task was left primarily to the department's county foresters due to their considerable knowledge of forestry activity in their respective counties. Over the last 21 years, the duties of the county foresters have changed substantially, with a much greater emphasis on the administration of the Use Value Appraisal program. So, while the county foresters were consulted, much more emphasis was placed on obtaining information directly from the individuals who were more intimately involved with each THO. Hundreds of letters and

[10] AGS (Acceptable growing stock) – a commercial species less than rotation age with relatively good vigor, containing no pathogens that may result in the death or serious deterioration of the tree before rotation age, and which contains, or has the potential of producing, merchantable sawtimber of USFS grade 3 quality or better (see Appendix F for USFS grading standards).

[11] UGS (unacceptable growing stock) – a tree (mature or immature) that will not grow or prospectively meet AGS standards,, primarily because of roughness, poor form, or non-commercial species (see Appendix F for USFS grading standards).

emails requesting information were sent to private consulting foresters, loggers, primary wood-using industries, forestry associations, USDA Forest Service foresters, county foresters, state lands stewardship foresters, and state foresters involved with Acceptable Management Practices (AMP) and “Heavy Cut” Law enforcement. Follow-up phone calls were made to non-responders to ensure as complete a list of THOs as possible. As in the previous assessment, an attempt was made to compile as comprehensive a list of THOs as possible. A master list of over 450 sales was compiled, and after removal of duplicates, the final list included 420 distinct THOs from 13 counties. Participation in the assessment was completely voluntary and some individuals chose not to participate. As a result, the final list does not represent all of the timber harvesting operations completed during the period.

The goal of the assessment team was to complete at least 80 field assessments, in order to roughly correspond to the sample size completed in 1990. A stratified random sample of 100 THOs was drawn from the master list prior to the beginning of the field season. The additional 20 operations in excess of the 80 THO goal were drawn in anticipation of the need to compensate for disqualified harvests or denial of landowner permission. Each county was sampled[12] and the number of sites selected per county was proportional to the number of operations listed by county in the master list. Before the field season ended, an additional 16 operations were drawn for specific counties to ensure that the sample was properly proportioned from county to county. A minimum sample size of two THOs per county was required (as in the 1990 protocol). Eighty-one (81) field assessments were completed and permission was received for an additional seven (7) THOs that ultimately were not visited; eight (8) THOs were disqualified because of incorrect close-out dates; and twenty (20) THOs were dropped because permission was denied or landowners could not be contacted.

Data Collection

Once the sample was drawn, the identified contact person for each sale was contacted to obtain permission to visit the site and to complete a brief interview to obtain detailed background information about the particular THO. A map of the harvest area was also requested. In many cases, more than one person had to be contacted in order to collect all necessary information and gain permission for the on-site visit. Field data were collected by a 3-person team of Forests, Parks and Recreation foresters. In most cases, a two-person crew completed the assessment on each THO. Occasionally, all three team members worked on a single THO. This practice facilitated consistency in data collection and recording. Data were collected using handheld data loggers, with a field application designed to expedite data entry and perform data validation. Post-field processing imported all data to Microsoft Access where it was reviewed, edited if necessary, and stored. The analyses by individual Technical Committee members were largely done in Microsoft Excel, with data exported from the database. See Appendix D for a complete description of data collection methods and coding.

[12] All counties were sampled with the exception of Grand Isle. As was the case in 1990, no information on sales was received from Grand Isle County so Grand Isle and Franklin counties were combined.

Understanding and Interpreting These Results

It is important to recognize that THO acres reported in the following chapters of this report reflect only those acres on which cutting actually occurred. For some types of silvicultural treatments (most notably group selection and patch or strip clearcut harvests) only a portion of a forested stand is actually cut when managing a stand. These types of treatments are designed to establish regeneration in the entire stand over a series of treatments, which are often 10-20 years apart. As a result, the THO acres (on which cutting actually occurred) may be substantially less than the treated acres in some cases. Members of the project Technical Committee chose to utilize the acres on which cutting actually occurred to define the area of each THO in order to better estimate the positive and negative impacts of the actual cutting, which was the goal of the assessment.

Since pre-harvest conditions were not assessed as part of this project, it was not possible to evaluate some attributes that might have been affected by the harvest (e.g., growth rate, tree health, or wildlife habitat quality and use).

Readers should recognize the following limitations of this assessment:

- The results reported are based solely on the harvests assessed, represent a single point in time, and can not be representative of every timber harvesting operation in Vermont.
- Assessments were conducted after harvest operations had been completed and were intended to evaluate potentially ongoing effects of timber harvesting. Impacts (positive or negative) that might have occurred during the active period of the harvest may not have been captured.
- For the purpose of comparing results with the 1990 assessment, every effort was made to replicate the methods and measurements during 2012. However, this was not always possible, and in some cases improved methods were used, making comparisons impossible.

Because data collection procedures were based on those used for the 1990 assessment, the data analyses and reporting throughout this document generally follow the analyses performed for that report. However, changes to the metrics assessed, data collection methods, and the wording of interview questions have all affected the ability to make direct comparisons with the data from the previous report. As a consequence, the 2012 results are first discussed on their own merits, followed by a comparison of data from the 1990 and 2012 assessments, where methods allowed for valid comparisons.

The methodology used for reporting THO statistics throughout the report is generally consistent with that used for the 1990 assessment. Three general types of statistics are reported. The *percentage of operations* indicates the relative frequency that a particular characteristic occurred on a per operation basis. The *mean size of operation* provides an estimate of the mean acreage harvested for the operations that are associated with the listed characteristics. The third statistic is the *statewide percentage of harvested area* for the various operational characteristics. Acreage statistics were weighted in order to reflect the relative value of the harvest. Based on the mean size and percentage of operation statistics, this figure estimates the percentage of the estimated statewide harvested acres that can be linked with each of the characteristics. Unless otherwise stated, these three statistics are based on all 81 harvesting operations.

CHAPTER 3: STATUS OF TIMBER HARVESTING IN VERMONT

INTRODUCTION

Before discussing the results of the analysis of timber harvests in Vermont, it is necessary to put those results in context by providing information on the general nature and extent of harvesting in the state. With this knowledge, it is then possible to interpret the relative importance of the potential effects described in later chapters of this report.

The 81 commercial harvesting operations that were sampled ranged in size from 2 acres to 468 acres. The mean size of harvest operations was 62 acres (median 37 acres), with a minimum size of 2 acres and a maximum of 468 acres. From the harvest information we received, it is estimated that during the specified one-year period, some form of harvesting activity took place on at least 26,040 acres of timberland (420 operations with a mean size of 62 acres).[13] *Vermont's Forest Resources, 2011* estimated that there are 4,476,800 acres of timberland in Vermont. Therefore, based on the estimated level of harvesting activity, at least 0.6% of the state's timberland experienced some form of harvesting during the sample year (Figure 3-1).

DESIGN

Much of the data collected on the general characteristics of timber harvests in Vermont were obtained by interviewing one or more individuals familiar with each operation. In most cases this was a forester (60 THOs) and/or the landowner (20 THOs). The interview was designed with specific questions regarding operational characteristics such as: size of operation; degree of forester involvement (if any); type of skidding equipment used; products derived from the harvest; and duration of operations. For the most part, the interviews were conducted over the phone, but in some cases a copy of the interview questions was emailed, mailed, or faxed to the individual providing the information. A copy of the full interview script can be found in Appendix D of this report. Most of the interview questions mirrored those used in the 1990 assessment. However, some questions were updated or reworded in an attempt to obtain a clearer picture of the general characteristics associated with the timber harvesting operations.

During the field visits, general observations were made to further categorize harvesting objectives and to more accurately measure harvested areas.

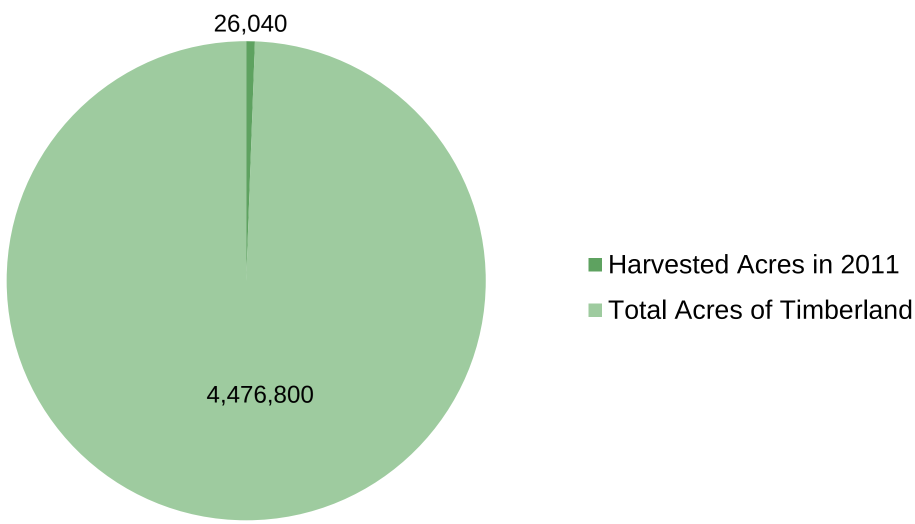
- The primary objective for the THO was noted after visiting the site. This determination was based on field observations (parcel is currently growing trees,

[13] A query of the USDA Forest Service's Forest Inventory and Assessment (FIA) database estimates that during the five-year period from 2007-2011, 301,681 acres of timberland in Vermont had at least some cutting apparent, or some cutting occurred on approximately 60,336 acres annually. FIA estimates of cutting activity record all harvesting, including non-commercial and personal use treatments (such as personal use firewood harvesting), so this number is NOT an accurate estimate of "commercial" sales as defined in this assessment. Based on the estimate from the FIA, approximately 1.3% of the timberland experiences at least some cutting annually.

being developed, or converted to agricultural land, etc.) and any goals stated by the contact person during the interview.

- After visiting an operation, the overall harvested area[14] of each THO was refined through the use of aerial photos and a geographic information system (GIS) to ensure that the overall acreage of each timber harvesting operation was as accurate as possible.
- The approximate acreage of each of the various silvicultural methods employed was estimated through the use of aerial photo interpretation and GIS mapping, informed by on-the-ground observations.

Figure 3-1. Estimated annual level of harvesting activity in relation to total acres of Timberland in Vermont, 2012.



RESULTS AND ANALYSIS

General Characteristics

According to Frieswyck and Malley (1985), the southern forest region of Vermont includes Addison, Bennington, Chittenden, Rutland, Windham, and Windsor counties. The northern forest region of Vermont includes Caledonia, Essex, Franklin/Grand Isle, Lamoille, Orange, Orleans, and Washington counties. The sampled operations were nearly evenly split between the northern and southern regions, with 40 operations in the north and 41 operations in the south. Of the operations that were included in our statewide sample, the mean operation size in the southern region of Vermont was 42

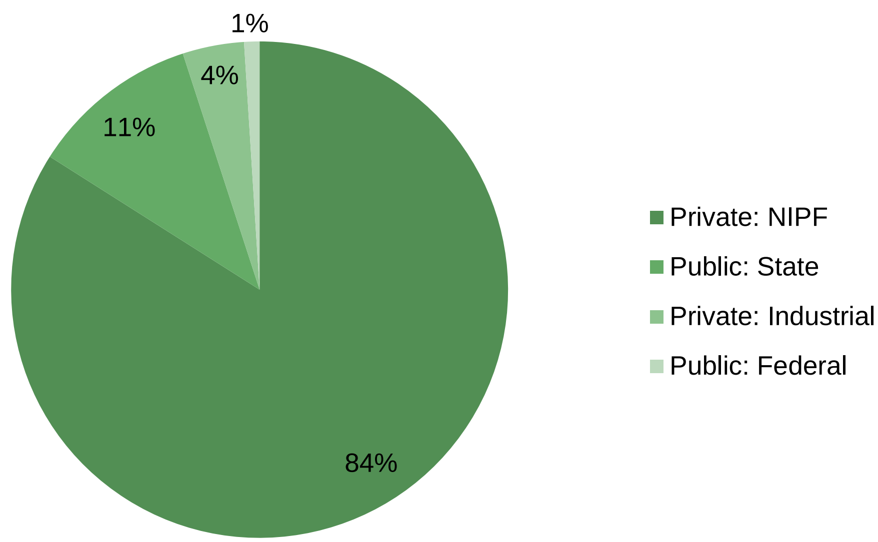
[14] It is important to note that "operation size" and "parcel size" are not synonymous in this context. Operation size was defined as the actual acreage treated during the 2012 assessment. No attempt was made to analyze the size of parcels on which harvesting occurred.

acres (maximum: 200 acres, minimum: 3 acres, median: 32 acres), while the mean operation size in the northern region of Vermont was 84 acres (maximum: 481 acres, minimum: 2 acres, median: 30 acres).

Ownership

Eighty-eight percent of operations in the sample took place on private land and these operations had a mean size of 62 acres (maximum: 481 acres, minimum: 2 acres, median: 31 acres). Four percent of those private sales took place on industrial forest land, with the remaining 84% took place on non-industrial, private forestland (NIPF) (Figure 3-2). The mean operation size on NIPF land was 63 acres, and timber sales on NIPF land represent approximately 85% of the statewide harvested area (Figure 3-3). The mean operation size on industrial timberland was 34 acres.

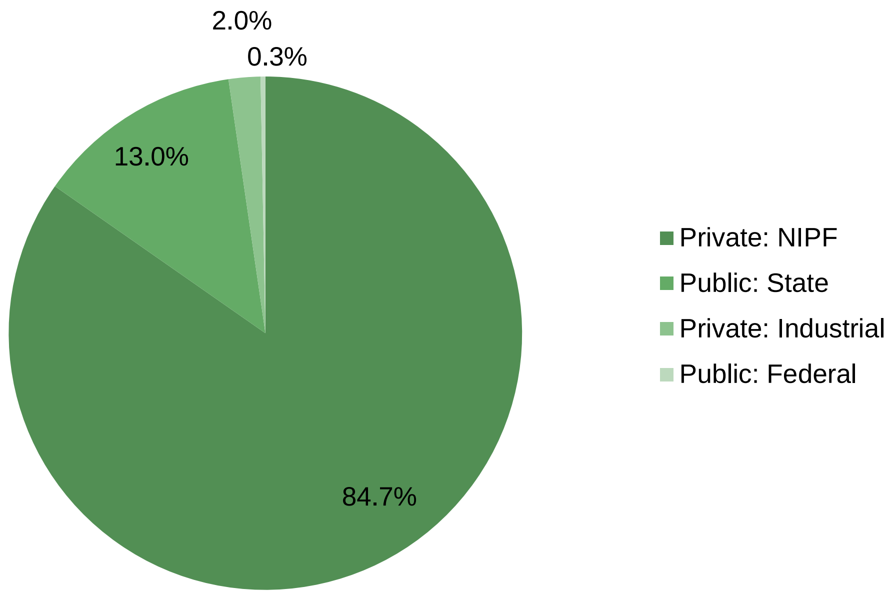
Figure 3-2. Percent of timber harvesting operations by ownership class, 2012.[15]



Twelve percent of harvesting operations took place on public land (Figure 3-2). The mean acreage of operations on public land was 67 acres (maximum: 181 acres, minimum: 14 acres, median: 45 acres). The largest operation sampled, a 182-acre operation, was located on state owned land. Harvesting operations on state land represented 13% of the statewide harvested area (Figure 3-3). Harvesting operations on federal land made up only 1% of the operations in the sample, even though the quantity of timber sold annually on federal land is very similar to the volume sold on state lands. It is possible that, on average, federal sales may be larger than those on state land, resulting in fewer numbers of sales being included in the overall population. Further analysis of this discrepancy is impossible with the data collected for this assessment.

[15] Harvesting operations on federal land made up only 1% of the operations in the sample even though the quantity of timber sold annually on federal land is very similar to the volume sold on state land. It is possible that, on average, federal sales may be larger than those on state land resulting in fewer numbers of sales being included in the overall population. Further analysis of this discrepancy is impossible with the data collected for this assessment.

Figure 3-3. Primary ownership class by percent of statewide harvested area, 2012.[15]



The percentage of operations by ownership category generally follows the percentage of land area in each ownership type. The USDA Forest Service Forest inventory and Analysis (FIA) estimates that roughly 80% of the state's forest is privately owned and the results of the assessment showed that 88% of harvesting operations occurred on private lands. Likewise, federal, state, and municipal ownership accounts for 20% of the forested acres and accounted for 12% of the THOs sampled. While beyond the scope of this assessment, it is likely that at least a portion of the discrepancy on public lands is due to the higher percentage of high-elevation and non-productive lands, as well as the presence of areas where harvesting is specifically excluded (designated Wilderness and natural areas).

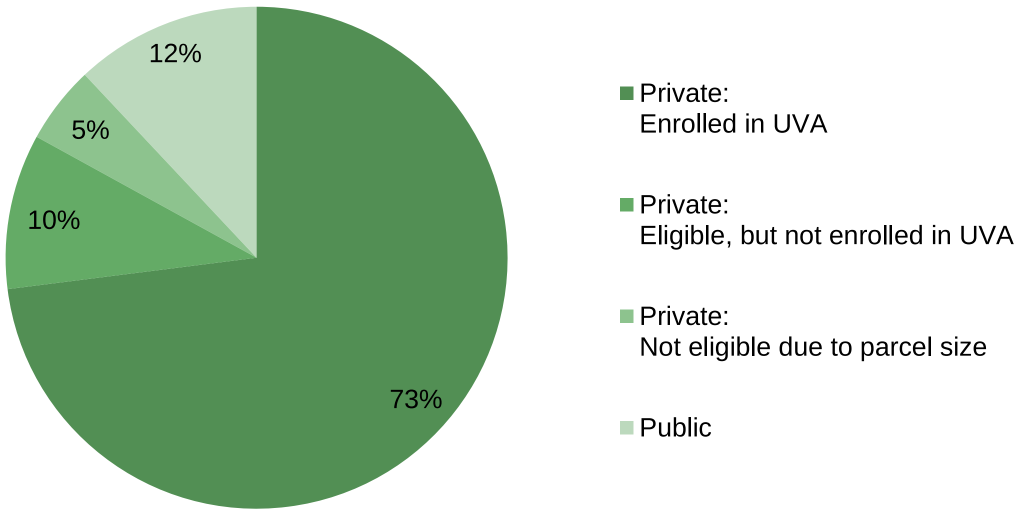
Similar to the 1990 *Impact assessment of timber harvesting in Vermont* (Newton et al. 1990), there was only a slight difference between the mean harvest operation size on private land (approximately 62 acres) and public land (approximately 67 acres).

Use Value Appraisal Participation

Timber harvests on private property enrolled in the Use Value Appraisal (UVA) or Current Use program represented 73% of sampled timber harvesting operations (Figure 3-4) and 76% of the statewide harvested area. *The Economic Importance of Vermont's Forest Based Economy* 2013, reports that 14,000 landowners, owning roughly 1.8 million acres of forestland in Vermont, were enrolled in UVA. This amounts to approximately 39% of the privately owned forestland base.

The mean harvest operation size on private lands enrolled in UVA was 65 acres (maximum: 481 acres, minimum: 2 acres, median: 37 acres).

Figure 3-4. Ownership class and UVA status by percentage of operations, 2012.



Ten percent of harvesting operations were on lands that were determined to be eligible for, but not enrolled in, the UVA program.[16] The mean harvest operation size on eligible private lands that were not enrolled in UVA was 64 acres, and these sales represented 10% of the statewide harvested area.

The sample included very few sales that were not eligible for enrollment in UVA due to tract size. Five percent of the commercial timber harvests were on private land that was not eligible for the UVA program for this reason. Of these operations, the mean operation acreage was 7 acres. This represents less than one percent of the total statewide harvested area.

Harvesting Objectives

The primary harvesting objective for 85% of the harvest operations in the sample was silvicultural,[17] as defined in the 1990 assessment (Table 3-1). The mean harvested acreage among these operations was 67 acres (maximum: 481 acres, minimum: 2 acres, median: 41 acres), representing 93% of the statewide harvested area. This implies that the majority of harvested lands were intended to remain as forest land.

Agricultural conversion was the primary objective for 4% of the sampled harvesting operations, with a mean operation size of 13 acres. Sales of this type represented 1% of the statewide harvested area.

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[16] Eligibility for enrollment was determined based on total parcel acreage. For the purposes of this analysis, eligible parcels were those with a total acreage greater than 25 acres.

[17] "Silvicultural" refers to vegetative manipulation for purposes such as timber production, recreation, aesthetics, and wildlife habitat.

Table 3-1. *Operation area and frequency, and statewide percentage of harvested area by primary harvesting objective for timber harvesting operations in Vermont, 2012.*

Primary Harvesting Objective	Count of Operations	Percentage of Operations	Mean Size of Operation (acres)	Statewide Percentage of Harvested Area
Silviculture	70	86%	67	93%
Other [18]	8	10%	41	6%
Agricultural Conversion	3	4%	13	1%
Total	**81**	**100%**	**62**	**100%**

There were a wide variety of goals reported during the interview for each of the harvest operations in the sample. These ranged from simply satisfying a management plan requirement to a combination of goals such as generating income, recreation, improving or creating wildlife habitat, and aesthetics. On 98% of THOs, contacts reported that the stated goals were met.

Silvicultural Treatments

Silvicultural treatments were broadly defined for the purposes of the assessment. It is important to remember that the classification of the treatments employed reflects only the outcome of the treatment and not the intent, and that the descriptions and definitions of the treatments used are identical to those used in the 1990 Assessment to allow for comparisons. The field assessors had only the residual stand from which to classify the treatment; no attempt was made to ascertain what the prescribed or envisioned treatment was or how the intent compared with the results. Silvicultural method was determined at each of six vegetative data plots randomly located on each THO.

For the purposes of the assessment, the following classifications and definitions were used:

- Partial Cutting/Thinning:[19] partial cutting resulting in >75% crown closure.[20]
- Group Selection: regeneration treatment removing trees in groups or patches from 1/20 acre to 2 acres in size.
- Shelterwood/Seed Tree/Prep Cut: intermediate regeneration treatment resulting in crown closure of 25 to 74%.
- Overstory Removal/Clearcut:[21] regeneration treatment resulting in crown closure of less than 25%. Includes both removals of trees over established regeneration and clearcuts.

[18] For Primary Harvesting Objective, the “Other” category was intended to include liquidation, salvage, and clearing for purposes other than agriculture. For sales included in the “other” category during the 2012 assessment, interviewees indicated their harvests were completed to “generate income,” daylight buildings or roads, and to clear for a future gravel pit.

[19] The term “Partial Cutting and Thinning” is used here to describe a treatment that resulted in a crown closure of >75%. For the purpose of comparison with the 1990 Assessment, this level of cutting was termed “Partial Cutting/Thinning.”

[20] Field assessors also utilized residual basal areas that reflected these crown closure levels to ascertain silvicultural methods. These basal areas vary with forest cover type.

[21] While the resulting stocking levels from Overstory Removal Cuts and Clearcuts are often the same, it should be noted that Overstory Removal Cuts can be and often are the final harvest in a shelterwood system.

- Strip Cut: regeneration treatment resulting in strips of trees removed, alternating with strips of retained trees or regeneration.
- Other: non-silvicultural treatments, such as conversion to agriculture.

Percentages of each silvicultural treatment used were determined based on an analysis of timber harvest operation maps, aerial photographs, and observations made during the on-site visits to harvest areas. It is important to remember that the classification of the methods employed reflects only the outcome of the treatment and not the intent.

Sixty-two percent of operations, 67% of the statewide harvested area, used multiple silvicultural treatments on individual harvest operations (Table 3-2).

Table 3-2. *Operation area and frequency, and statewide percentage of harvested area by silvicultural treatment for timber harvesting operations that used a single silvicultural treatment in Vermont, 2012.*

Silvicultural Treatment[22]	Count of Operations	Percentage of Operations	Mean Size of Operation (acres)	Statewide Percentage of Harvested Area
(Multiple Silvicultural Treatments Employed)	(50)	(62%)	(68)	(67%)
Partial cutting/thinning[23]	13	16%	35	9%
Overstory removal/clearcut[24]	13	16%	73	19%
Other[25]	3	4%	13	1%
Shelterwood/seed tree/prep cut[26]	2	2%	120	5%
Total	**81**	**100%**	**62**	**100%**

Of the THOs where a single silvicultural treatment was used on the entire operation, 16% of operations, representing 19% of the statewide harvested area, employed only the overstory removal/clearcut treatment. These operations averaged 73 acres in size. Sixteen percent of operations solely used partial cutting/thinning treatments, with a mean area of 35 acres, representing 9% of the statewide harvested area. Other treatments and the shelterwood/seed tree/prep cut treatment were used on 4% and 2% of operations, respectively.

When operations with multiple silvicultural treatments were subdivided according to treatment and then combined with the operations employing a single treatment (Table 3-3), partial cutting/thinning was used on 70% of all operations, representing 49% of the statewide harvested area. The overstory removal/clearcut treatment was used on 40% of operations, representing 29% of the statewide harvested area. The shelterwood/seed tree/prep cut treatment represented 17% of the statewide harvested area. Operations

[22] "Multiple Silvicultural Treatments" indicate timber harvest operations (THO) where more than one treatment was employed. For a THO to be included in one of the single treatments listed, that treatment was employed on 100% of the harvested area.

[23] Partial Cutting/Thinning refers to a partial cutting resulting in >75% crown closure.

[24] Overstory Removal/Clearcut refers to a regeneration treatment resulting in crown closure of less than 25% and includes both removals of trees over established regeneration and clearcuts.

[25] For Silvicultural Treatments, "Other" treatments were all agricultural conversions.

[26] Crown closure of 25 percent to 74 percent in the overstory was used to characterize shelterwood and seed tree methods.

that employed the group selection treatment represented 6% of the statewide harvested area.

Table 3-3. *Operation area and frequency, and statewide percentage of harvested area by silvicultural treatment for timber harvesting operations in Vermont, 2012.* *<u>Single and multiple treatments combined.</u>*

Silvicultural Treatment Used: Singularly or in combination with other treatments	Count of operations[27]	Percentage of Operations Where Treatment was Used	Mean Size of Operation Where Treatment was Used (acres)	Statewide Percentage of Harvested Area
Partial cutting/thinning	57	70%	58	49%
Group selection[28]	33	41%	62	6%
Overstory removal/clearcut	32	40%	73	29%
Shelterwood/seed tree/prep cut	26	32%	80	17%
Other[29]	3	4%	13	1%
Strip cut	1	1%	184	1%

Professional Assistance and Contracts

Many of the assessed harvesting operations involved consultation with a "professional forester."[30] Some operations involved a forester as well as a wildlife biologist or ecologist. In a few cases a forester became involved as a result of regulatory actions (Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont technical assistance or violations). During the interview, the interviewer asked whether a "professional forester" (state lands, county, federal, company, or private consultant), wildlife biologist, ecologist, or stream alteration engineer was involved with the timber harvesting operation. In addition, in operations that resulted in regulatory involvement, the Vermont state acceptable management practices forester (AMP forester) was listed. Eighty-six percent of the operations sampled, representing 92% of the statewide harvested area, were operations on which the person knowledgeable of the operation indicated that the operation was executed with the involvement of a professional forester (Table 3-4).

The average harvested area of operations without known forester involvement was 38 acres. The acreage of sales with known forester involvement was significantly larger, averaging 66 acres.

[27] Count and percentage totals are greater than the 81 operations in the sample and 100%, respectively, because the table shows the total amount (count and acres) for each method used, both singly and in combination with other methods, and many operations used more than one method.

[28] Group selection methods were characterized by a residual stand composed of open patches ranging in size from 1/20 acre to 2 acres.

[29] The category "Other" included only agricultural conversions.

[30] The term "professional forester" was specifically used in the interviews of "a person knowledgeable of the operation" and was carried over from the 1990 Assessment to facilitate comparisons. A professional forester was defined in both assessments as a person eligible for SAF membership at any level.

Table 3-4. *Operation area and frequency, and statewide percentage of harvested area by professional forester involvement in timber harvesting operations and type of involvement for timber harvesting operations in Vermont, 2012.*

Professional Forester Involved with Harvest	Type of Involvement in the Timber Harvesting Operation	Count of Operations	Percentage of Total Operations	Mean Size of Operation (acres)	Statewide Percentage of Harvested Area
No		**11**	**14%**	**38**	**8%**
Yes		**70**	**86%**	**66**	**92%**
	Written forest management plan[31]	67	83%	68	90%
	Forester marking/ designation	65	80%	62	79%
	Contract negotiations	60	74%	74	88%
	Responsible for skid trail layout	55	68%	75	81%
	Responsible for landing designation	49	60%	69	67%
	Responsible for sale closeout	42	52%	48	40%

The forester's degree of involvement varied across the sample of operations. For those operations with known forester involvement, 83% had a written forest management plan for the property, amounting to 90% of the statewide harvested area. Five percent of the operations were on parcels that had a forest management plan, but no forester involvement with the THO itself. No attempt was made to analyze individual aspects of forester involvement on individual THOs, so it is impossible to draw conclusions on how involvement in one area may or may not have influenced another, such as whether or not the forester who authored the plan was the same forester involved in the harvest.

According to interview responses, foresters were least likely to be responsible for sale closeout (52% of operations, representing 40% of the statewide harvested area). Sale closeout is an activity that is often detailed in harvesting contracts, and many contracts have clauses delegating the responsibility for implementation of Acceptable Management Practices to maintain water quality (a major component of sale closeout) to the logger. It is likely that foresters, in many cases, oversaw and were responsible for insuring proper installation of the practices. As a result, it is likely that, at least in part, the percentages reported above reflect the manner in which the question was asked in the interview: *Who was responsible for sale closeout?*

Contracts

Most operations had a written contract with which the forester was involved. The mean size of operations having a written contract (with forester involvement) was 71 acres. In contrast, sales purportedly with forester involvement, but without formal written contracts, averaged 22 acres. The data suggest that the larger the harvest operation, the more likely a written contract outlining the terms of the sale exists. Operations with a

[31] Seventy-one owners reported having forest management plans, but only sixty-seven of those had a forester involved with the harvest.

written contract (with forester involvement) represented 89% of the statewide harvested area.[32]

There was considerable variability in the reported "special provisions" (Table 3-5) included in timber sale contracts. Operations representing 22% of the statewide harvested area had contracts in which no special provisions were reported to have been included.

***Table 3-5**. Operation area and frequency, and statewide percentage of harvested area by reported types of special provisions[33] in harvesting contracts for timber harvesting operations in Vermont, 2012.*

Type of Special Provision Reported	Count of Operations Stating each Special Provision[34]	Percentage of Operations	Mean Size of Operation (acres)	Statewide percentage of Harvested Area
Total with contract	**69**	**85%**	**70**	**96%**
No contract or unknown	**12**	**15%**	**17**	**4%**
Water quality	43	53%	82	70%
Harvest timing	32	40%	70	44%
Slash/residuals	28	35%	77	42%
No special provisions	27	33%	42	22%
Aesthetics	20	25%	64	25%
Wildlife habitat	12	15%	98	23%
Trail construction	12	15%	67	16%
Recreation	8	10%	98	15%
Archaeological and historic sites	9	11%	69	12%
Invasive plants	8	10%	61	10%
Bridge building	6	7%	60	7%
Rare, threatened, endangered spp.	5	6%	138	14%
Unknown	7	9%	26	4%
Protection of physical sites on THO	4	5%	49	4%
Apple tree release	2	2%	24	1%

Fifty-three percent of operations had contracts with special provisions for water quality, with a mean harvested area of 82 acres. The ultimate responsibility for maintaining water quality, by statute, lies with the landowner. As a result, provisions designed to protect water quality and shift this responsibility to the logging contractor are often included in the standard provisions in many contracts. Here again, it is likely that the manner in which the question was asked, "Did the contract include any *special* provisions?," may have led some respondents to discount provisions that they may have considered to be standard in a contract. As a result, the number of contracts that addressed water quality, for instance, is likely to have been under reported.

[32] Numbers presented reflect only THOs that "had a formal written contract with which the professional forester was involved." Unknowns were not included.

[33] Interviewees were specifically asked about "special conditions" included in the contract and not all contract conditions.

[34] Count of operations stating each special provision sums to more than 81 operations because many contracts had more than one special provision.

Forty percent of operations had special provisions for harvest timing, and 35% of operations had conditions that addressed slash[35] and/or residuals. Once again, it is difficult to make any inferences about the importance of the features listed in Table 3-6 on any particular harvest because of the way the questions were posed during the interview. Future surveys of this sort should consider asking what provisions were included in the contract to avoid this occurrence.

Table 3-6. *Operation area by region, and area and frequency on a statewide basis by duration of timber harvesting operation in Vermont, 2012.*

Duration of Operation (months)	Count of operations	Percentage of Operations	Mean Size of Operation (acres)		Statewide Mean Operation area (acres)	Statewide Percentage of Harvested Area
			North	South		
1-3	43	53%	37	26	31	27%
3-9	22	27%	146	51	90	39%
9-18	9	11%	202	38	129	23%
>18	6	7%	35	118	76	9%
Unknown	1	1%	109	--	109	2%
Total	**81**	**100%**	**84**	**42**	**62**	**100%**

Operational Characteristics

From an operational perspective, the majority of timber sales in the sample were completed in a relatively short time frame. Fifty-three percent of operations were completed in 1-3 months, representing 27% of the statewide harvested area (Table 3-6). Generally, sales that were completed over a longer time frame had larger acreages than those completed in a shorter time frame. Operations in the northern region averaged twice the acreage of those in the southern region.

Harvest Duration[36]

The duration of operations on public land was generally longer than that on private land, with 40% of public harvests requiring more than 18 months to complete. Sixty-seven percent of harvests with durations in excess of 18 months were on public land. The reasons for the increased duration of public land operations is complex and may involve factors such as acreage, the use of “lump-sum” contracts of a specified duration, and limitations on the allowable seasons of operation.

Landings

Landings were evaluated on 69 timber harvest operations. Landing evaluations were not completed unless the exact location and extent of the landing could be identified. This was not possible on all THOs due to post-harvest activities or operations. For example, in several instances a field was used as a landing site and subsequently restored to its original condition, or planted to corn.

[35] Slash is defined as the residue, e.g., treetops and branches, left on the ground after logging.

[36] Harvest duration was defined during the interview as the length of time from “start to close-out.”

The bulk of operations (68%) had only one log landing. The mean acreage of operations with a single landing was 44 acres. The greatest number of landings observed on a single operation was 7, on an operation of 350 acres in the northern region of Vermont. The largest operation in our sample (481 acres) had four landings.

The size of landings ranged from 0.1 acre to 2 acres. There was no obvious relationship between size of the landing and size of the operation. Landing size was, however, related to the products that were harvested from each operation. Operations that harvested roundwood and chips had, on average, larger landings than operations that harvested only one type of wood product (Table 3-7). This relationship may be explained by the fact that as the number of product sorts increases on an operation, so then does the area needed to accommodate them.

Table 3-7. *Mean size of landing by products harvested from timber sales in Vermont, 2012.*

Product(s)	Mean size of landing (acres)
Roundwood and Chips	0.60
Roundwood	0.45
Chips	0.23

Designation of Trees for Harvest

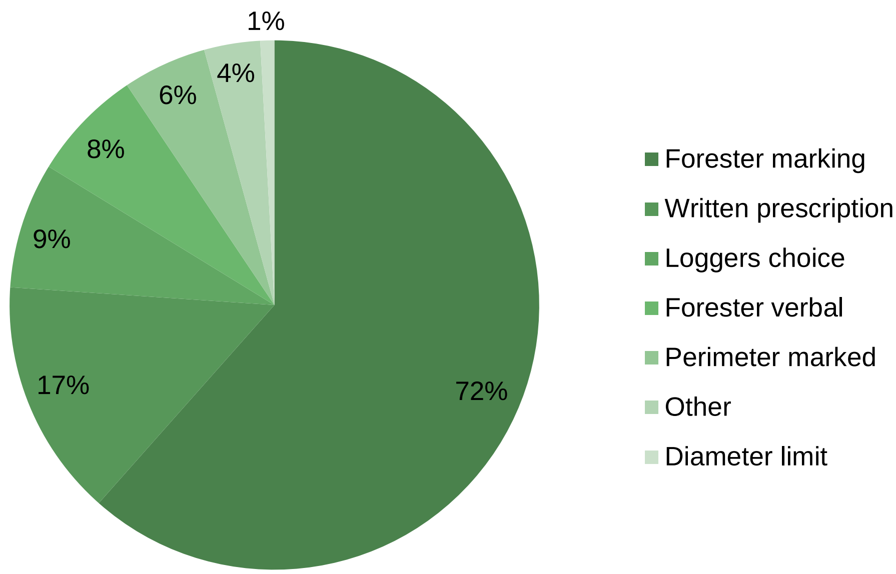
Methods of designating trees for harvest can vary considerably, depending on the objectives and the prescribed treatment for the area to be harvested. While a harvest using individual tree selection methods generally requires marking of individual trees to ensure desired outcomes are achieved, group selection harvests or patch clearcuts might only require marking the perimeter of the areas to be harvested. Likewise, written or verbal direction to the harvesting contractor may be sufficient in cases where, for instance, residual overstory trees are to be removed in areas with established regeneration.

In the majority of operations, survey respondents indicated that a forester marked trees for removal (75% of operations in the sample, 72% of the statewide harvested area) (Figure 3-5).[37] Operations where a forester marked the trees for removal averaged 60 acres. Although written prescriptions to designate trees for removal were less commonly used (7% of operations with a mean size of 143 acres), it accounted for 17% of the statewide harvested area because the operations that used this method had larger acreages. Operations on which respondents indicated that loggers were allowed to choose the trees to cut averaged approximately 49 acres. These “logger’s choice”[38] sales accounted for 11% of all operations in the sample, and 9% of the statewide harvested area.

[37] Percentages shown in Figure 3-5 total more than 100% because some operations used more than one method of designating trees for removal.

[38] “Logger’s choice,” as the term implies, meant that the logging contractor chose the trees to be cut without input from a forester or other resource professional.

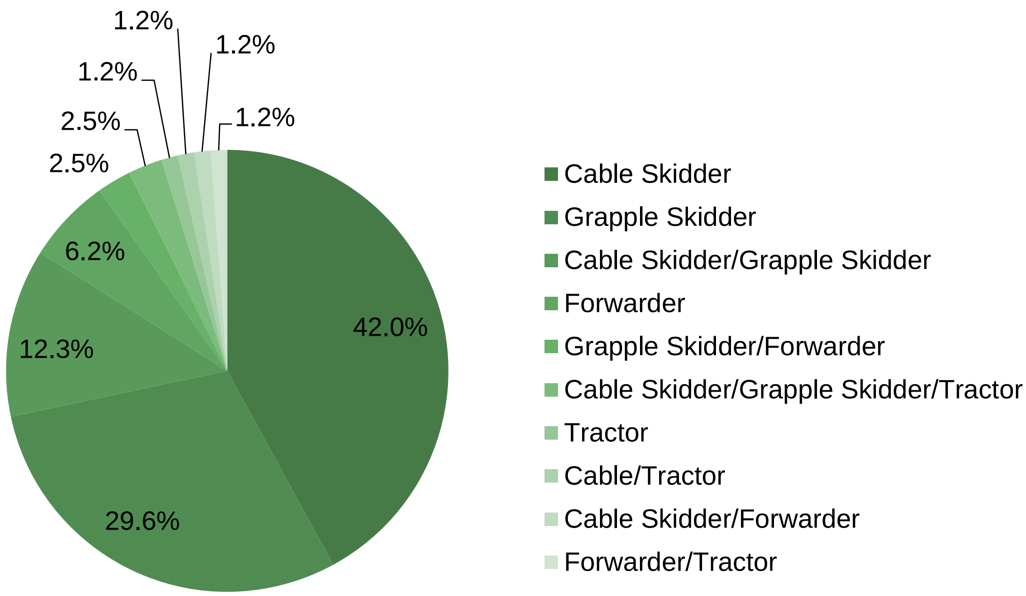
Figure 3-5. Percentage of the statewide harvested area with trees designated by each method: singly or in combination, 2012.



Skidding Equipment

Many operations used a combination of skidding equipment (Figure 3-6). Where a single type of skidding equipment was used on a given operation, the most commonly used piece of equipment was a cable skidder, accounting for 42% of all harvest operations. Grapple skidders were used exclusively on nearly 30% of all operations.

Figure 3-6. Percent of operations using each individual type or combination of skidding equipment, 2012.



When each type of skidding equipment was tallied to include both single-use or used in combination with other types, cable skidders remained the most common at 59% of operations (Table 3-8). Grapple skidders were used on 47% of all operations. The mean size of operations that used grapple skidders was considerably larger than those that used cable skidders (a mean of 85 acres for grapple skidders and 56 acres for cable skidders).

Table 3-8. *Operation area and frequency by type of skidding equipment used (singly or in combination) on timber harvesting operations in Vermont, 2012.*[39]

Skidding Equipment (used singly or in combination)	Count of Operations	Percent of Operations	Mean Size of Operation (acres)
Grapple Skidder	38	47%	85
Cable Skidder	48	59%	56
Forwarder	9	11%	51
Tractor	5	6%	68

Skidding Methods

Skidding method refers to the form of the tree when transported from stump to landing. These methods can be broadly classified into two categories: tree-length/log-length skidding or whole-tree skidding. As the name implies, whole-tree skidding involves moving the entire tree to the landing with branches and top intact. Tree-length skidding typically involves transport of the entire stem of the tree in one piece, less the branches and top. Log-length "skidding" involves skidding shorter sections of tree stem, often cut into log lengths. Log-length skidding techniques are typical of operations using smaller equipment (tractors or bulldozers) or forwarders.

Table 3-9 lists all combinations of skidding methods used on timber harvesting operations and reported during the assessment interviews. Log- or tree-length (individually or in combination) skidding was used exclusively on 58% of all operations sampled. Whole-tree skidding (alone or in combination with log-/tree-length) was used on 41% of operations.

Of the operations where a single skidding method was used,[40] whole-tree skidding was the most commonly employed method on the operations assessed (37% of operations, amounting to 44% of the statewide harvested area). Log-length skidding was carried out on 27% of operations in our sample, representing 14% of the statewide harvested area, and tree-length skidding (without branches) was employed on 27% of operations in the sample, representing 27% of the statewide harvested area. An analysis of the equipment used on operations that reported log-length skidding indicates that the term may have been misinterpreted by some individuals being interviewed, and the amount of log-length skidding may be overestimated.

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[39] Percentages total more than 100% because each operation could have used more than one of each type of equipment listed (i.e., singly or in combination).

[40] Single skidding method refers to the use of only one method (log-length, tree-length, or whole-tree) of skidding products from the stump to the landing on a timber harvesting operation. Eight percent of operations used more than one method.

Table 3-9. *Operation area and frequency, and statewide percentage of harvested area by skidding method(s) for timber harvesting operations in Vermont, 2012.*

Skidding Method(s)	Count of Operations	Percentage of Operations[41]	Mean Size of Operation (acres)	Statewide Percentage of Harvested Area
Log-length	22	27%	32	14%
Tree-length (without branches)	22	27%	63	27%
Tree-length (without branches), Log-length	3	4%	33	2%
Whole-tree (with branches)	30	37%	75	44%
Whole-tree (with branches), Log-length	2	2%	225	9%
Whole-tree (with branches), Tree-length (without branches)	2	2%	88	3%
Total	**81**	**100%**	**62**	**100%**

A recently completed survey of 99 Vermont logging contractors by the University of Maine, School of Forest Resources (Leon and Benjamin 2012) found that while 22% of respondents used whole-tree logging systems, they accounted for 46% of the volume harvested. In contrast, 71% of respondents used tree-length systems but accounted for 34% of the harvested volume. These data support the findings of this assessment, suggesting that contractors utilizing whole-tree systems must either complete more harvesting operations or harvest larger areas than contractors using tree-length systems.

Forest Products Produced

The most common product harvested from timber sales sampled was roundwood (including logs, pulp, and firewood). Roundwood products were harvested from 96% of operations assessed (Table 3-10). In many cases, multiple products were harvested from the same operation. A combination of roundwood and chips was harvested from 33% of operations in the sample, with a mean operation size of 83 acres. Operations that harvested chips alone were, on average, 8 acres in size and represented 4% of operations in the sample.

Table 3-10. *Operation area and frequency by type of forest product(s) produced, for timber harvesting operations in Vermont, 2012.*

Type of Product (removed singly or in combination)	Count of Operations	Percentage of Operations	Mean Size of Operation (acres)
Roundwood only	51	63%	55
Roundwood and Chips	27	33%	83
Chips only	3	4%	8
Total	**81**	**100%**	**62**

Not all operations using whole-tree skidding methods produced chips. While 34 operations assessed used at least some whole-tree skidding, only 30 operations actually produced chips. On those jobs not producing chips, tops were removed at the

[41] Total of individual methods does not add up to 100% due to rounding.

landing and returned to and deposited on the sale area. Top and limb wood is often used to prevent rutting on timber harvesting operations. Ruts can collect and carry water, which can result in soil erosion and sediment reaching streams or other bodies of water.

Felling Methods

Chainsaw or hand felling was the dominant felling method, with 50% of operations solely employing this method (Table 3-11). A feller-buncher alone was used on 34% of operations, and a combination of chainsaw and machine felling was used on 11% of operations sampled. A feller-buncher with a processor head was used on 4% of operations.

Table 3-11. *Percent of total operations that produced various forest products, by felling method on timber harvesting operations in Vermont, 2012.*

Felling Method	Roundwood Only	Roundwood and Chips	Chips Only
Chainsaw/hand felling	49%	1%	0%
Feller-buncher	7%	23%	4%
Hand felling and feller-buncher	2%	9%	0%
Feller-buncher with processor head	4%	0%	0%

Results Comparison: 1990 and 2012

The estimated annual statewide area (acres) of harvesting activity saw a substantial drop between the 1990 and 2012 assessments. The 2012 assessment estimated that during the specified one-year period, some form of harvesting activity took place on at least 26,040 acres of timberland (420 operations with a mean size of 62 acres). *Vermont's Forest Resources, 2011* estimated that there are 4,476,800 acres of timberland in Vermont. Therefore, based on the estimated level of harvesting activity, at least 0.6% of the state's timberland experienced some form of harvesting during the sample year. In contrast, the 1990 assessment reported harvesting activity on 70,122 acres and timberland acreage in the state of 4,422,100 acres, resulting in 1.6% of the timberland being harvested on an annual basis at that time.

Overall reductions in harvesting activity between 1990 and 2012 are supported by the Vermont Forest Resource Harvest Summary, which reports a sizeable overall reduction in forest product volume harvested during the period (VT Dept. of Forests, Parks and Recreation website: http://www.vtfpr.org/util/for_utilize_harvsumm.cfm). A number of factors, including generally poor economic conditions, mill closures with related reductions in demand, and restrictions on the accessibility of timberland (through factors such as owner attitudes or parcelization), may have contributed to these reductions. In addition, salvage harvests carried out following the 1998 ice storm resulted in large areas of commercial timberland being removed from consideration for harvesting for 20-30 years following the event. Actual determination of the reason for this reduction in harvest levels is beyond the scope of this assessment.

Ownership Category and Operation Size[14]

Table 3-12 compares land ownership class, operation size, and proportion of statewide harvested area between the two samples. The 1990 and 2012 assessments reported that 85% and 88% of operations were conducted on private lands, respectively. These percentages are roughly proportional to the percentage of private forestland ownership in Vermont as reported in *Vermont's Forests 2007* (Morin et al. 2011); a total of over 3.6 million acres, or 80% of the total forestland in the state.

Table 3-12. *Operation area and frequency, and statewide percentage of harvested area by type of land ownership class for timber harvesting operations in Vermont, 1990 and 2012.*

Primary Ownership Class		Percentage of Operations		Mean Size of Operation (acres)		Statewide Percentage of Harvested Area	
		2012	**1990**	**2012**	**1990**	**2012**	**1990**
Private	NIPF	84%	73%	63	51	85%	40%
	Industrial	4%	12%	34	369	2%	48%
	Private Total	**88%**	**85%**	**62**	**94**	**87%**	**86%**
Public	State	11%	8%	73	134	13%	11%
	Federal	1%	5%	14	54	<1%	3%
	Municipal	-	2%	-	6	-	<1%
	Public Total	**12%**	**15%**	**67**	**86**	**13%**	**14%**
	Total	**100%**	**100%**	**62**	**93**	**100%**	**100%**

The percentage of the statewide harvested area represented by sales on private land was nearly identical from 1990 to 2012 as well, with 86% in 1990 and 87% in 2012. In 1990, the mean operation size on private land was 94 acres, which is considerably larger than the mean size of 62 acres in 2012 (Table 3-12). Much of this reduction may be explained by the significant decline in the percentage of private land in industrial ownership, and in the mean size of operations on the remaining industrial land. This notable ownership change was a result of a number of large industrial landowners, primarily paper companies, divesting themselves of their land holdings over the last 20+ years. Many of these parcels were purchased by investor groups and have remained nearly intact and were not sub-divided extensively. This fact may help explain the increase in the mean size of operations on NIPF land over the last assessment, since any large sales on former industrial parcels would have been included in this category.

FIA reports that approximately 80 percent of the privately owned forestland in the state is owned by families and individuals, while the remaining 20 percent is categorized as "Other Private," which includes corporate and timber investment groups (Morin et al. 2011). No attempt was made during the 2012 assessment to further subdivide NIPF owners.

In 1990, public land accounted for 14% of the statewide percentage of harvested area, while in 2012 public lands amounted to 13% of the statewide percentage of harvested area. Harvest operations on public lands followed the same trends as operations on private ownerships, with harvested areas being smaller, on average, in 2012 than in 1990, decreasing from a mean of 86 acres (1990) to 67 acres (2012). The percentage of harvest operations on public lands in both samples was similar: 15% in 1990 and 12% in 2012.

A number of factors may have contributed to the decrease in the mean acreage of THOs between the two assessments, but the investigation of those factors was beyond the scope of this project. It is important to note, however, that the technology available to the assessment teams may have had an impact on the results. During the 1990 assessment, the field assessors relied on maps prepared by a "person knowledgeable of the sale" (i.e., landowner or forester) to delineate the area harvested on topographic maps. During the 2012 assessment, the initial maps were again provided by a person knowledgeable of the sale. However, the field assessors were able to use global positioning systems (GPS), GIS, and aerial photographs taken in 2012 to refine those initial maps and very accurately determine the acreage actually harvested.[42]

The assessment team noted that in most cases, the THO[43] contained fewer acres than the original estimate obtained from the interview. In most cases, treated stands contained areas that were intentionally avoided such as wet areas, stream buffers, or areas that for one reason or another did not require treatment, thus reducing the acreage where cutting actually took place. Stands treated through patch clear cutting or group selection methods were another example of THOs where "reported" versus "actual" acres of harvest often differed. When regenerating a stand through patch cutting, foresters consider the entire stand to have been treated, even though perhaps only a percentage of the entire stand is actually cut. In collecting information on harvested sites for the 2012 assessment, foresters often reported the acreage of the stand treated and not the actual acres harvested. This more accurate measurement of the acreage where cutting occurred and more strict definition of harvested area may well have contributed to the smaller mean size of THOs as defined herein.

Use Value Appraisal Participation

Enrollment in Vermont's Use Value Appraisal (UVA) program has increased substantially since 1990. In 1987, an estimated 669,353 acres of forestland, 18% of the potentially eligible forestland in Vermont, was enrolled in UVA (Sendak and Dennis 1989); in 2011 a reported 1,734,012 acres was enrolled, an increase of roughly 225%. The proportion of UVA-enrolled parcels in the 2012 assessment sample also showed a substantial increase: 40% of operations in 1990, compared to 73% of operations in 2012 (Table 3-13). Percentages of operations ineligible for UVA due to tract size have not changed appreciably from 1990 to 2012: 8% and 5% respectively, both accounting for approximately 1% of the statewide harvested area.

[42] The 2012 Assessment focused on actual acres where cutting took place in order to obtain as accurate an estimate as possible of the acres that may have been impacted through cutting. The details of the methods for determination of acres treated during the 1990 assessment were not clear from the 1990 report.

[43] See explanation of THO acreage determination in Chapter 2 of this report. While the methodology used likely resulted in a more accurate representation of the area actually cut during a timber harvesting operation, this method is likely to have resulted in an underestimate of the acreage considered "treated" when managing forests.

Table 3-13. *Operation area and frequency, and statewide percentage of harvested area by ownership class, UVA program eligibility and enrollment status for timber harvesting operations in Vermont, 1990 and 2012.*

Ownership Class and UVA Enrollment Status	Percentage of Operations		Mean Size of Operation (acres)		Statewide Percentage of Harvested Area	
	2012	**1990**	**2012**	**1990**	**2012**	**1990**
Private	**88%**	**85%**	**62**	**94**	**87%**	**86%**
Enrolled in UVA	73%	40%	65	74	76%	32%
Eligible but not enrolled in UVA	10%	37%	64	135	10%	54%
Not eligible due to tract size	5%	8%	7	6	1%	<1%
Public	**12%**	**15%**	**67**	**86**	**13%**	**14%**
Total	**100%**	**100%**	**62**	**93**	**100%**	**100%**

Harvesting Objectives

Data related to landowner harvesting objectives were collected in slightly different ways during the 1990 and 2012 assessments, but the results are generally comparable. In 1990, the contact person who provided the interview data was asked to classify the primary harvesting objective (silvicultural, agriculture conversion, development, other, or unknown). During interviews for the 2012 assessment, the interviewers asked about the primary goal of the timber harvest (generate income, satisfy forest management plan, agricultural conversion, development, recreation, wildlife habitat, or aesthetics); but multiple answers were accepted. The final determination of the “primary harvesting objective” was made by the assessors based on the stated goals and field observations.

Landowner objectives for harvesting timber from forest land in Vermont were found to be primarily silvicultural[17] in both 1990 and 2012 (83% of operations in 1990, and 86% of operations in 2012), representing 92% of the statewide percentage of harvested area in both 1990 and 2012 (Table 3-14). The mean THO size of silviculturally-focused operations decreased from 103 acres in 1990, to 67 acres in 2012. The overall mean THO size in the sample in 2012 was 62 acres, compared to the mean operation size of 93 acres in 1990. Development was the primary objective for 9% of operations in the 1990 sample, while there were no operations with the goal of development in the 2012 sample.

Table 3-14. *Operation area and frequency and statewide percentage of harvested area by primary harvesting objective for timber harvesting operations in Vermont, 1990 and 2012.*

Primary Harvesting Objective	Percentage of Operations		Mean Size of Operation (acres)		Statewide Percentage of Harvested Area	
	2012	**1990**	**2012**	**1990**	**2012**	**1990**
Silviculture	86%	83%	67	103	92%	92%
Other/unknown	10%	8%	41	88	6%	7%
Agricultural conversion	4%	-	13	-	1%	-
Development	-	9%	-	7	-	1%
Total			**62**	**93**		

Silvicultural Treatments[44]

During both assessment periods, multiple silvicultural treatments were commonly employed on timber sales included in the samples. This fact creates particular challenges in summarizing data into a meaningful and understandable format. In order to provide a complete picture of the silvicultural treatments used, data are summarized in two different ways in Table 3-15 and Table 3-16.

Table 3-15 reports the data on single silvicultural treatments[45] used versus multiple methods.[46]

The use of multiple silvicultural treatments[46] declined between the 1990 assessment and 2012. 72% of all operations used multiple treatments in 1990 versus 62% in 2012 (Table 3-15). The mean size of operations employing multiple silvicultural treatments saw a substantial decrease between 1990 and 2012 as well, from 116 acres to 68 acres. Partial Cutting/thinning[41] and overstory removal/clearcut were the most commonly used single silvicultural treatments on operations sampled during the 2012 assessment (16% of operations each). This was nearly the same percentage as in 1990 for the Partial Cutting/Thinning treatment, but represented an increase for the overstory removal/clearcut treatment.

Table 3-15. *Operation area and frequency, and statewide percentage of harvested area by silvicultural treatment for timber harvesting operations that used a single silvicultural treatment, 1990 and 2012.*

Silvicultural Method (Single vs. Multiple Treatments)	**Percentage of Operations**		**Mean Size of Operation (acres)**		**Statewide Percentage of Harvested Area**	
	2012	**1990**	**2012**	**1990**	**2012**	**1990**
Multiple Silvicultural Treatments Employed	**62%**	**72%**	**68**	**116**	**67%**	**90%**
Partial cutting/thinning[19]	16%	15%	35	35	9%	6%
Overstory removal/clearcut[21]	16%	9%	73	15	19%	1%
Other	4%	-	13	-	1%	-
Shelterwood/seed tree/prep cut	2%	4%	120	68	5%	3%
Total	**100%**	**100%**	**62**	**93**	**100%**	**100%**

Table 3-16 reports data on the total acreage of each silvicultural method employed (THOs using single methods and multiple methods combined) statewide.

When single treatments and proportioned multiple treatments were combined (Table 3-16), the treatments most commonly employed during both periods were Partial Cutting/Thinning and group selection. While selection/thinning was the most common technique employed across operations in both assessments, it was used less frequently during the later period (81% of operations in 1990 and 70% in 2012). Both the overstory removal/clearcut and group selection methods were more common during the 2012

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[44] The classification of the treatments employed reflects only the outcome of the treatment and not the intent. The descriptions and definitions of the treatments used are identical to those used in the 1990 Assessment to allow for comparisons.

[45] Single treatment refers to the use of a single silvicultural treatment on an entire timber harvesting operation.

[46] Multiple silvicultural treatments refers to the use of more than one treatment on the same timber harvest operation.

assessment than in 1990. Without knowledge of the objectives of the harvesting operations assessed, it is not possible to speculate on the reasons for these trends.

Table 3-16. *Operation size and frequency, and statewide percentage of harvested area by silvicultural treatment employed, singly or in combination, for timber harvesting operations in Vermont, 1990 and 2012.*

Silvicultural Treatment Singly or in Combination	Percentage of Operations		Mean Size of Operation (acres)		Mean Size of Area, per Operation, of Method (acres)[47]		Statewide Percentage of Harvested Area	
	2012	1990	2012	1990	2012	1990	2012	1990
Partial cutting/thinning	70%	81%	58	106	43	49	49%	42%
Group Selection	41%	36%	62	91	9	16	6%	6%
Overstory removal/clearcut	40%	23%	73	92	45	32	29%	8%
Shelterwood/seed tree/prep cut	32%	63%	80	125	33	65	17%	44%
Other	4%	-	13	-	13	-	1%	-
Strip cut	1%	1%	184	100	64	10	1%	<1%

Professional Involvement and Contracts

Professional forester[48] involvement in harvesting operations increased from the 1990 assessment, from 77% in 1990 to 86% in 2012 (Table 3-17). Foresters were most likely to be involved with the preparation of a written forest management plan in 2012, as compared to 1990 when foresters were most likely to be involved in conducting a general reconnaissance of the property.

Foresters were more commonly involved in all aspects of timber harvesting operations in the most recent assessment except when asked about “responsibility for sale close-out.” While the reduced involvement reported with respect to sale close-out activities may seem troubling on the surface, the change may well be due to differences in the way the question was asked during the two assessments. During the interviews for the 1990 assessment, the interviewee was asked if the forester was “involved in close-out supervision,” while during the 2012 assessment interviews the question was “who was responsible for the close-out of the sale?” This seemingly subtle difference is, in reality, quite significant. Many timber sale contracts used by foresters in Vermont have standard clauses that make the logging contractor responsible for implementation of the Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont. These practices constitute a majority of the close-out work required on most harvests. Therefore, while it would be common for a forester to be involved in layout

[47] Mean Size of Area per Operation, under method is calculated per operation where method was found at all. For instance, 45 acres overstory removal/clearcut (on average) only reflects those THOs where overstory removal/clearcutting occurred at all (i.e., 40% of THOs).

[48] The term “professional forester” was specifically used in the interviews of the person knowledgeable of the operation and was carried over from the 1990 Assessment to facilitate comparisons. A professional forester was defined as a person eligible for SAF membership at any level in both assessments.

and supervision of the installation of these practices, the ultimate responsibility is generally the logger's. As a result of the change in survey wording, a comparison of the data is not appropriate.

Table 3-17. *Operation area and frequency, and statewide percentage of statewide harvested area by professional forester involvement and type of involvement in timber harvesting operations in Vermont, 1990 and 2012.*

Professional Forester Involved	Type of Involvement	Percent of Total Operations		Mean Size of Operation (acres)		Statewide Percentage of Harvested Area	
		2012	**1990**	**2012**	**1990**	**2012**	**1990**
No	N/A	14%	23%	38	48	8%	12%
Yes	Written forest plan[49]	83%	56%	68	126	90%	76%
	Forester marking/designation	80%	71%	62	107	79%	82%
	Contract negotiations	74%	59%	74	120	88%	76%
	Responsible for skid trail layout	68%	51%	75	116	81%	64%
	Responsible for landing designation	60%	58%	69	120	67%	75%
	Total	**86%**	**77%**	**66**	**107**	**92%**	**88%**

Eighty-five percent of operations in 2012 had a written contract as compared to 71% of operations with a contract in 1990. Special contract provisions were included in contracts for both assessment years, but as noted earlier in this chapter, standard timber sale contracts have become significantly more complex and inclusive in the 22 years between assessments. Many provisions that are included in standard contracts today were considered special provisions or perhaps not even considered in 1990. Asking interviewees about "special conditions" included in contracts in 2012 may have introduced an unexpected bias against provisions that respondents considered to be "standard" and is therefore, not included in the comparison of results.

Operation Size[43]

Operational characteristics related to the size of THOs were subdivided into the northern region of Vermont and the southern region[50] of Vermont, in order to assess any regional characteristics that might exist.

The mean size of operation in both regions was smaller during the 2012 assessment (Table 3-18). While timber harvests in the northern region were larger than those in the southern region during both the 1990 and 2012 assessments, the difference between the two regions was less pronounced in 2012, with a larger percentage reduction in the north between 1990 and 2012.

[49] Seventy-one owners reported having forest management plans, but only sixty-seven of those had a forester involved with the harvest.

[50] The southern region includes Addison, Bennington, Chittenden, Rutland, Windham, and Windsor counties, while the northern region includes Caledonia, Essex, Franklin/Grand Isle, Lamoille, Orange, Orleans, and Washington counties.

Table 3-18. *Operation area by FIA geographic region and frequency for timber harvesting operations in Vermont, 1990 and 2012.*

Count of Operations		Mean Size of Operation (acres) North		Mean Size of Operation (acres) South		Statewide Mean Operation Area (acres)	
2012	**1990**	**2012**	**1990**	**2012**	**1990**	**2012**	**1990**
81	79	84	137	42	53	62	93

Landings

In 1990 and 2012, the number of landings on any given timber harvesting operation was correlated with the acreage of the operation, for operations with up to four landings (Table 3-19).

Table 3-19. *Operation area and frequency by number of log landings per timber harvesting operation in Vermont, 1990 and 2012.*

Number of Landings	Percentage of Operations		Mean Size of Operation (acres)[51]	
	2012	**1990**	**2012**	**1990**
1	68%	53%	44	47
2	23%	29%	75	83
3	6%	18%	104	244
4	1%	-	481	-
7	1%	-	350	-
Total[52]	**100%**	**100%**	**65**	**-**

The majority of timber harvesting operations evaluated in both years had only one landing (68% of operations in 2012 and 53% of operations in 1990). The mean size of the evaluated landings increased from 1990 to 2012. THOs evaluated in 2012 had landings with a mean size of 0.5 acres with a range of 0.1 to 2.0 acres. THOs evaluated in 1990 had a mean landing size of 0.3 acres and a range of 0.1 to 1.4 acres. Increased numbers of sales producing multiple products (roundwood and chips) and the need for additional space to sort those products on a landing appear to contribute to the increased landing size.

Landings were not evaluated on all harvesting sites in 2012 due to a number of conditions that made it impossible to identify the location and/or extent of the actual landing site. Landing areas on agricultural land that were subsequently replanted to corn or hay, and landings that had become home sites were included in this category.

[51] The mean size of an individual log landing in 2012 was 0.5 acres with a range of 0.1 to 2 acres. In 1990, the mean size of a landing was 0.3 acres with a range of 0.1 to 1.4 acres.

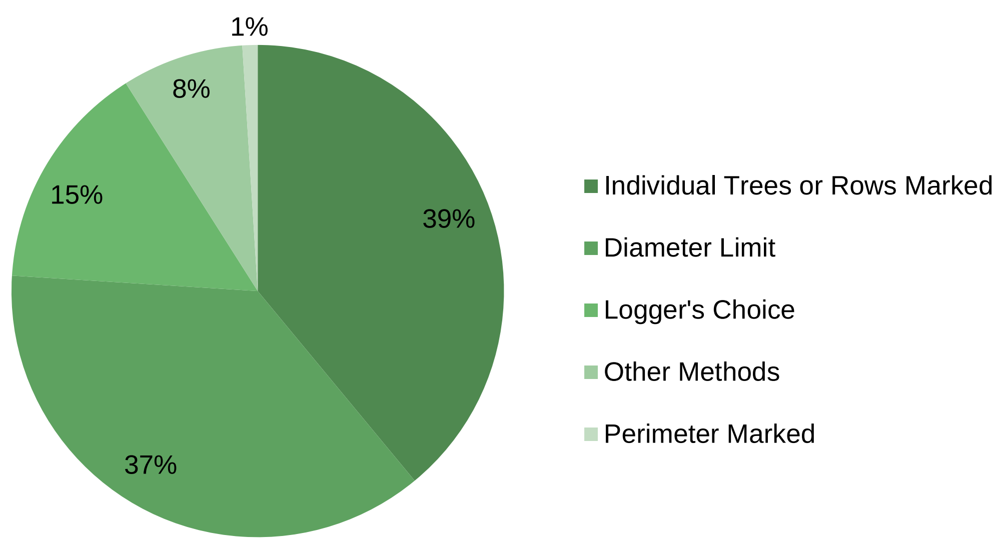
[52] Landings were not evaluated on all harvesting sites due to a number of conditions that made it impossible to identify the actual landing site. Included in this category were landing areas on agricultural land that were replanted to corn or hay, and landings that had become home sites.

Designation of Trees for Harvest

The process of designating trees for removal was carried out in a number of different ways during both assessment periods. Due to differences in the way the interview question was asked and data were recorded, a direct comparison is not possible, but it is possible to make some general statements related to changes observed between the two assessments.[53]

When presented with a list of designation methods,[54] interview respondents indicated that forester marking was the most common method for designating trees for removal in 1990 (Figure 3-7), but was even more extensively used for timber harvests included in the 2012 sample (Figure 3-8). Survey responses also indicated that "logger's choice" sales were much less common during the 2012 assessment than in the previous assessment. Perhaps the most noticeable finding is the reduction in of the use of the diameter limit technique of designation. Diameter limit designation was used in only 1% of the operations observed and accounted for only 1% of the statewide harvested area during the most recent assessment according to individuals surveyed.

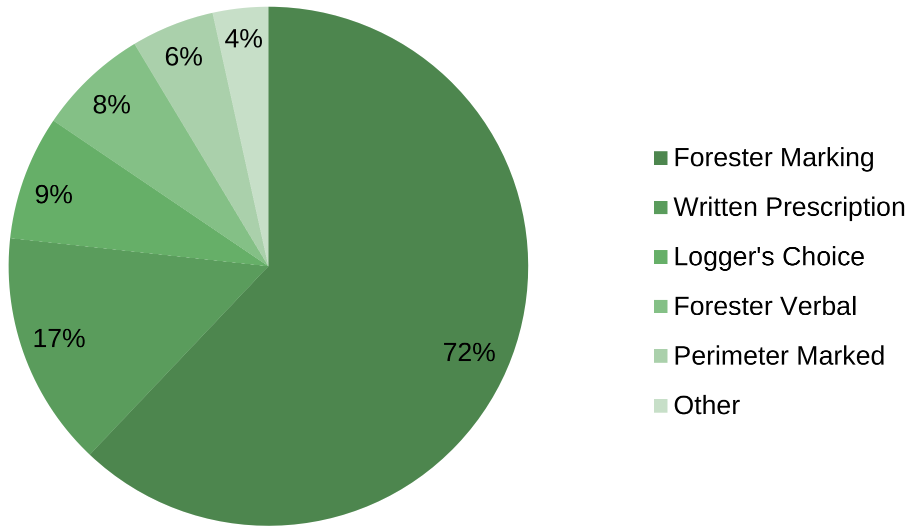
Figure 3-7. Percentage of the statewide harvested area by primary method of designating trees for harvest, 1990.



[53] These data cannot be directly compared to the previous assessment because the 1990 assessment asked for the "primary" method of designation and the 2011 assessment simply asked how trees were designated for removal and allowed for more than one method to be reported.

[54] See Data Collection Procedures in Appendix D.

Figure 3-8. Percentage of the statewide harvested area by method used to designate trees for harvest: singly or in combination, 2012.



Felling and Skidding Methods

Some of the most significant changes seen in timber harvesting since the 1990 assessment are made clear by the comparison of the commonly used log transport equipment. The fact that we must expand our view from “skidding equipment” to “log transport equipment” helps to point out the increased options available today for moving wood from the stump to a landing.

The most commonly used piece of equipment was a rubber-tired skidder in both 1990 and 2012 (Table 3-20). Skidder type was specified in the interview in 2012, but not in 1990. In 2012, cable skidders were used on 59% of operations, while grapple skidders were used on 47% of operations. Tracked skidders (included in the definition of “tractor” in the 2012 assessment) have fallen out of use and, while horse logging is still practiced in Vermont, no commercial sales included in the 2012 sample used this technique. The use of forwarders was not noted in the report of the 1990 assessment, but in 2012 they were used on 11% of sales sampled.

The shift in the form in which trees are transported to the landing is illustrated in Table 3-21 and provides a striking insight into the changes in timber harvesting since 1990. The earlier assessment found that 10% of operations used whole-tree skidding, entirely or in part, and the use of feller-bunchers to harvest trees was not even mentioned. However, by 2012, 41% of the operations sampled were using at least some whole-tree skidding and 34% used a feller-buncher exclusively to harvest trees.

Table 3-20. *Operation area and frequency by type of log transportation equipment used (singly or in combination) on timber harvesting operations in Vermont, 1990 and 2012.*

Log Transportation Equipment used (singly or in combination)	Percent of Operations		Mean Size of Operation (acres)	
	2012	**1990**	**2012**	**1990**
Cable Skidder	59%	92%	56	100
Grapple Skidder[55]	47%	-	85	-
Forwarder	11%	-	51	-
Tractor	2%	-	96	-
Other	4%	5%	49	145
Tracked Skidder	-	24%	-	83
Horse	-	3%	-	11

Table 3-21. *Operation area and frequency, and statewide percentage of harvested area by tree form during log transportation to the landing for timber harvesting operations in Vermont, 1990 and 2012.*

Tree Form During Transportation to Landing	Percent of Operations		Mean Size of Operation (acres)		Statewide Percent of Harvested Area	
	2012	**1990**	**2012**	**1990**	**2012**	**1990**
Log-length	27%	12%	32	63	14%	8%
Tree-length (without branches)	27%	46%	63	90	27%	45%
Tree-length (without branches), Log-length	4%	29%	33	30	2%	9%
Total operations using Log-/Tree-Length methods <u>ONLY</u>	**58%**	**87%**				
Whole-tree (with branches)	37%	6%	75	243	44%	16%
Whole-tree (with branches), Log-length	2%	-	225	-	8%	-
Whole-tree (with branches), Tree-length (without branches)	2%	3%	88	708	3%	20%
Whole-tree (with branches), Tree-length (without branches), Log-length	-	1%	-	10	-	<1%
Total operations using at least some Whole-tree methods	**41%**	**10%**				
Unknown	-	3%	-	55	-	2%
Total	**100%**[56]	**100%**	**62**	**93**	**100%**	**100%**

Tree-length skidding typically involves transport of the entire stem of the tree in one piece, less the branches and top. Log-length "skidding" involves skidding shorter sections of tree stem, often cut into log lengths. Log-length skidding techniques are typical of operations using smaller equipment (tractors or bulldozers) or forwarders. An analysis of the equipment used on operations that reported log-length skidding indicates that the term may have been misinterpreted by some individuals being interviewed, and the amount of log-length skidding may be overestimated. It is clear that, while in

[55] Skidder type was specified in the interview in 2012, but not in 1990.

[56] The column does not total 100% due to errors in rounding to whole numbers.

combination, log- and tree-length “skidding” techniques were used on the majority of operations (Table 3-21), the trend toward increased mechanization is clear.

Forest Products Produced

The interview questions asked, and the data collected, on the production of forest products on operations sampled during the 2012 and 1990 assessments differed significantly and, as a result, detailed comparisons are not possible. Both assessments found that the majority of operations produced multiple products, which could range from sawlogs and veneer logs to pulpwood, firewood, whole-tree chips, and any number of combinations thereof, further complicating any analysis. It is, however, possible to make some general observations.

The most common product harvested from timber sales sampled during both assessments was roundwood (including logs, pulp, and firewood). Roundwood products were harvested from 96% of operations assessed in 2012. This finding is consistent with Vermont’s Forest Product Harvest Summary for 2010 (De Geus 2011) which indicates that over 75% of the total harvest of forest products was roundwood. The 1990 assessment reported that 95% of operations produced sawtimber, 70% produced pulpwood, and 72% produced firewood.

Of the THOs sampled during the 1990 assessment, 13% of operations produced at least some whole-tree chips and the mean operation size for those operations producing chips was 284 acres. The 2012 assessment found that whole-tree chips were produced on 37% of operations. The mean size of operations that produced a combination of chips and roundwood was 83 acres, while those operations producing only chips (4% of operations) averaged 8 acres.

CONCLUSIONS

The assessment data indicate that the average timber harvest in Vermont was smaller in size (acres) and, statewide, fewer acres were harvested during the 2012 assessment period than was estimated from the 1990 assessment.

Data from the Vermont Forest Resource Harvest Summary document the fact that the total forest product harvest in Vermont, on a volume basis, reached a peak in 1995 and declined at a relatively steady pace through 2010, supporting the reduced level of harvesting suggested by this assessment. Participation in the Use Value Appraisal program has increased substantially between the two assessments contributing to increased professional influence over and positive changes in forest management in Vermont.

> Seventy-six percent of the statewide harvested area represented by the 2012 Harvesting Assessment sample was enrolled in the UVA program. The increase in the proportion of UVA-enrolled lands has several positive implications for the state of forest management in Vermont. To be eligible to enroll, landowners must have a professional forester prepare a forest management plan, which in turn must be approved by VT FPR using standards developed and adopted for the program.

The 2012 assessment indicates that landowners, in the vast majority of cases, engage a professional forester to help them implement the harvests called for in that plan. These harvests are subject to regulatory oversight to ensure compliance with silvicultural and operational standards adopted for the program.

The UVA program's goal of increasing the equity of tax treatment for working lands may be, in part, responsible for the reduction in the number of operations reporting that the primary goal of the harvest was development (9% of operations in 1990, but none in 2012).

More sampled timber harvesting operations were conducted with the involvement of a forester in 2012 than in 1990.

Across nearly all aspects of harvesting operations where foresters are commonly consulted, including the preparation of forest management plans, negotiating timber sale contracts, and the designation of skid trail and landing locations, professional involvement has increased. Enrollment in the UVA program is likely to be the reason for the initial involvement of professional foresters in many instances, but this trend is also likely a reflection of an increasing level of acceptance of professional advice by private landowners in matters related to managing forest land for an ever-growing variety of goals and objectives.

One particularly positive set of statistics relate to the way trees are being designated for harvest. Foresters were much more likely to have marked the trees for removal and "logger's choice" sales were much less common than in 1990.

The increase in the percentage of timber harvesting operations conducted using written contracts, prepared with forester involvement, between the two assessments suggests an increase in professional involvement, but the specific content of those contracts remains unclear.

Anecdotal evidence suggests that, while timber sale contracts and in-woods practices have clearly become more sophisticated and increasingly sensitive to multiple resource values, the 2012 assessment's methodology made it impossible to accurately determine which values were specifically addressed in those contracts.

There is a clear trend to increasing mechanization of timber harvesting operations in Vermont.

While over half of the operations assessed used at least some hand felling and cable skidders were used on nearly 60% of the operations, this assessment clearly documents a significant increase in the use of mechanical harvesting equipment and whole-tree harvesting over the last 20 years. Increasing the use of complex machinery has allowed contractors to increase productive capacity, while reducing manpower needs and increasing worker safety.

Mechanical harvesting has already begun to transition from the use of fixed-head feller-bunchers and grapple skidders to cut-to-length harvesters and forwarders to further automate operations and improve efficiency. Mechanical harvesting was not even mentioned in the report of the 1990 assessment.

The increase in mechanical harvesting may reflect a move on the part of harvesting contractors to reduce crew size, as well as a shortage of workers willing or able to hand-fell timber.

Use of whole-tree skidding is linked to the use of mechanical feller-bunchers and has become much more common.

Log- and tree-length “skidding” techniques were used on the majority of operations, but operations utilizing at least some whole-tree skidding were, on average, larger and accounted for more than half of the statewide percentage of the harvested acres.

Additional results related to the use of tree-length vs. whole-tree skidding are found in subsequent chapters of this report.

Whole-tree harvesting does not always result in the production of whole-tree chips.

While whole-tree harvests often result in the production of whole-tree chips used for fuel, the 2012 assessment clearly shows that not all harvests producing whole-tree chips use mechanical harvesters, and not all whole-tree harvests produce chips. While 34 operations (42% of THOs) assessed used at least some whole-tree skidding, only 30 operations (37% of THOs) actually produced chips. On those jobs not producing chips, tops were removed at the landing and returned to and deposited on the sale area.

RECOMMENDATIONS

Continue to conduct periodic assessments of timber harvesting activity on a ten-year cycle.

Conducting a voluntary census of operations by contacting landowners, loggers, and foresters individually is clearly inefficient, time consuming and would likely miss operations. Alternate methods of identifying timber harvesting operations should be explored.

Monitoring the positive and negative effects of timber harvests should be incorporated into the forest health monitoring efforts carried out by the Department of Forests, Parks and Recreation and the University of Vermont. Future monitoring efforts related to timber harvesting should consider not only assessments such as those conducted in 1990 and 2012, but should also incorporate studies to compare pre- and post-harvest site conditions.

Monitoring of harvested, as well as unharvested, control sites could allow for an evaluation of any long-term changes to forest health.

A timbersale contract fact sheet should be prepared and distributed to foresters for use with landowners, suggesting possible contract conditions and language designed to help better manage potential negative impacts to a variety of forest attributes such as aesthetics, archaeologic and historic sites, water quality, and wildlife habitat.

CHAPTER 4: AESTHETIC VALUES

INTRODUCTION

The aesthetic assessment was designed to measure the visual impacts of the timber harvest operations (THOs). The assessment also compares the results with the 1990 Impact Assessment of Timber Harvesting Activity in Vermont, and notes some positive changes. Each THO was assessed from the point of view of a typical observer, e.g., a driver on a public road or hiker on a trail. As in the 1990 assessment, specific attributes of timber harvesting were selected based on research conducted concerning public perceptions of timber harvesting activities, as well as general landscape characteristics affecting visibility, such as distance and duration of view. It should be noted that negative public perceptions do not necessarily indicate poor forestry practices.

SURVEY DESIGN

Considerable research concerning public perceptions of the visual impacts of forest management activities has been conducted in the US since the 1960s and 70s. Since perceptions of timber harvesting may vary somewhat by region, many of the research papers noted below focus on the New England landscape.

Several results have been documented consistently in studies of aesthetic perceptions of forests and timber harvesting:

- Patch cuts producing large openings generally receive negative scenic ratings (Ribe 2009).
- Basal area per acre is positively related to scenic value, especially when overstocked trees are thinned to allow more space between trees; thinning to create lower densities has a positive visual effect (Ribe 2009, Ribe 1990, Brush 1979, Hull and Buhyoff 1986).
- The presence or dominance of large trees (>15”) is positively related to aesthetic preference in forests generally (Ribe 2009, Ribe 1989, Brown and Daniel 1986, Brush 1979).
- Dense stands of saplings are viewed negatively from an aesthetic perspective. Where saplings (1-5” diameter breast height [dbh]) are mixed with larger trees, a higher number of stems per acre is more tolerable (Ribe 2009, Ribe 1990, Hoffman and Palmer 1996, Hull and Buhyoff 1986, Brush 1979, Patey and Evans 1979).
- The retention of downed wood is generally viewed negatively from an aesthetic perspective, especially if greater than 3’ in height. However, public education about benefits for habitat and soil retention results in more positive perceptions (Ribe 2009, Ribe 1990, Schroeder et al. 1993, Vodak et al. 1985, Benson and Ullrich 1981).

- Snag retention or creation in harvests is often viewed negatively in perceptions of scenic beauty, but can appear more favorably when viewers are informed about environmental benefits (Ribe 2009).

The research results noted above formed the basis of the 1990 assessment and were similarly incorporated into the current assessment. Measures of other visual attributes known to affect visual perceptions of changes in the landscape, were also replicated, with the survey addressing the following questions:

- To what extent are harvesting operations visible from important public and quasi-public outdoor use areas?
- To what extent do these operations occur in close proximity to important public viewing areas?
- To what extent are the cuts seen at a distance?
- How significant are the positive and negative visual impacts of harvesting operations?
- What specific attributes of the timber harvesting cause positive, negative, or no visual impacts?

While most timber harvesting operations have an impact on at least one person somewhere, this assessment sought to identify the extent to which timber harvesting produced significant visual impacts on the public in general. For the purposes of this assessment, a harvesting operation was evaluated for visual impacts only if it was visible from a public or quasi-public outdoor area. The outdoor area must receive considerable public use (more than a few people) and have recreational or scenic values. These areas were defined as paved public roadways, public recreation areas (such as parks and downhill ski areas), designated trails (hiking, bicycle, equestrian, and cross-country ski trails), streams (with watersheds greater than 10 square miles), lakes and ponds (greater than 25 acres in size), designated natural areas, and designated scenic areas. Unpaved roads were not included as viewpoints in order to simplify data collection and because they do not carry the volumes of regional traffic that paved public roadways do. Smaller ponds and streams were not included for the same reasons.

If the timber harvesting operation was visible from one of the areas noted above (including Partial Cutting/Thinning treatments that were only visible to the trained eye) a potential aesthetic impact was assumed and detailed data were collected. The collected data provided the basis for the evaluation of the nature and severity of the impact. In some cases, the operation was seen from two or more locations, or in several locations along a view corridor such as a road or trail. In these cases, views were evaluated at several points along the view corridor, and the overall evaluation of impacts was based upon only those points of greatest impact. For each evaluation point, both the length of the view corridor and the area of the harvest that was visible were recorded. For each viewing location, photographs were taken of the associated harvesting operation.

For operations that could be seen in the foreground (within 0.5 miles), information was collected concerning the following, where visible: (1) the visual characteristics of the exposed harvest area (size of openings, edge transition, edge configuration, horizon line, stumps, slash and debris, and exposed earth); (2) the residual stand (size, health, and spacing of trees); (3) forest roads and landing areas (size, alignment, cut and fill slopes, and public access); and (4) any related wetlands (buffer, slash, and access). A total of 17 attributes were evaluated on a scale of 1 to 3, where 1) minimal (change would not be evident to the average person); 2) moderate (change is evident but not dominant); or 3) severe (changes are very noticeable and dominate the view). In addition, contributing elements were evaluated, such as the opening up of new views that could be noted as either positive (enhancing) or negative (detracting). Data collectors also noted whether any new public access resulted from the operation.

If the view of the operation was not in the foreground (0.5 mile) of the operation, it was evaluated as a middleground view (0.5 to 4 miles away) or a background view (> 5 miles away). Details of the harvest, such as slash and exposed earth, become less significant as distance from the viewer increases, while the characteristics of size and shape of the cut and its contrast or conformance with surrounding land use patterns become more significant. Edge transition and the treatment of the horizon line (ridge) were also important considerations.

The team of two to three field investigators present on each THO provided an overall evaluation of the aesthetic impacts for each viewpoint from the perceived viewpoint of the general public, using the general rating system found in Table 4-1. The system ranked the overall operation as improving the view, little visual change (imperceptible to the average person), moderate visual impact (visible evidence that logging occurred), or a severe visual impact (lingering effects of the timber harvest operation dominate views and are highly noticeable to passersby).

Table 4-1. *Overall Visual Rating*

1 - Improves View
2 - Little Visual Change
3 - Moderate Visual Impact
4 - Severe Visual Impact

Field investigators were also asked to rank each viewpoint according to the USDA Forest Service's system for visual management objectives (Table 4-2) as follows:[57]

[57] In 1974 the USDA Forest Service published National Forest Management Volume 1 and the Visual Management System (Volume 2, Chapter 1), which provided a systematic methodology for evaluating scenic quality and visual impacts. This was updated in 1995 as The Scenery Management System (Landscape Aesthetics, A Handbook for Scenery Management, Handbook #701).

Table 4-2. *USFS Visual Impact Ranking System*

Enhancement	Operation results in improvements to the visual quality of the landscape by adding diversity (e.g., adding plantings or opening up positive views).
Preservation	Operation represents no discernible change to the forest landscape from viewing areas.
Retention	Operation is barely discernible to an observer and would have very short-term impacts.
Partial Retention	Harvesting activities that are visually subordinate to the surrounding landscape (i.e., appear as a very small part of the total view) and appear to fit reasonably well into the landscape (i.e., shape, size, and edge of cuts are not highly noticeable). Duration of impacts will be short (one to two years) beyond observation.
Modification	Operation may be visually dominant (i.e., quite noticeable), but the cut does not strongly contrast with the surrounding landscape (e.g., moderate size openings that do not break the horizon line with natural edge transition).
Maximum Modification	Operation is visually dominant, large openings, but avoids negative features such as abrupt edge with bare tree trunks, distinct horizon line cut, or poor quality trees dominating open areas.
Unacceptable Modification	Operation results in a view that is highly obtrusive and unsightly with strong contrasts with the surrounding landscape.

RESULTS AND ANALYSIS

The design of the survey allowed the particular visual attributes of each THO to be examined individually or in combination. Photographs taken from each vantage point provided further information about the particular visual characteristics of each THO and how a combination of factors might affect its aesthetic condition.

Overall impact ratings were determined using two steps. First, impact ratings assigned by field data collectors for 17 characteristics (minimal, moderate, or severe) were tabulated (Table 4-3). Significant aesthetic impacts are unlikely to result from any single problematic attribute, but rather from a combination of characteristics. As in the 1990 assessment, an overall rating was determined for each viewpoint based on the total number of occurrences of a minimal, moderate, or severe rating. Viewpoints with four or more severe ratings were rated as having severe impacts. Those with three highly rated visual characteristics were given an overall moderate to severe rating, and those in which one or two characteristics had a high impact were assigned an overall moderate rating. Viewpoints with only moderate to low ratings on all factors were rated as having minimal impacts.

Table 4-3. *Number of occurrences of contributing factors to visual impacts rated as severe for timber harvesting operations in Vermont, 2012. Each THO was rated minimal, moderate, or severe for each attribute (if visible).*

	Criteria for Severe Impact Rating	# Severe
Harvesting Characteristics	Large Openings (> 3 acres) that are noticeable or dominate views	1
	Abrupt Edges with wall of trees and dead branches visible	3
	Straight Edge along Cut Line	5
	Horizon Line Cut with Few Trees Remaining	0
	Numerous Stumps over 1’ visible; very noticeable	0
	Slash high, common; large piles; hanging or large downed trunks and limbs common	1
	Exposed earth very visible	0
Residual Stand	Clearcut with only occasional trees remaining	4
	Residual stand primarily saplings with few larger trees	3
	Wounded, dead or dying trees remain and are common	0
Roads and Landings	Large Areas of Exposed Earth; evidence of Erosion	0
	Roads wider than 18’	0
	Long, straight roads designed against contours	0
	Large areas of wood chip and debris remain preventing plant growth	0
Wet-lands/ Streams	Slash left in and adjacent to wetlands/streams	0
	No buffer	0
	Total Attributes Rated Severe	**17**

This preliminary impact rating was then refined based on several factors, as follows:

- <u>Improving or Degrading Distant or Foreground Views</u>: In some cases timber harvesting operations opened up distant views or provided new foreground views that were rated as either improving the view, no change, or degrading the view. Adding a new distant view could add 1-2 positive points depending on the extent, anticipated duration, and scenic quality of the distant view.
- <u>Size or Area of Timber Harvest Operation Visible</u>: In many cases vegetation remained between the THO and the viewing location, or the THO faced away from the viewer on downward slopes, making the operation less visible.
- <u>Characteristics of the Viewing Area</u>: The distance away from the THO and the duration of view may affect visual impacts. Viewpoints in close proximity (e.g, on-site or adjacent) enable details to be perceived such as slash, stumps, or exposed earth. In some cases the THO may be visible repeatedly or over a large area or long distance. Duration of view can also be a factor of the mode of travel such as driving vs. hiking.

General Findings

Of the 81 operations surveyed, 80% (65 operations), were not visible from a public or quasi-public outdoor area. Approximately 20% (16 operations), were visible from a public vantage point.[58] In the 1990 Assessment a much higher percentage of THOs were visible from public areas (46 out of a total 78, or 60%). In the 2012 Assessment some THOs were viewed from more than one location and a total of 22 vantage points were evaluated. These vantage points included interstate, state, and local paved highways; a lake; a state park entry road; a US Forest Service Recreation Area; a mountain biking/hiking trail; and a back-country ski trail. Viewing distances varied, although most viewpoints (82%) were within the foreground (within 0.5 mile). 81% of the visible THOs were on private land. The distribution of both viewing distance and public/private ownership were similar to the 1990 Assessment (Table 4-4, Table 4-5, Table 4-6). Note that some tables examine the visible harvests within the context of all surveyed THOs, while others compare only those harvests or viewpoints in relation to the total that were visible.

Table 4-4. *Number and percentage of viewpoints by distance from observer and visual impact for timber harvesting operations in Vermont, 2012. Percentages based on individual viewpoints (22).*

	Improved	Minimal	Minimal-Moderate	Moderate	Moderate-Severe	Severe	Total
On Site	1	1		0		0	2
Adjacent	1	2	1	3	0	0	7
Foreground (< 0.5 mile)		2	1	7	0	0	9
Middleground (0.5 - 4 miles)		1		0	0	0	1
Background (> 4 miles)		1		1	0	0	2
Combined Assessment	**2 (9%)**	**7 (32%)**	**2 (9%)**	**11 (50%)**	**0**	**0**	**22**

Table 4-5. *Distribution of visual impact by ownership type for 81 timber harvesting operations in Vermont, 2012. Percentages based on total number of THOs (81).*

	Not Visible*	Improved	Minimal	Minimal-Moderate	Moderate	Moderate-Severe	Severe	Total
Public	-	0	1	1	1	0	0	3 (4%)
Private	-	0	8	1	4	0	0	13 (16%)
Total	**65**	**0**	**9**	**2**	**5**	**0**	**0**	**81(100%)**
% Total THOs	80%	0%	11%	3%	6%	0%	0%	

*Includes Agricultural Conversions that may have been visible but were not analyzed.

[58] Of the 81 timber harvests inventoried, three (3) were agricultural conversions. One of these was visible from a public road but was eliminated from the aesthetics analysis because no forest remained and the land use had changed to agriculture. Thus, although 17 THOs were visible, the analysis in this report focuses on the 16 that remained in forest use.

Table 4-6. *Distribution of visual impact by ownership type for 16 timber harvesting operations visible from a public outdoor area in Vermont, 2012. Percentages based on visible THOs only (16).*

	Improved	Minimal	Minimal-Moderate	Moderate	Moderate-Severe	Severe	Total
Public	0	1	1	1	0	0	3 (17%)
Private	0	8	1	4	0	0	13 (81%)
Total	**0**	**9 (56%)**	**2 (13%)**	**5 (31%)**	**0**	**0**	**16 (100%)**

Impact Ratings

The majority of visible harvesting operations (69%) were rated as having “minimal” or “minimal to moderate” impacts. Minimal visual impacts were those for which there were no noticeable openings, stumps were difficult to see, and slash was non-existent or consistent with natural decay. Evidence of change would be nearly imperceptible to the average person. In some instances these were classified as partial cutting/thinning treatments on hillsides seen at a distance but with no discernible openings. For others, only an access road was visible that had been largely re-vegetated. Table 4-7 shows that even some of the more heavily cut operations resulted in minimal visual impacts, largely due to the limited visibility of the cut itself. A large overstory removal/clearcut treatment for example, was located primarily along a downward slope facing away from the viewer or hidden by intervening vegetation.

Table 4-7. *Distribution of visual impacts by predominant silvicultural method for 16 timber harvesting operations visible from a public outdoor area in Vermont, 2012. Percentages based on visible THOs only.*

	Minimal	Minimal - Moderate	Moderate	Moderate-Severe	Severe	Total
Partial cutting/thinning	5 (31%)	1 (6%)	2 (13%)	0	0	8 (50%)
Shelterwood/seed tree/prep cut	3 (19%)	1 (6%)	0	0	0	4 (25%)
Overstory removal/clearcut	1 (6%)		3 (19%)	0	0	4 (25%)
Total	**9 (56%)**	**2 (13%)**	**5 (31%)**	**0**	**0**	**16**

Operations rated as “minimal to moderate” were those in which some evidence of timber harvesting was present but it was relatively modest. On one of these operations, tall maple trees at the edge of the log landing were noticeable due to their tall, unbranched trunks, a contrast with the full branching typically observed along naturally occurring woods edges. Patches of bark chips also provided evidence of an earlier landing area (Figure 4-1).

There were two viewpoints observed with an enhanced condition where distant views were revealed by timber harvesting (Figure 4-2). While the viewpoints themselves gained an “improved” rating, the overall visual impacts of the operation were rated as moderate due to other factors associated with the harvest operation. The percentage of positive visual impacts was comparable to the 1990 assessment.

Figure 4-1. This operation was rated as "minimal to moderate" due to the evident clearing and remaining tall, unbranched trees and wood chips. This landing is small with good herbaceous vegetative growth.

Figure 4-2. The operations below revealed views of distant hills or mountains.

“Moderate” visual impacts were those in which the timber harvesting operation was readily discernible, but in which there was at most one attribute rated as “severe.” Just under one third (31%) of the visible THOs were rated as having moderate visual impacts (this is equivalent to 6% of the total evaluated THOs). The attributes contributing to this rating varied widely. Several were classified as shelterwood/seed tree/prep cuts but were separated from the vantage point (often a road) by vegetation. The harvest was evident with the forest beyond appearing noticeably more open, and with a distinct change in light and texture. In most cases, these were along paved roads where drivers are likely to pass quickly. One THO was rated as moderate due to the presence of slash that was common, well over 3’ high, and often hanging from shrubs or branches of trees (Figure 4-3). Another identified negative attribute resulted from unattractive trees remaining on a site. An example of one such operation involved a clearcut that extended up to a narrow band of pines near the roadside (Figure 4-3). These were tall, heavily overstocked, red pine trees with bare, unbranched boles reaching up to limited crowns lining the roadside. The daylight visible through the trees drew the attention of passing motorists to this ungainly row, creating a noticeable visual impact. Figure 4-4 provides another example of an operation where poorly formed and broken trees resulted in a negative visual impact.

Figure 4-3. The operation below left was rated as a moderate impact due to abundant slash left near a ski trail. The photo below right shows a thin row of tall pines left between a clear cut and the roadside. The pines help screen the clear cut, but are noticeably ungainly due to their close proximity and lack of branching.

One THO had sufficient negative attributes to receive a rating of “moderate to severe” visual impacts. However, the operation also revealed scenic views of mountains in the middleground to background (Figure 4-4) resulting in a positive visual impact. Harvesting techniques identified for this operation were 50% overstory removal/clear-cut, and 50% shelterwood/seed tree/prep cut. The operation would likely also be visible to a nearby ski area, although this was not inventoried as a vantage point due to poor visibility on the day the site was assessed. The high visibility of this heavily cut area from several points along a public road, and straight-edged and abrupt transitions along the cut lines contributed to the negative ratings. Exposed earth and debris were also visible. Some remaining larger trees detracted from views, as many were poorly formed and ungainly, some with missing tops, leaning, and/or with limited branching or crowns. While there is certainly value in leaving dead and dying trees for wildlife purposes, the trees left in this case did not serve this purpose. Several factors, however, ameliorated the impacts of this operation in addition to the distant views provided to passersby: a narrow vegetative screen was left along portions of the roadside, and much of the operation was located on slopes facing away from the road (viewer) so that only the front edge of the operation was visible. There is a snowmobile trail through the logging operation, but this was assumed to be the case before the operation was undertaken.

Figure 4-4. Two views of a THO identified as a combination of overstory removal/clearcut and shelterwood/seed tree/prep cut. Its high visibility and the poorly formed and broken remaining trees in the foreground would have resulted in a moderate to severe rating, but the distant views revealed by the cut added positive points, giving it a moderate rating overall.

In comparison with the 1990 assessment, none of the timber harvesting operations were rated as having moderate-to-severe or severe aesthetic impacts. The severe impact ratings in the earlier assessment were the result of heavy cutting along visible hillsides, including along ridge tops, leaving a noticeably thinned ridgeline. This condition was not observed in the current assessment and may have been at least in part due to the Heavy Cutting Law passed in 1997 after the previous assessment. Although not confirmed, the kinds of visual impacts observed in the 1990 assessment may have influenced the enactment of this law. Some of the timber harvesting operations surveyed in 2012 could have created severe visual impacts had they been visible from important public vantage points.

Other Results

There was a slight relationship observed between the use of the overstory removal/clear cut treatment and visual impacts demonstrated in the assessment (Table 4-7). Three of the five operations rated as "moderate" involved overstory removal/clearcutting methods. A fourth operation was classified primarily as a partial cutting/thinning treatment, but a small portion of the total operation (approximately 2.5 acres) was a patch clear cut that was visible at several locations from a nearby trail. By contrast, another overstory removal/clearcut treatment was largely invisible from a public viewing area due to its location on a hillside sloping away from the viewer.

Foresters were involved in 69% of the visible THOs surveyed.[59] Logging operations in which a forester participated were far less likely to result in visual impacts. Foresters were involved with nearly all operations with minimal visual impacts. Four out of five (80%) of the operations with moderate visual impacts did not have a professional

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[59] Forester involvement was documented during the interview of the person knowledgeable of the operation. The individual was asked if a "professional forester" was involved with the operation.

forester involved (Table 4-8).

Table 4-8. *Distribution of visual impacts by forester involvement for 16 timber harvesting operations visible from a public outdoor area in Vermont, 2012. Percentages based on visible THOs only.*

	Minimal	Minimal - Moderate	Moderate	Moderate-Severe	Severe	Total
Forester	8 (50%)	2 (13%)	1 (6%)	0	0	11 (69%)
No Forester	1 (6%)	0 (0%)	4 (25%)	0	0	5 (31%)
Total	**9 (56%)**	**2 (13%)**	**5 (31%)**	**0**	**0**	**16 (100%)**

In the 1990 assessment a greater number of operations rated moderate to severe were located in northern Vermont. This distribution was not distinctive with respect to aesthetic impacts in the current assessment (Table 4-9). Also, compared to the 1990 assessment, no new public access was associated with THOs. On the other hand, overall public access to public and private lands in Vermont has increased in the 22 years since the last assessment, and in some cases new trails provided access to views of the timber harvesting operations reviewed in the assessment.

Table 4-9. *Distribution of visual impacts by region for 16 timber harvesting operations visible from a public outdoor area in Vermont, 2012. Percentages based on visible THOs only.*

	Minimal	Minimal - Moderate	Moderate	Moderate-Severe	Severe	Total
North	4 (25%)	1 (6.5%)	2 (12%)	0	0	7 (44%)
South	5 (31%)	1 (6.5%)	3 (19%)	0	0	9 (56%)
Total	**9 (56%)**	**2 (13.0%)**	**5 (31%)**	**0**	**0**	**16 (100%)**

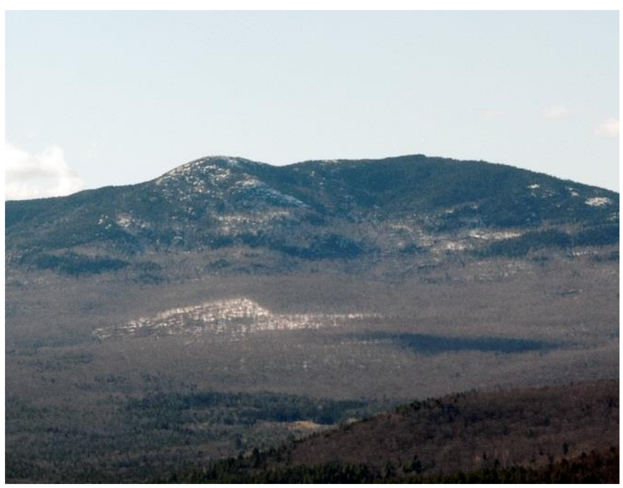
Harvesting Attributes Contributing to Visual Impacts

A few of the specific harvesting attributes that contributed to the visual impact ratings are worth noting. Slash, the tree tops and branches left following a harvest, is often a contributor to visual impacts. Slash was highly visible in only one THO surveyed (the percentage of visibility is similar to the 1990 assessment). Leaving slash is a recommended practice for enhancing wildlife habitat and soil fertility. Since slash has been shown in research studies (Hoffman and Palmer 1996) to detract from aesthetics, public education programs, or variations in practices near certain public vantage points may be needed. Slash does not appear to be a significant contributor to aesthetic impacts in Vermont.

Figure 4-5. Example of slash that is close to the ground and consistent with natural decay (minimal visual impacts).

A number of THOs received attribute ratings noted as “severe” by field observers for cuts that exhibited a “straight or rectangular edge,” and/or “tall, unbranched trunks along the edge of the cut.” This is a characteristic typical of patch cuts, a fairly common silvicultural approach for regenerating stands. Since most of these operations were very small, the overall visual impacts, while sometimes resulting in moderate ratings, did not approach a rating of severe.

Figure 4-6. Straight-line cuts are most noticeable on hillsides and in winter. This cut was not included in the 2012 assessment.



An aesthetic impact in several operations was the stark appearance of remaining forest grown trees in which tall, unbranched trunks leave an awkward and noticeable contrast to surrounding vegetation (Figure 4-3, right). Several of these operations involved the thinning of highly overstocked pine plantations in which very tall unbranched boles and minimal crowns remained. Addressing these old, unmanaged plantations is a challenge and the results can be unsightly no matter what approach is used. In one example, a single row of tall unbranched trees was left by the roadside, creating a thin and awkward screen for a large clear cut beyond (Figure 4-3). Solutions will require a multi-year management process of waiting for sufficient regeneration of the clear cut area before removing the older foreground trees.

Figure 4-7. Although these tall, unbranched pines appear awkward, evidence shows that thinning these stands improves their visual acceptability especially over time.

Landing areas had few visual impacts. Of the few that were visible, none showed evidence of large quantities of wood chips or logging debris. Nearly all had re-vegetated except those that continued to serve uses other than logging. There were no examples of slash or cutting near streams or wetlands, although streams were visible from only one viewpoint in the assessment.

Figure 4-8. A forest access road with minimal visual impacts despite evidence of graded cut slopes.

CONCLUSIONS

While poorly executed timber harvest operations can loom large in the public eye, this assessment does not indicate any serious aesthetic impacts resulting from timber harvests observed in this assessment.

The occurrence of factors contributing to negative visual impacts was lower than the results reported for the 1990 assessment. One significant improvement was the lack of heavy cutting along visible hillsides and ridgelines. Another was the lack of highly visible landing areas in which remaining wood chips or other debris were highly evident. Slash, described as “left where it falls, large trunks and limbs dominate the scene,” was notable in only one THO. The retention of downed wood is generally viewed negatively from an aesthetic perspective, especially if it is greater than 3’ in height.

Some of these improvements may be partly attributable to laws such as the 1997 Heavy Cutting Law (H. 536, Act 15), which requires a permit for heavy cutting over large areas.[60]

The vast majority of assessed timber harvests were not visible from visually sensitive vantage points, and therefore had no aesthetic impacts.

No data were collected during the assessment related to the level of planning which may have occurred on THOs relative to minimizing visual impact, but there were a number of THOs for which severe impacts could have resulted if they had been located along hillsides facing public viewing areas, rather than away from them.

A number of visual impacts resulted from remaining trees, rather than those that were removed.

Tall, spindly trees tend to be highly noticeable, especially when they tower over existing vegetation. Addressing heavily overstocked forests and plantations is always challenging and involves a multi-year management process that is likely to involve some ungainly results over the short term. In some cases, more cutting is preferable to leaving isolated individual trees (vs. groupings of trees) with tall, unbranched boles and minimal crowns, especially if these trees are of poor structural form and are highly visible from public viewing areas.

RECOMMENDATIONS

Ensure that recommended practices, guidelines, statutes and other directives related to timber harvesting adequately address visual impacts.

Provide foresters and timber harvesting professionals with tools and training on public perceptions of the visual results of forest management practices to allow aesthetic concerns to be better addressed.

Provide demonstration areas designed to educate foresters, loggers, landowners, and the general public about a variety of timber harvest practices, their benefits, and how they can be managed to reduce aesthetic impacts.

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[60] See http://www.vtfpr.org/regulate/documents/Timber_Harvest09_web.pdf.

Sustainable forest management practices and treatments are sometimes at odds with public perception of what is aesthetically acceptable. For example, the retention of snags, tops, and logging residues meets wildlife and other biodiversity goals, such as ensuring long-term site productivity, maintaining hydrologic functions, and sequestering carbon, but is often viewed as negative by casual observers. The public needs to be educated about the ecological benefits of these practices to better understand and accept them.

Provide incentives and educational programs for loggers and landowners that help foster appropriate forest management practices, including considerations for reducing aesthetic impacts.

CHAPTER 5: ARCHAEOLOGICAL RESOURCES

INTRODUCTION

The Society for American Archaeology defines an archaeological site as “any place where physical remains of past human activities exist.” There are two general types of archaeological resources that could occur within timber harvest areas: Historic period (ca. A.D. 1609-1950's), and “precontact” sites. Historic period archaeological resources may be categorized as historic sites (settlement or military), historic structures > 50 years old, and historic landscapes that can contribute valuable information to the existing record of historic places, events, or activities. Precontact period sites are locations with evidence of Native American settlement and/or resource exploitation that date to before the arrival of Europeans, or between roughly 9,000 B.C. and A.D. 1600 (University of Vermont 2009). Native American sites can contain both historic period and precontact artifacts that provide insight into the human habitation of Vermont over the past 11,000 years.

As noted in the 1990 Impact Assessment of Timber Harvesting Activity in Vermont, “The value of archaeological sites is recognized during agency reviews of all federally funded or licensed undertakings; such reviews are specifically mandated for all timber sales on USDA Forest Service and US Fish and Wildlife Service land. The importance of cultural resources, including archaeological sites, is reflected at the state level by the Vermont Historic Preservation Act of 1975 and Act 250, Criterion 8 (Vermont’s land development law).” Under section 743 of the Vermont Historic Preservation Act, all state agencies, departments, divisions, and commissions are required to “institute procedures to assure that their plans, programs, codes and regulations contribute to the preservation and enhancement of sites, structures and objects of historical, architectural, archaeological or cultural significance (Newton et al. 1990).”

Due to the lack of written records, all Native American sites are considered a potentially significant source of information about the history and culture of Vermont’s first inhabitants. However, historic period sites are not all equally significant. Stone wall segments, isolated fields, parts of a single homestead, and sections of roads are very common throughout the state, as most of the landscape was settled and nearly all was used for timber harvesting. Significant historic sites include a combination of features (foundations, dams/mill sites, roads, field patterns with stone walls, graves, etc.) from which the historic context of a settlement can be interpreted, or which contain evidence of significant military or cultural history. Significant historic roads are those that remain relatively intact and functioned to connect communities or industrial sites, or were part of significant historic events (e.g., Bailey-Hazen Road, Civilian Conservation Corps roads).

Archaeological resources are particularly vulnerable to negative impacts from timber harvesting. While most resources evaluated in this report are dynamic and capable of restoration given sufficient time, protection, or reparations (e.g., water quality, timber quality, soils, wildlife, habitat, and aesthetics), archaeological resources have no reparative mechanisms that can restore their integrity over time. Impacts to archaeological resources are irreparable and permanent. We have no idea to what extent many of these resources may already have been lost, so it is important to preserve intact the resources which remain undisturbed until the information they contain can be systematically extracted; damage or disturbance that modifies the physical artifacts or their temporal context will obliterate the potential value they hold. Because most archaeological resources are not visible on the soil surface, but may be located at shallow depths, timber harvesting operations can destroy the integrity of a site in a variety of ways: structural modifications caused by equipment impacting artifacts and features, intentional soil movement (clearing and grading roads or landings), unintentional soil rutting caused by skidding trees, and site modification due to soil erosion resulting from harvest operations. Any activity resulting in disturbance to any part of an archaeological site is considered to be an adverse impact.

Few options exist for preserving the integrity of an archaeological site within the boundary of an active timber harvest. Timber harvesting operations conducted on sensitive sites have the potential to completely obliterate those sites. Ideally, potential sites would be buffered from any disturbance by harvest operations in order to preserve their value. An alternative, but potentially less effective strategy, would be to conduct the harvest in the sensitive area under winter conditions (frozen ground, or >12” snow cover), ideally using tracked equipment and pre-existing roads and trails as much as possible. Not all timber harvesting activities result in adverse impacts to archaeological resources. Carefully planned and executed removal of trees growing in close proximity to foundations and other structures (without ground disturbance) is a strategy for preserving the structures and surrounding artifacts from damage caused by root invasion and disturbance due to wind throw.

HISTORIC ARCHAEOLOGICAL RESOURCES

DESIGN

In order to facilitate comparisons between the results of this study and the 1990 assessment, the 2012 study design duplicated the measures from the 1990 assessment to the extent practical. The following excerpts from the 1990 report (shown in italics) guided field sampling for historic sites in 2012:

> *Based on recognized site types and settlement patterns that are characteristic of Vermont's historic past, the most commonly encountered historic period sites in any geographical area are likely to be either late eighteenth, nineteenth, or early twentieth century residences/farmsteads or small industrial sites such as sawmills or gristmills. Other types of sites may exist in lower frequencies and may range from small family cemeteries, charcoal kilns, lime kilns, or sugar houses, to larger Civilian Conservation Corps camps, mining complexes, old logging camps, or small rail heads. Except for perhaps the cemeteries or other bounded “activity areas,” it is essential to recognize that historic archaeological sites are not defined solely on the basis of structural remains. At a farmstead, for example, the entire landscape context of site components or features may consist of the house foundation, surrounding yard where many domestic and farm related activities occurred, associated remains of outbuildings (barns, sheds, wells, privies), pens, wells, refuse disposal areas, and a much larger field pattern which may be identified by stone walls, tree lines, and farm roads.*

Many highly visible structural remains, as well as many historic features and deposits that are not easily recognized, are distributed across the Vermont landscape. Due to a number of constraints, it was not feasible to compile an exhaustive inventory during the course of this study. However, various categories of information were collected with respect to historic archaeological sites in order to address three questions. First, do historic sites exist within areas where timber harvesting operations are conducted? Second, if historic sites do exist, what types of sites are likely to be encountered and with what frequency? This is important because not all components of an historic site possess the same informational value. Rather, on any relative scale that measures archaeological significance, such elements as stone walls or farm roads would rank considerably below residential or industrial complexes that contain structural remains and deposits associated with one or more activity areas. Third, what is the general nature and extent of site disturbance produced by timber harvesting activities?

The identification of historic sites in this study relied on the recognition of the more visible features that might be expected to occur, but also included those feature types that are likely to be associated with significant archaeological deposits. Eight categories of features were defined. These features include: 1. house foundations or cellar depressions, 2. outbuilding foundations or depressions, 3. dams and mill foundations, 4. remnant plantings (lilac, apple trees), 5. rock alignments or depressions of unknown origin, 6. stone walls, 7. shacks (collapsed or otherwise), and 8. "other" to cover such things as sugar arches, cemeteries, wells, charcoal kilns, or features that could not be specifically identified as to function (Newton et. al., 1990).

As in the 1990 assessment, references such as historic maps were not consulted to assist in site location and investigators did not systematically search for historic features. In some cases, observers located historical features via information from the landowner, forester, or other individual who was knowledgeable about the property. In other cases, observers encountered historical features in the course of navigating through the forest en route to a vegetative plot, while assessing a stream segment or skid trail/truck road, or because it was visible near the landing site. Due to the limitations of assessing impacts within each THO on individual parcels, it was not possible to determine if isolated historic features (foundations, stone walls, etc.) found on a THO were part of a historic district or road network, so these features were conservatively considered significant as part of a *potential* larger historic district. Evaluation of impacts to a potential historic district was beyond the scope of this study because of the geographic limitations. Field data collection for historic resources on the 81 THOs focused on potential impacts to discrete sites such as foundations, stone walls, and structures. For all historic and precontact archaeological resources, the goal of the assessment was to describe the types and severity of impacts resulting from timber harvesting operations.

For each historic site identified, the visible causes and potential extent of impact were recorded if possible. Visible causes of site disturbance were categorized as 1. truck road, 2. skid trail, 3. log landing, 4. erosion, 5. substantial rutting, 6. felling, or 7. equipment (one time skid), and categories were not mutually exclusive. Although many foundations and stone walls may be partially visible to an observer, associated elements at a site are likely to be buried, albeit at fairly shallow depths, and can be detected only through subsurface testing. In terms of impact assessments related to this study, this difference in visibility limits the reliability of the inferences that can be drawn. …Because a detailed evaluation of disturbance at any archaeological site *would involve considerable subsurface testing and because the available time for the evaluation of any given operation was very limited, only a preliminary evaluation of potential disturbance was practical. …Without subsurface testing, some impacts can only be inferred, not demonstrated. Therefore, observations at historic sites were made at two levels. The first involves observations about visible features such as foundations. For each structural component, the observer recorded damage attributed to only one of the following categories: 1. breached, 2. filled, 3. rearranged, or 4. no impact. The second damage metric involves observations about areas surrounding structural remains where other elements of the site may be present, but where little surface evidence is likely to be observed. As a rough measure of the potential severity of impact, ground disturbance surrounding all structural features was recorded as one of three categories: 1. within 20 feet, 2. within 100 feet, or 3. not within 100 feet.* (Newton et. al. 1990).

RESULTS AND ANALYSIS

The following data represent a conservative estimate of the actual number of historic features present, due to the variable proportion[61] of each THO observed. Within the sample population of 81 operations, historic structures or related features were observed on 44% (36) THOs (Table 5-1).

Table 5-1. *Frequency and percentage of observed historic features on 81 timber harvesting operations in Vermont, 2012.*

Type of Feature Observed	Frequency of Observations	Frequency of THOs (Percentage)
House foundation/depression	6	6 (7%)
Outbuilding foundation/depression	4	3 (4%)
Dam or mill foundation	0	0 (0%)
Historic planting (lilac, apple, etc.)	0	0 (0%)
Rock alignment/depression	0	0 (0%)
Stone wall	57	34 (42%)
Shack (collapsed or otherwise)	0	0 (0%)
Other	1	1 (1%)
All categories combined	**68**	**36 (44%)**

The total number of observed historic features was 68, with a range of zero to six historic structures or features per operation. Historic sites were observed within at least one operation in Addison, Bennington, Caledonia, Franklin, Orange, Orleans, Rutland, Washington, Windham, and Windsor counties. Residential sites were found in Franklin, Orange, Rutland, Washington, and Windsor counties.

Stone walls were the most common feature, observed in 42% of operations (Table 5-1, Figure 5-1). Structural remains (house, outbuilding foundation/depression), the second most common feature, were found in only 9% of operations. A single occurrence of a sugaring arch (Figure 5-2) was placed in the “other” category. Among THOs where they

[61] Sampled THOs were not systematically sampled for historic features. Features were assessed when observed while traversing the operation or completing assessments of other attributes, so it is assumed that the actual number of occurrences is underestimated.

occurred, generally only one foundation was found, but the frequency of encountered stone walls ranged from one to six.

Figure 5-1. Examples of stone walls avoided (left) and breached (right) on sampled timber harvesting operations.

Figure 5-2. Remains of a sugarhouse disturbed during a timber harvesting operation.

Several factors and sources of potential bias identified by Newton et al. (1990) were applicable to these results as well, including:

- intensity with which the field survey was conducted
- density of vegetation cover
- time of year (May-October, fully leaved vegetation)
- weather conditions
- recognition abilities of the field observers
- variable percentage of each operation actually observed

During field studies of some timber sale areas in July and August 1988 in the Green Mountain National Forest, the observed site inventory underrepresented the population of historic sites by nearly 50% when rechecked by the field team in late November after the leaves had fallen (David Lacy, archaeologist, Green Mountain National Forest, personal communication, *in* Newton et al. 1990). In a few cases, consulting foresters did note known locations of historic sites on the THO map when responding to the assessment survey. However, due to the factors noted above, the site density must be considered a minimal estimate.

Of the 68 historical structures or features evaluated at 36 THOs, 20% of the foundations (2 of 10) were directly impacted by timber harvest operations (Table 5-2).

Table 5-2. *Observed level of direct impact to historic features on 81 timber harvesting operations in Vermont, 2012.*

Type of Historic Feature	Total Frequency	Extent of Observed Impact		
		Breached	**Filled/Rearranged**	**No Impact**
House foundation	6	0	1	5
Outbuilding foundation	4	1	0	3
Other	1	0	0	1
Stone wall	57	14	13	30

Because stone walls are linear features that often traverse a substantial portion of a THO compared to other types of historic features at discrete locations, there is a higher likelihood that they will be intersected by truck roads or skid trails, which are also linear features that traverse the THO. Stone walls were disturbed at a much higher rate than other structures. Twenty seven of the 57 walls recorded (47%) were either breached or otherwise disturbed (Table 5-2). In general, these impacts are considered minor compared to disturbances in the vicinity of foundations, which are more likely to have significant deposits of artifacts near them (Peebles 2008). The primary resource value of stone walls is that they delineate field patterns and historic roads, so wide-scale destruction of walls could obscure the interpretation of these cultural features. However, most timber harvesting operations simply need passage through a section of wall, and the minimal breach required for this purpose retains the interpretive value of these features.

Timber harvesting operations are clearly affecting the integrity of the soil environment in the immediate vicinity of identified structural remains (Table 5-3). As in 1990, the 2012 assessment evaluated 7 potential causes of impacts to foundations. Each of the impact types was observed within 20 feet of at least 1 of the 10 foundations, suggesting that careful planning is required to avoid impacts to archaeological sites during timber harvesting.

Skid trails or evidence of skidding were found within 100 feet of 67% (4) of house foundations, and felling impacts were visible within 100 feet of 83% (5) of them. Outbuildings were not avoided either. A skid road existed[62] within 100 feet of all 4 (100%) of the outbuilding foundations, evidence of equipment operation within 100 feet

[62] No attempt was made to determine whether or not skid roads were pre-existing on these sites or if they had been established for the operation being assessed.

was visible at 75% (3 of the 4), and landings, erosion, and/or felling impacts were observed within 100 feet of all 4 outbuilding sites (100%).

A truck road was present within 100 feet of only 1 (16%) of the 6 house foundations. Because historic roads were generally located in the most favorable topographic locations, it's possible that the truck road was established on a historic access road, resulting in minimal impact to the foundation site. At 80% (8 of 10) of these foundations, one or more of the types of impact were observed within 20 feet of the foundation.

Table 5-3. *Frequencies of proximity of* <u>*potential*</u> *impacts to buried archaeological deposits, by cause, on timber harvesting operations in Vermont, 2012.*

Cause and Proximity of Impact*		Type of historic feature: House Foundation (n=6)	Outbuilding Foundation (n=4)	Other (n=1)	Stone Wall (n=57)
Truck Road	**1**	1	0	0	2
	2	0	0	0	2
	3	5	4	1	53
Skid Road	**1**	2	1	0	37
	2	2	3	0	12
	3	2	0	1	8
Landing	**1**	0	2	0	2
	2	1	0	0	4
	3	5	2	1	51
Erosion	**1**	1	2	0	11
	2	1	0	0	6
	3	4	2	1	40
Rutting	**1**	1	1	0	10
	2	0	0	0	8
	3	5	3	1	39
Felling	**1**	2	2	0	42
	2	3	0	0	7
	3	1	2	1	8
Skid or Equipment	**1**	1	3	0	36
	2	3	0	0	10
	3	2	1	1	11

* Proximity of potentially disruptive activity:
1 = at or within 20 feet
2 = within 20-100 feet
3 = greater than 100 feet

PRECONTACT ARCHAEOLOGICAL RESOURCES

DESIGN

As noted for historic resources, efforts were made to replicate the 1990 study design to facilitate comparison of results with this assessment. The following excerpts from the 1990 assessment design guided data collection methods in 2012:

"Evaluating impacts to precontact sites presents a particular dilemma for such a study as this one. Except for bedrock quarries where chert, quartzite, or quartz was secured as raw material for tool manufacture, all archaeological sites are buried and exist only as clusters of artifacts and features such as hearths, cooking pits, storage pits, or arrangements of post molds left by houses or shelters. Thus, without conducting a subsurface survey, there is no way to actually document site presence or absence. For this reason, evaluating potential impacts to precontact sites can only be done at an inferential level."

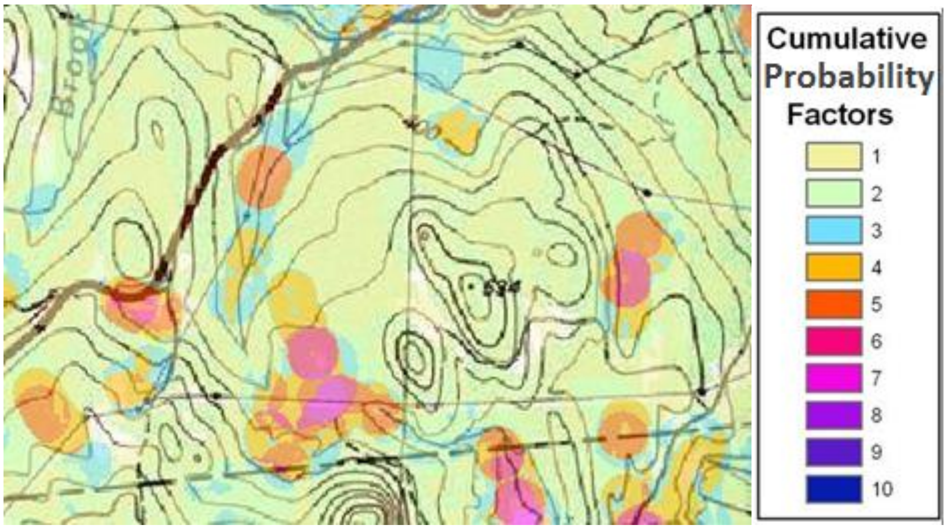
"The one type of precontact site that might be easily visible is a quarry site where chert, quartzite, or quartz was extracted as raw material for stone tool manufacture. For this reason, the field observer was asked to identify any prominent exposures of these varieties of bedrock."

(Precontact) sites are known to occur in a wide variety of Vermont's physiographic environments, including mountainous areas within the Green Mountain National Forest." However, precontact sites are not distributed randomly across the landscape. "In all geographical areas there is a strong positive correlation between most residential sites and portions of the landscape where there is relatively easy access to a source of water, along terraces or where slopes are 5% or less, and where the aspect is south to west." (Newton et al. 1990)

The correlation increases with factors such as the confluence of two rivers, river confluence with a lake or pond, vicinity of wetlands, natural travel corridor between two watersheds, source of stone for toolmaking, and other factors. The Vermont Division of Historic Preservation has ranked 28 such significant factors to develop a predictive model (Appendix A) to aid in identifying areas with high potential for containing precontact archaeological sites. The model was adapted from an environmental stratification model developed by researchers at the University of Maine at Farmington Archaeology Research Center in 1989. This model score sheet was used by a team of researchers at the University of Vermont Consulting Archaeology Program (UVM-CAP), University of Maine at Farmington Archaeology Research Center (UMFARC), and Earth Analytic, Inc. to develop a Geographical Information System (GIS)-based precontact archeological predictive map for the entire state (ESRI 2006). The maps illustrate areas relative to water, wetlands, surficial geology and topographic features favorable to Native American habitation or recurrent activity. The areas are depicted as overlapping shaded layers, ranging from 0 favorable factors (no color) to 10 factors (favorable for a higher density of precontact sites, Figure 5-3). For the purpose of this assessment, areas with 6 or more overlapping factors were considered *high risk* for potentially impacting precontact archaeological resources through timber harvesting activity.

The precontact archaeological predictive model GIS layer was overlaid on the timber harvest operation maps in order to identify timber harvests that contained archaeologically high risk sites (≥ 6 factors). Observers then visited the areas mapped as high risk and noted on-site characteristics such as a noticeable terrace, obvious pits and mounds, whether harvesting activity took place in the area, whether the site had been previously disturbed (i.e., plowed or graded), or whether there was a prominent rock exposure, and then provided a general description of the site. For such identified locales, it is assumed that a precontact site might be present. Because the possible types of subsurface impacts to potential sites comprise a wide diversity of variables, visual estimates were used for expediency to record soil surface disturbance in one of three categories: 1. obvious disruption or point-specific disturbance, 2. limited surface disturbance with occasional depressions, or 3. no disturbance observed.

Figure 5-3. Example GIS based precontact archaeological predictive map.



Several factors and sources of potential bias identified by Newton et al. (1990), some of which differ from the factors that bias the identification of historic period resources, are applicable to these results, including:

- intensity with which the field survey was conducted
- density of vegetation cover
- recognition abilities of the observer
- limited time involved to survey each operation
- variable percentage of each operation actually observed

An additional potential bias in this assessment is the accuracy of the data input into the GIS model. These factors dictate the same caveat as stated in the 1990 assessment: "...some impacts on areas mapped as sensitive have undoubtedly gone undetected. Clearly, this approach has produced a data base with some unknown biases, and any inferences that are drawn must be considered minimal estimates."

RESULTS AND ANALYSIS

A total of 12 areas mapped as highly favorable for precontact sites (high risk) were identified on 12% (10) of the 81 harvesting operations. These sites were located in Caledonia, Essex, Franklin, Orange, Washington, Windham, and Windsor counties.

Three of the 12 high-risk areas were alluvial terraces and two were outwash terraces (Table 5-4). The remaining 7 areas mapped as high risk (≥ 6 factors) by the model had no terrace. Evidence of pit and mound relief was observed on 8% of high-risk areas (1 of 12 areas), suggesting that the soil layers and thus archeological deposits on the terraces remained undisturbed by the natural disturbance of tree wind throw. One rock outcropping site was found within a timber harvest, and it was without major site disturbance.

Table 5-4. *Characteristics of potential precontact archeological site areas in 10 timber harvesting operations in Vermont, 2012.*

Potential Precontact Site Number	**Type of Terrace** 1 = outwash 2 = alluvial 3 = no terrace	**Pit/Mound Relief** 1 = none 2 = occasional 3 = extensive	**Level of Disturbance** 1 = obvious 2 = limited 3 = none observed	**Harvesting Activity** 1 = trail/road 2 = landing 3 = rutting 4 = combo 9 = none
1	2	1	1	4
2	3	1	1	2
3	3	1	1	2
4	3	1	1	4
5	3	1	3	9
6	2	1	2	4
7	1	2	3	9
8	3	1	2	1
9	3	1	3	9
10	3	1	3	9
11	2	1	3	9
12	1	1	2	4

As noted in the 1990 assessment, the level, well-drained topography of terraces make them particularly attractive sites for establishing roads, trails, and landings for timber harvesting operations. For the 5 identified terraces, substantial disturbances were evident in one instance (20% of terraces), and limited surface disturbances were observed in two cases (40% of terraces). Three of the 5 terraces (60% of terraces) were crossed by either a skidder trail or truck road, were used as a log landing site, or were impacted by rutting during the harvest. Overall, of the 12 high-risk areas, some level of disturbance was observed at 58% (7) of them.

For precontact sites that may be present on the THOs, a limited amount of data are available that provide insight about the degree of accuracy of the GIS predictive model for predicting where precontact archaeological resources actually occur. During the period 2005-2012, applying the same GIS model used in this study, VT Agency of Natural Resources (ANR) mapped 11 areas containing ≥ 6 factors (same criteria as this study) on VT ANR lands. Standardized test pit excavations conducted by archaeologists revealed that two of the areas (18%) actually contained archaeological resources. Based upon the 18% accuracy rate for the precontact archaeological GIS model layer, only 2 of the 12 areas identified as “high risk” in this assessment are likely to actually contain archaeological resources. If the sample of 81 THOs is representative of the population of 420 THOs in 2012, then approximately 52 areas within them would be mapped as high risk for impacts. If 18% of these areas mapped as high risk actually contain resources, then approximately 9 of them would contain some precontact resources. A little over half (58%) of the high-risk areas mapped in this study were impacted by timber harvesting, suggesting that slightly more than 1% (5 of 420) of all harvests statewide might have actually impacted archaeological resources in 2012.

Precontact sites do occur in areas with < 6 factors mapped as favorable for Native American activity, (indeed, with only 1 mapped factor), so this extrapolation must be considered a minimum estimate. However, the density and occurrence of sites decreases on a continuum with decreasing factor overlap, so based on the available sample data, it may be inferred that between 1-2% of all THOs statewide actually impacted precontact resources in 2012.

Chapter 3 of this report (Table 3-5) may provide some insight into the perceived importance of archaeological resources by landowners and managers. For the 71 operations where contracts were written, only 11% of survey respondents noted that the operation contained “special provisions” related to archaeological resources. As noted in Chapter 3, the actual number may be somewhat higher, as respondents may have interpreted this question to mean site-specific or harvest-specific conditions, rather than any protections required under “general” contract provisions related to these resources.

Results Comparison: 1990 and 2012

The most striking contrast between the 1990 assessment and this assessment is that for nearly every metric, the 2012 assessment produced fewer results or results of a more moderate scale. Although nearly the same number of THOs was evaluated (81 in 2012 vs. 78 in 1990), the mean timber harvest size of 62 acres was 1/3 smaller than the 93 acre mean in 1990. The largest harvest in the study sample was 468 acres, compared to harvests exceeding 1000 acres in 1990. This reduced scale is significant because it reduces the likelihood that a THO will contain historic or precontact archaeological sites. Potential evidence of this relationship is the fact that 25 farmhouse/outbuilding foundations were found in 1990, while less than half as many (10) were found in this assessment. The disparity in the number of non-farm building structures (dams, mills, kilns, sugar arches, pens, etc.) is even greater. While 18 non-farm building structures were observed in 1990, only one, a sugarhouse, was found in 2012.

Although the reduced *scale* of the THOs may be a partial explanation for the disparity in the number of structures observed and impacted, two other factors have been proposed by observers to explain the reduced number of sites in this assessment. First, the *detectability* of historic structures in a woodland setting decreases over time as the sites and artifacts become increasingly overgrown with vegetation and covered with organic matter, wood decays, foundations subside and collapse due to weather effects, and landscape cues such as old roads, landscape plantings, field patterns, orchards, etc. become obscured or die. The intervening 22 years between the assessments may encompass a critical tipping point in the detectability of such sites, progressing from conditions in which sites were barely detectable in 1990, but are no longer visible to observers in 2012 as forests continued to reclaim the agricultural landscapes and structures abandoned in the late 19^{th} and early 20^{th} century. A reduction in detectability would result in impacts to a higher number of sites than suggested by this assessment.

Second, the *landscape context* of the THOs visited in 2012 may be different from those sampled in 1990. One observer noted that many of the 2012 harvests were located in remote, high-elevation or mountainous areas. Evidence for this trend was provided through an analysis of the spatial data for this assessment. As noted in the Wildlife Habitat section of this report (Chapter 10), an analysis of forest blocks >25 acres in size revealed that the mean size of forest blocks containing one or more THOs is significantly larger than the mean size of all such forest blocks statewide (14,046 vs. 1,165 acres, unpaired t-test, $p<0.0001$). Forest blocks in the 10,000 – 20,000 acre range are by definition areas un-fragmented by roads, fields, or other anthropogenic features. Such areas tend to be found in more mountainous or higher-elevation areas of the state rather than the valley locations, which are more fragmented by development and agriculture. While the 1990 assessment predicted that 190 mill sites would be present on THOs over the next decade, no mill sites or dams were observed in this assessment, suggesting fewer THOs in valley locations. The assumption that the 2012 THOs were located in more remote areas is also supported by the findings in the Aesthetics section of this study (Chapter 4), which reported that approximately 20% were visible from a public vantage point, whereas in 1990 a much higher percentage of THOs were visible from public areas (46 out of a total of 78, or 60%). Another possible explanation for the lack of dams and mill sites is an increased awareness of water quality protection and the tendency for forest management professionals to more frequently avoid or buffer streams and other waterbodies than was common practice 22 years ago. As a result, most mill and dam structural remains would have fallen outside the THOs and would not have been identified or assessed.

Although nearly 80% of the state was cleared for agricultural, commercial, or residential development by the mid 1850's, the distribution of farms, residences, mills, dams, and other infrastructure switched from a low-density, homogenous landscape distribution to a more clustered distribution with the onset of the industrial age. River corridors provided fertile valley soils, water power and transport, and topography suitable for rail and highway development, which dictated the land use and development pattern. This general pattern created a higher density of historic sites (including dams, mills, and farmsteads) in valley locations and a lower density in mountainous regions. Vermont experienced extensive farm abandonment during the late 19th and early 20th century. Examples of this pattern, derived from U.S. Census data for several New England settlements provided by Vermont Natural Resources Council (VNRC) (2014) and Foster and Aber (2004), indicate a general 30% to 50% reduction in the rural population 1850-1950, and a concurrent 300% to 400% growth in the urban population in valley towns. This rural exodus, combined with industrial development leading to a shift of the population toward urban centers, resulted in the reversion of abandoned farmland to forest across the landscape throughout the 20th century (Foster and Aber 2004). Timber harvests were first implemented in the most accessible locations nearest roads and villages. Although locations for the 1990 THOs are not available, less development and more timber land available near valley locations (compared to 2012), combined with a higher density of terraces, mills, dams, and historic sites observed in 1990, suggest that a much higher proportion of the THOs were located near villages and valley foothills in the previous assessment.

In the 22 years since the 1990 assessment, Vermont has experienced a steady trend of dairy farms going out of business, divestiture of industrial timber company lands (Block and Sample 2001), and other large land holdings being subdivided, resulting in suburbanization and land parcelization for commercial development and second home construction. This trend has been well documented in several studies. The Vermont Natural Resources Council (VNRC 2013) reported that, according to the U.S. Census of Agriculture, over the past 50 years Vermont has lost over 2 million acres of farmland, and more than 10,000 working farms. In the period 1993-2003 Vermont's population grew 8.2%, and the rate of land development was 2.5 times greater than the rate of population growth (VNRC 2013). From 2003-2009 the amount of forest land in parcels ≥ 50 acres without a dwelling decreased by approximately 4%, or roughly 34,000 acres (Brighton et al. 2010). These trends have resulted in a reduced number of forest parcels of sufficient size to allow commercially viable timber harvesting, particularly in valley and foothill locations. This fragmentation of low elevation forestland has forced THOs to be located in the remaining "large forest blocks," which are less suitable for agriculture or development. These areas are typically higher-elevation, mountainous, low-fertility sites dominated by more severe climate conditions, thus they exhibit lower density of both precontact and historic sites.

Regarding impacts to historic structures, there was apparently less protection for foundations in 2012 than in 1990. While in 1990 no erosion or rutting was noted within 100 feet of any of the 25 foundations identified, in 2012 half of the 10 identified foundations had ruts or erosion within 100 feet. In 1990 a road, trail, or landing was located within 20 feet of 36% (9 of 25) of foundations, but these potential sources of impact increased to 50% of foundations in 2012.

Compared with this assessment, the 1990 methodology for identifying potential precontact sites was more exclusive, summarized by the following criteria: "*Although conservative, potential precontact areas were identified in the field during this study if they were within 100 feet of a stream, pond, lake, wetland, or obvious relict drainage, had a slope of less than or equal to 5%, and were either flat or had a south to west exposure. For such identified locales, it is assumed that a precontact site might be present*." Data in Table 5-5 in the 1990 study indicate that these criteria were interpreted by field observers as the presence of either a glacial outwash or alluvial terrace. Ultimately, only terraces were considered to be high risk for precontact sites, and a total of 17 terraces were identified on the 78 THOs (22%). In 2012, these terraces were found on only 5 of the 81 THOs (6%). While approximately 1/3 of this disparity in the presence of terraces may be partially explained by the smaller mean THO size in 2012, the majority of the lack of terraces on THOs in 2012 may be due to the previously noted evidence that a much larger proportion of the 2012 THOs were sited in more upland, mountainous locations, whereas glacial outwash and alluvial terraces are much more likely to be found in valley locations. Although the methodology for identifying potential precontact "high risk" sites in 2012 expanded the terrace criteria, allowing a greater range of sites to be considered as potential locations for precontact resources, only 12 areas were identified (within 10 THOs, or 12% of all THOs evaluated) compared to 22% of the THOs in 1990.

The 1990 assessment estimated a broad range of potential impacts based upon a conservative assumption that only 25% of potential sites held precontact archaeological resources, up to the liberal estimate that 100% of high-risk sites (terraces) held precontact artifacts. These assumptions yielded estimates of 400 (conservative), 800 (moderate), or 1600 precontact sites that would be adversely impacted over the next decade. Based on the criteria used to predict “high risk” sites for impacting precontact resources in 2012, a minimum of 5 of the 420 harvests actually impacted archaeological resources (1% of the harvests statewide). While the loss of any archaeological data is permanent and detrimental, this refined estimate, based on the percent of a sample of non-timber harvest GIS-mapped sites confirmed to actually contain resources, is approximately 1/16th of the moderate estimate of 80 sites impacted per year predicted in the 1990 study. Thus the 2012 estimate is substantially less, even though this assessment used a more liberal model that considers areas in addition to terraces and outcrops as potential sites. Based on the 2012 assessment, impacts to precontact and historic sites are estimated to be substantially lower than those estimated in 1990. However, this is due to smaller THOs, refinement in estimates of the percentage of precontact sites that actually contain resources, and perhaps a much greater proportion of 2012 THOs being conducted in more remote areas with a lower density of historic and precontact sites, rather than a change in timber harvesting practices. Data for historic sites based on actual impacts indicate that the level of concern and protection appears to be lower in 2012 than in 1990, while the number of contracts with protections for resources is comparable (9 contracts or 11% or THOs in 2012, compared to 10% in 1990).

CONCLUSIONS

Based on the 2012 assessment, impacts to precontact and historic sites are estimated to be substantially lower than those estimated in 1990.

The reduced number of potentially impacted sites may be partially due to the fact that, although nearly the same number of THOs were evaluated (81 in 2012 vs. 78 in 1990), the mean timber harvest size of 62 acres was 1/3 smaller than the 93 acre mean in 1990. Other possible explanations include refinements in identification of potential precontact sites (resulting in fewer potential sites), the tendency for sampled harvesting operations to be located in more remote regions of the state, and the possibility that forest managers more frequently avoid or buffer streams and waterbodies where some types of sites are more likely to be found.

With respect to the avoidance of waterbodies, in 2012 41% of the operations had no waterbodies within or adjacent to the harvest area, compared to 31% in 1990. Although comparable data are not available for 1990, data reported in Chapter 9 of this study indicate a high level of avoidance of waterbodies in 2012:

- No machine entries within 25 feet of streams were recorded on 78% of observations.
- Protective strips associated with truck roads met or exceeded recommended widths on 95% of the observations.
- Protective strips associated with skid trails met or exceeded recommended widths on 96% of the observations.
- Eighty-six percent of log landings observed were located outside of protective strips.

Results of this assessment indicate that the potential for loss of archaeological information due to current timber harvesting practices remains a significant concern.

Archaeological resources are finite and irreplaceable, and the loss of archaeological data is permanent and cumulative, so the destruction of even a small percentage of sites annually adds up to a significant net loss over time.

With regard to impacts to historic structures, there was apparently less protection for foundations noted in 2012 than in the 1990 assessment.

While in 1990 no erosion or rutting was noted within 100 feet of any of the 25 foundations, in 2012 half of the 10 foundations had ruts or erosion within 100 feet. In 1990 a road, trail, or landing was located within 20 feet of 36% of foundations, but these potential sources of impact increased to 50% of foundations in 2012. The reasons for this increased activity could not be determined from the data available.

Based on the available sample data, it may be inferred that between 1-2% of all THOs statewide actually impacted precontact Native American resources in 2012.

Of the high-risk areas identified by the precontact archaeological predictive model, some level of disturbance was observed at 58% (7) of them. Testing of the model suggests an 18% accuracy rate for the GIS model layer. If 18% of the areas mapped as high risk actually contained resources, and 58% of the high-risk areas mapped in this study were impacted by timber harvesting, then 1% (5 of 420) of statewide harvests might have actually impacted archaeological resources in 2012. Extensive subsurface testing and archaeological excavation beyond the scope of this assessment would need to be conducted in order to determine the significance of the resources and the extent of damage incurred.

RECOMMENDATIONS

An important initial step toward preserving archaeological resources is to increase awareness of these resources among landowners, loggers, foresters and other land management professionals. Dissemination of information about potential archaeological resources, their values, and how to preserve them, should be a priority for organizations seeking to promote responsible timber harvesting.

Produce an updated guide to the stewardship of historical and archaeological resources including recommended best management practices applicable to private land owners, land managers, and loggers.

Develop and implement educational materials, programs and workshops for presentation to a wide range of audiences, particularly landowners, loggers and professional foresters on recognizing potential archaeological sites and avoiding

or mitigating impacts to them. Educational materials should include a listing of timber harvest regulations affecting private lands relative to cultural resources.

Conduct focused training for ANR staff and other resource professionals on recognition of less obvious historical sites and how to avoid them during harvesting operations on state and private lands.

Integrate data from the Vermont Archeological Inventory (VAI) and the predictive model GIS layer developed for the VT Map Tool (currently not publicly accessible) into the new ANR Natural Resource Locator.

Encourage consulting foresters to prepare Forest Stewardship Program eligible management plans, which include consideration of cultural resources, when preparing plans for enrollment in the Use Value Appraisal (UVA) Program.

CHAPTER 6: RARE, THREATENED, AND ENDANGERED SPECIES

INTRODUCTION

Rare native plants and animals, those species that have few populations in the state or that face threats to their continued existence, are an important part of Vermont's natural landscape. These species, such as the ram's head lady slipper, spiny softshell turtle, Indiana bat, and bald eagle, can play important roles in their ecosystems, and many are compelling for people to observe in the wild. Some of Vermont's rare species are legally protected by Vermont statute as 'threatened' or 'endangered' species. In most cases, these species cannot be disturbed without approval from the Agency of Natural Resources. However, persons engaging in "normal silvicultural activities" are exempt from the provisions of Vermont's Endangered Species Act (10 V.S.A. §123).

Timber harvesting operations have the potential to benefit or harm populations of rare plants. If the operation is guided by special considerations aimed at improving the habitat or conditions for a particular rare species, the overall effect may be positive. In contrast, an operation that alters suitable habitat for a rare species, or that causes physical damage to individual rare plants or animals, is likely to have a negative effect on the long-term persistence of that population.

DESIGN

The Vermont Fish and Wildlife Department's Natural Heritage Inventory maintains a spatial database of all known occurrences of rare, threatened, and endangered species (RTE species). At the time of writing, this included 4,270 occurrences, or separate instances, of rare species. While this database is not a complete index of every site that supports a rare species in Vermont (new sites are discovered and recorded regularly), it does represent the best understanding of the distribution of RTE species in Vermont. Using this database, it was possible to use locations of the sampled timber harvest operations to determine whether any operations overlapped known occurrences of an RTE species. Methodology for assessing potential impacts to RTE species was based on methods used for the 1990 assessment. Mapped locations of sampled timber harvest operations were compared with recorded locations of RTE species using a geographic information system (GIS). Overlap of these features did not in itself demonstrate impact (positive or negative), but can be used as a broad indicator of the degree to which timber harvesting operations have the potential to impact RTE species.

RESULTS AND ANALYSIS

Of the 81 timber harvest operations (THOs) considered in this assessment, three overlapped with the mapped locations of RTE species as recorded by polygons in the VT Fish and Wildlife Department's Natural Heritage Database. The three species that overlapped were:

- One endangered animal species: This record is over 30 years old. There are no present-day records suggesting the species' presence in the vicinity of the THO. Interview data indicate that both a wildlife biologist and an ecologist were involved in this THO.
- One rare animal species: This record is from a relatively recent observation, and is associated with a cluster of wetland features that are outside of the timber harvest area. Interview data indicate that an ecologist was involved in this THO.
- One threatened plant species: This record is over 100 years old, and is based on a documented plant collection in the vicinity of the THO. There are no present-day records indicating the species' presence. Interview data indicate that an ecologist was involved in this THO.

No additional efforts were made in this analysis to suppose whether the THOs resulted in positive or negative impacts to the above species. Such an assessment is beyond the scope of the available data. The involvement of a wildlife biologist and ecologists, however, at least suggests that these RTE records were consulted and considered in the course of the operation.

Interestingly, all three sites were on land managed by the state of Vermont. This offers some important insights. First, state lands can have exceptional ecological diversity (often the reason for state ownership), and thus, it is not necessarily surprising that RTE species may be found in proximity to timber harvest operations. Second, Agency lands have often been subject to extensive searches for RTE species, both by Agency staff and by the general public who may visit these lands. The results of this assessment emphasize the importance of ongoing efforts by the Agency to consider RTE species prior to timber harvests. The results also emphasize, however, the possibility that RTE species could be overlooked on other lands where such surveys are unlikely to have been undertaken.

Several programs focused primarily on private lands do however emphasize the practice of consulting databases of known occurrences of RTE species and addressing them if present. Programs such as the Forest Stewardship Program (USDA Forest Service 2009) and forest certification programs sponsored by the Forest Stewardship Council, Sustainable Forestry Initiative and Tree Farm Program all place emphasis on identifying and addressing these species.

Results Comparison: 1990 and 2012

In contrast to the current results, the timber harvest impact assessment conducted in 1990 identified no overlaps between the THOs and the locations of threatened or endangered species. (The previous assessment only considered species listed in Vermont's Endangered Species Act.) However, in 1990 there was substantially less information available on the locations of RTE species. While 4,270 spatially-referenced RTE records were available for use in this present assessment, only around 1,100 such records existed in 1990. If anything, this suggests that timber harvests in 1990 had a much greater chance of having unintended negative impacts on RTE species simply because many sites with RTE species had yet to be identified.

At the same time, increased awareness about RTE species, and an increased ability to access information on the locations of these species (through digital mapping) may help to decrease the chance of inadvertent negative impacts to RTE species. For example, RTE species are also considered for timber harvests that require regulatory review (e.g., Act 250 or chip harvest notifications), and provisions in Vermont's Use Value Appraisal program provide opportunities for landowners to consider RTE species in management.

CONCLUSIONS

Of the 81 timber harvest operations (THOs) considered in this assessment, three overlapped with the mapped locations of rare, threatened, and endangered species as recorded by polygons in the VT Fish and Wildlife Department's Natural Heritage Database.

> All three sites were on land managed by the State of Vermont and a wildlife biologist or ecologist was involved in all three THOs.

Due to the limited available data on the actual occurrences of RTE species, it is impossible to definitively measure any potential impact to them, positive or negative, as a result of timber harvesting.

> Overall, despite much progress in mapping the locations of RTE species over the past two decades, these results still indicate at least the potential for timber harvest operations to result in adverse impacts to RTE species. Unfortunately, given that RTE populations are often scattered and small, with limited opportunities for natural recovery, even minor impacts can result in permanent damage to RTE species.

RECOMMENDATIONS

Future assessments of this type should consider a more robust assessment of RTE species. Consideration should be given to utilizing expertise in this field to more closely evaluate harvest sites for the presence of RTE species where data are lacking.

Continue statewide efforts to find, record, and monitor the locations of RTE species, and continue to use the Vermont Fish and Wildlife Department's Natural Heritage Database as the primary archive of this information.

Continue to widely distribute information on the locations of RTE species using tools such as the Vermont Agency of Natural Resources Natural Resources Atlas (Vermont Agency of Natural Resources 2013).

Encourage greater involvement from ecologists or biologists in pre-harvest inventories or forest management planning to identify whether RTE species are present, particularly where observations or pre-screening tools suggest a possibility of their presence.

Educate landowners and managers to the full suite of options and programs available to them to identify and address RTE species when managing forests. A few examples of these include:

- **The Natural Heritage Inventory of the Vermont Department of Fish and Wildlife can provide information on known occurrences of rare, threatened, and endangered plant and animal species.**
- **The Wildlife Habitat Improvement Program (WHIP) may be able to provide financial incentives and cost-sharing for management and conservation of rare species.**
- **Sites with rare species can also be enrolled as Ecologically Significant Treatment Areas under the Use Value Appraisal (UVA) program.**

CHAPTER 7: TIMBER QUALITY, REGENERATION AND FOREST HEALTH

Residual tree Damage, health, stand composition and stocking level assessments

Regeneration Assessment

Down Woody Material Assessment

INTRODUCTION

Harvesting effects on timber quality and forest health can be assessed through a number of measures. The 1990 Assessment focused on a number of soil and vegetative parameters in evaluating "timber quality and productivity." The vegetative parameters included damage to residual trees, changes in species composition, adequacy of residual stocking, and abundance and species composition of regeneration.

In 2012, the timber quality, regeneration, and forest health assessment evaluated those same parameters and supplemented them with additional measures to provide additional insights into forest health. These included assessments of the health of residual trees (crown dieback), deer and moose browsing impacts, invasive plant competition, and the presence or absence of residual down woody material sufficient to replenish site productivity. Each of these factors influences future forest diversity, structure, and functions. Soil parameters were also evaluated in 2012, and are discussed in Chapter 8.

DESIGN

Vegetation plot data and coarse woody material measures were collected at six points on each of the THOs. Before initiating the site evaluations, the timber harvesting operation was mapped using a Geographic Information System (GIS). Six data collection points were systematically located using a regularly-spaced grid of sample points generated by the GIS software. At each point, observations[63] were made within a two chain (132') radius of plot center to determine:

- pre-harvest[64] and post-harvest Society of American Foresters' cover type
- pre-harvest and post-harvest stand size class
- site quality,[65] soil drainage class, surface characteristics, slope, aspect

[63] See Appendix D: Data Collection Procedures for complete definitions and descriptions of data collection methods.

[64] Pre-harvest cover type was estimated based on residual trees and stumps.

[65] Site quality was estimated using site indicator herbaceous plants, soils and sawlog heights of dominant and co-dominant trees in the vicinity of the point.

- dominant silvicultural treatment[66]
- expected dominant vegetation[67] (3-5 years post-treatment)
- expected dominant reproduction species (3-5 years post-treatment)
- expected dominant reproduction height and crown closure (3-5 years post-treatment)[68]
- disposition of slash and extent of deer and moose browsing impacts[69]

Tree data were taken using a variable radius plot method, using a Basal Area Factor 10 prism. Diameter at breast height (dbh), tree condition (living or dead), and wildlife use were recorded for each tree. Live trees were further examined to determine crown canopy position, live crown ratio, and dieback class, and were graded to classify them as Acceptable Growing Stock (AGS)[70] or Unacceptable Growing Stock (UGS).[71]

Coarse woody material (CWM) was also assessed at each vegetation data point by establishing three transects 24' long from the vegetation plot center. Each piece of CWM that intersected one of the transects was recorded, noting species, diameter at transect crossing, diameter at large end, diameter at small end (down to 3 inch diameter), total length (down to 3 inch diameter), and decay class (Woodall and Monleon 2008).

Complete details on the data and data collection procedures can be found in Appendix D.

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[66] For the purposes of the assessment the following classifications and definitions of Silvicultural Methods were used (observed silvicultural methods were established based on outcome. No information on silvicultural intent was available to the field observers):

- **Partial Cutting/Thinning**: partial cutting resulting in >75% crown closure.
- **Group Selection**: regeneration treatment removing trees in groups or patches from 1/20 acre to 2 acres in size.
- **Shelterwood/Seed Tree/Prep Cut**: intermediate regeneration treatment resulting in crown closure of 25 to 74%.
- **Overstory Removal/Clearcut**: regeneration treatment resulting in crown closure of less than 25%. Includes both removal of trees over established regeneration and clearcuts.
- **Strip Cut**: regeneration treatment resulting in strips of trees removed, alternating with strips of retained trees or regeneration.
- **Other**: treatments not fitting the above definitions such as conversion to agriculture.

[67] A measure of "expected dominant vegetation" was used for understory data and required the field crew to assess what was in place and whether it would be the dominant understory in 3 to 5 years. See Appendix D.

[68] Estimated reproduction height (greater than or less than 3 feet tall) and percent crown closure in one of 3 classes (3-33%, 34-66% and >66%).

[69] See Appendix E: Browsing Site Conditions for Managed Northern Hardwoods for a complete description of browsing impact assessment methods.

[70] AGS (Acceptable growing stock) – a commercial species less than rotation age with relatively good vigor, containing no pathogens that may result in the death or serious deterioration of the tree before rotation age, and which contains or has the potential of producing merchantable sawtimber of USFS grade 3 quality or better (see Appendix F for USFS grading standards).

[71] UGS (unacceptable growing stock) – a tree (mature or immature) that will not grow or prospectively meet AGS standards primarily because of roughness, poor form, or non-commercial species (see Appendix F for USFS grading standards).

RESULTS AND ANALYSIS

Residual Tree Damage

Plot Level Residual Tree Damage

Four types of recent, harvest-related, mechanical and felling damage were recorded for each of the residual trees in the variable radius plots, if present: *open wounds* (sapwood exposed), *broken tops* (crown), *damaged and/or exposed roots*, and *bent over trees*. In addition, the severity of damage for open wounds (< or ≥30% of tree circumference) and broken tops (16-49% or ≥50% of crown missing) were recorded. For open wounds, no differentiation was made between new damage present on trees along skid trails that might have been retained as "bumper trees" for future harvests and other residual trees in the stands. In recent years, retention of these wounded trees to provide protection to other potential crop trees during subsequent harvests has become more common.

Injuries of these types reduce merchantability and vigor, and increase the risk of insect and disease infestation. In a change from 1990 protocol, all sides of the stem were evaluated for damage. The threshold for open wounds of 30% was selected because tree health typically recovers from damage of <30% of circumference, but recovery is less likely from wounds of more than 30% (Kelley 1996). Based on findings from forest health monitoring efforts in the northeast, decay is the most common type of tree damage, found in 15% of living trees (Steinman 2004). Since open wounds are one of the initiation sites for decay, a lower incidence of wounding is desirable.

Additional damage types of "top broken," "root damage," and "bent trees" were included in this assessment. Based on research following the 1998 ice storm, trees with 16-49% of their crown broken or missing, have a lower chance of continued vigorous growth, while trees with 50% or greater crown loss are typically at high risk of death (Kelley et al. 2002).

Table 7-1 summarizes the harvest-related residual tree damage identified in 2012 as a proportion of total damaged basal area.

Table 7-1. *Frequency of residual tree damage, listed in order of severity, from least to most severe, on timber harvesting plots in Vermont, 2012.*

Type of Damage	Percent of Trees	Percent of Damaged Basal Area
No Damage	88	--
Open Wound < 30% Circumference	7	59
Top Broken, 16-49% of Crown Missing	2	20
Open Wound ≥ 30% Circumference	1	11
Top Broken, ≥ 50% of Crown Missing	1	4
Root Exposed, Torn/Broken	<1	3
Bent, Partially-Completely Destroyed	<1	3

A study of internal wood discoloration and decay from logging wounds 15 years after harvesting showed that sugar maple is effective at compartmentalizing wounds to prevent internal decay. Shigo (1966) found that the decay process is slow, such that wounds less than ten years old would rarely show decay, but at 30 years, may have extensive decay. In this light, Kelley's results can be considered an initial assessment or a "best-case scenario" of wound size and location that results in internal decay. He found that the volume of decay and discoloration increased with increasing wound width and increasing percent of circumference wounded. Decay was absent where wound width was less than 20% of stem circumference, but 93% of trees with wounds greater than 20% of circumference had decay. The extent of decay and discoloration increased substantially when wounds were 30% or greater (Kelley 1996, Shigo 1982).

In this assessment we evaluated open wounds of sugar maple and non-sugar maples and found that 88% of trees had no observable harvesting damage. An average of 7.7% of trees had open wounds, and only 1% of these were ≥30% of stem circumference.

Results for all damage types suggest that damaged trees were proportional to their representation in the sample of all trees (Table 7-2). The 5-9 and 10-14 inch size classes, which were the most abundant in the sample, were the most frequently damaged (37% and 40% of damaged basal area, respectively).

Table 7-2. *Frequency of all tree damage by tree size class (diameter breast height, DBH) on timber harvesting operations in Vermont, 2012.*

DBH Size Class (inches)	Percent of Total Damaged Basal Area	Total Basal Area With Damage	Percent of Damaged Trees per Acre	Percent of Total Number of Trees per Acre
5-9	37%	1115	68.3%	6%
10-14	40%	1231	26.0%	2%
15-24	20%	595	5.3%	1%
25 and over	4%	106	0.4%	<1%
Total	**100%**	**3047**	**100%**	**9%**

Residual Tree Damage by Harvest Operation

Normally, damage to residual trees within a harvested area is referred to as residual *stand* damage. In this assessment, tree damage was aggregated by plot then averaged for the operation. Kelley recommended keeping residual tree damage below 20% of trees (Kelley 1996). For the following results, all types of damage are included and are grouped using < or >20% damage as an acceptable threshold.

Tree damage on THOs ranged from 0% to 50% of residual basal area. No damage was found in 7 out of 78 operations (9%).[72] Most operations had less than 20% damage (92% of operations), while 58% had less than 10% residual tree damage. Only 8% of the 78 operations had greater than 20% of the residual basal area damaged (Table 7-3).

[72] Three THOs, out of the total of 81 visited, resulted in agricultural conversions and were excluded from many of the post-harvest analyses.

Table 7-3. *Number and percentage of timber harvesting operations by residual tree damage class (all types) for 78 timber harvesting operations in Vermont, 2012.*

Percent of Total Basal Area Damaged	Number of Operations	Percent of Operations
0%	7	9%
1 - 4.9%	18	23%
5 - 9.9%	20	26%
10 - 14.9%	17	22%
15 - 19.9%	5	6%
20 - 24.9%	5	6%
25 - 29.9%	3	4%
30 - 34.9%	1	1%
35 - 39.9%	1	1%
40 - 49.9%	1	1%
Total[73]	**78**	**100%**

When tree damage on parcels enrolled in UVA was compared to non-UVA parcels, 62% of the timber harvest operations with tree damage less than 20% (the threshold to be considered minimal damage) were enrolled in UVA, compared to 20% of the private lands not enrolled in UVA. The non-UVA properties represent a smaller portion of the study, so when the damage is presented as a percent of the total for each property group, 80% of UVA lands had minimal damage compared to 85% of non-UVA lands, basically the same distribution.

Residual Tree Damage by Treatment Type

Group selection and shelterwood harvests resulted in 12% and 15% average residual basal area damage (all damage types), respectively (Table 7-4). These harvest types accounted for 27% of the sampled plots on the 78 silvicultural operations. Partial Cutting/Thinning accounted for most operations, and had the lowest residual stand damage for partial cuts at 9.6%, similar to clearcuts, though with considerably higher residual density (105 ft^2/acre vs 22 ft^2/acre).

Table 7-4. *Average percentage of damaged basal area by silvicultural method for 78 timber harvesting operations in Vermont, 2012.*

Harvest Type	Number of Plots	Average Plot Total Basal Area (ft^2/acre)	Average Percent of Total Basal Area Damaged	Percent of Total Plots
Partial Cutting/Thinning	233	105	10%	50%
Overstory Removal/Clearcut	105	22	9%	22%
Group Selection	74	75	12%	16%
Shelterwood/Seed Tree/Prep Cut	52	48	15%	11%
Stripcut	4	25	0%	1%
Total	**468**	**75**	**10%**	**100%**

[73] Excludes 3 agricultural conversions.

Residual Tree Damage by Ownership Category

Damage levels below 20% were found on 90% of public land operations and 85% of private land harvests (Table 7-5). However, operations with no damage were found only on private lands, and represented 10% of those operations. It is not possible to determine from the available data if trees were not damaged during the harvesting operation or if all damaged trees were removed.

Table 7-5. *Number and percentage of timber harvesting operations by residual tree damage class and ownership category for 78 timber harvesting operations in Vermont, 2012.*

Percent of Basal Area Damaged	Number of Operations Private	Number of Operations Public	Percent of Operations Private	Percent of Operations Public
0%	7	0	10%	0%
5 - 9.9%	33	5	48%	50%
10 - 19.9%	18	4	26%	40%
≥ 20%	10	1	15%	10%
Total	**68**	**10**	**100%**	**100%**

Residual Tree Damage: North vs. South

Differences between damage levels from northern Vermont counties to southern Vermont counties[74] were notable (Table 7-6). At 90% of sites in the south, harvests resulted in less than 20% basal area damaged, compared to 81% of sites in the north. In general, higher levels of damage were observed on northern Vermont sites.

Table 7-6. *Percentage of timber harvesting operations by residual tree damage class and geographic distribution (north/south) for 78 timber harvesting operations in Vermont, 2012.*

Percent of Basal Area Damaged	North	South
None	8%	10%
1 - 9.9%	43%	54%
10 - 19.9%	30%	27%
≥ 20%	19%	10%
Total	**100%**	**100%**

Health of Residual Trees

Previous forest health monitoring in Vermont indicates that overstory trees with more than 50% crown dieback (new dead twigs in upper and outer portion of the crown[75]) are likely to die within a 15-year period (74% mortality rate) (Kelley et al. 2002). Recovery response varies by species, with sugar maple having one of the highest recovery rates. Recovery of sugar maple trees in more intensively managed stands was lower; 58% of

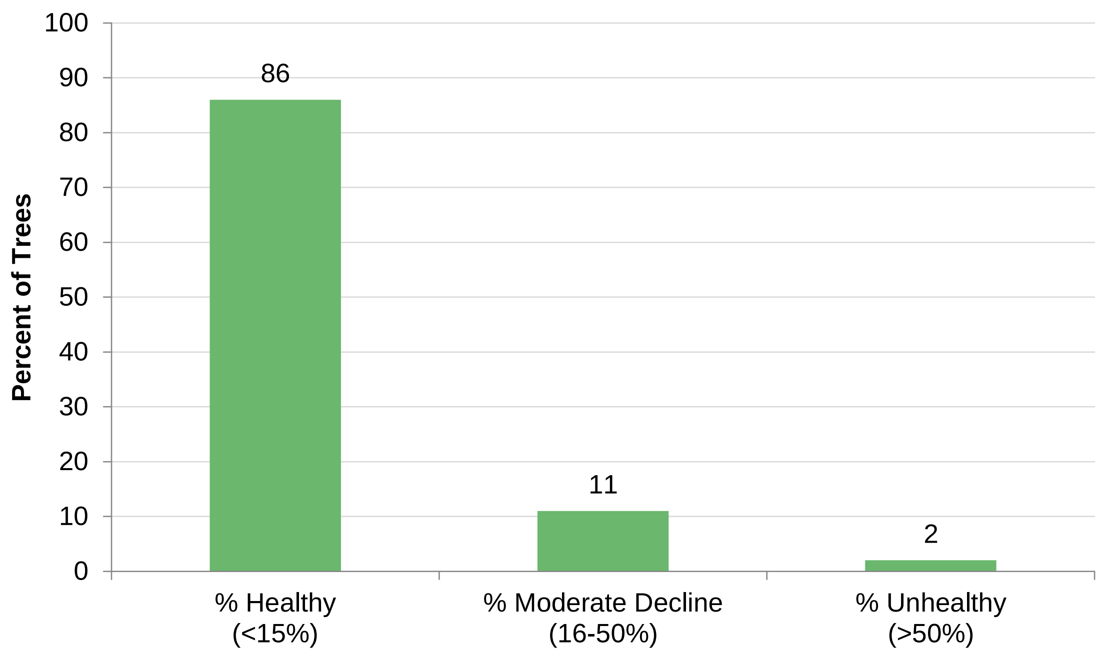
[74] The southern forest region of Vermont includes Addison, Bennington, Chittenden, Rutland, Windham, and Windsor counties. The northern forest region of Vermont includes Caledonia, Essex, Franklin/Grand Isle, Lamoille, Orange, Orleans, and Washington counties.

[75] See discussion of crown dieback assessment in Appendix G.

overstory sugar maples with more than 35% crown dieback were dead within 6 years (Allen et al. 1995). The categories of crown dieback used in this assessment were based on these and other previous tree health monitoring efforts to provide an indication of the relative health of residual trees.

An average of 86% of trees across all operations had low levels of crown dieback (<15%), 11% of trees were in the moderate crown decline category, and 2% of trees were rated as high risk (Figure 7-1). White pine and red maple were the species most commonly associated with moderate and severe dieback. The lack of pre-treatment tree health data makes it impossible to speculate on the timing, or reasons behind, the dieback observed.

Figure 7-1. Mean percent of trees with crown health ratings in healthy (<15% dieback), moderate decline (16-50% dieback), and unhealthy (>50% dieback) categories on timber harvesting operations in Vermont, 2012.



Live crown ratio (LCR), the ratio of live crown length to tree height, may be used to predict a tree's ability to respond and grow following release after partial cutting, and therefore its health and vigor. Trees with less than one third live crown are generally considered to be less likely to respond to release, so in this assessment, LCR was recorded in 2 categories: greater than or equal to 35%, or less than 35%. Only a small fraction of trees on all THOs, 17, had small LCR (< 35%).

This assessment showed a plot mean of 14.8 trees per acre were standing dead. Without knowledge of when these trees died, or the forest management goals for each operation (for example were dead or dying trees retained for wildlife habitat), no conclusions can be drawn about whether or not the logging operations had any effect on tree mortality.

Residual Stand Composition

As in 1990, residual stands were characterized based on Society of American Foresters (SAF) cover types (Table 7-7), as determined at each of six plots per THO. Pre-harvest types were estimated from the composition of the residual stand and stumps of dominant and codominant trees. Classification of the residual forest type was based on composition of dominant and codominant trees only. The influence of harvesting on composition was evaluated by comparing pre-and post-harvest cover types in partial cuts and pre-harvest types with expected dominant regeneration[76] in clear cuts and overstory removals.

Table 7-7. *Society of American Foresters cover types, cover type codes and broad forest type class (used in Figure 7-2 and Figure 7-3).*

SAF Number	SAF Type	Broad Forest Type Class*
0	not stocked or ag conversion	
11	aspen, white birch	IT
15	red pine	S
16	aspen	IT
17	pin cherry	IT
20	white pine, red oak, white ash	M
21	white pine	S
22	white pine, hemlock	S
23	hemlock	S
24	hemlock-yellow birch	M
25	sugar maple, beech, yellow birch	T
26	sugar maple, basswood	T
27	sugar maple	T
30	red spruce, yellow birch	M
31	red spruce, sugar maple, beech	M
32	red spruce	S
33	spruce-fir	S
35	northern white cedar	S
39	ash, elm, red maple	Im
54	red oak, basswood, white ash	Im
55	northern red oak	Im
108	red maple	Im

*IT Intolerant hardwood (Pioneer)
Im Intermediate hardwood
T Tolerant hardwood
M Mixed wood
S Softwood

Sugar maple-beech-yellow birch, SAF cover type 25, was by far the most abundant forest type before and after cutting on sampled harvests (Figure 7-2). There was a notable pre-harvest to post-harvest reduction in abundance of softwood types (Figure 7-3), primarily white pine types (21, 20, and 22), as well as spruce-fir (33), and red pine (15). Increases were measured for eastern hemlock (23), red maple (108), sugar maple

[76] When evaluating regeneration, the field crew was instructed to estimate and record expected dominant vegetation type, expected dominant reproduction species composition of trees, reproduction height and percent crown closure expected in 3-5 years after cutting. These estimates were based on vegetation currently present, site conditions, and professional judgment.

(27), and red oak-basswood-white ash (54) types. Increases were measured for pioneer and intermediate types such as aspen (16), pin cherry (17), and ash-elm-red maple (39). The majority of cover type changes (60%) were from the most commonly sampled types: type 21 (white pine), type 25 (northern hardwood), and type 20 (pine-oak).

Figure 7-2. Number of plots by SAF forest type class, pre- and post-harvest, on 78 timber harvesting operations (468 plots) in Vermont, 2012.

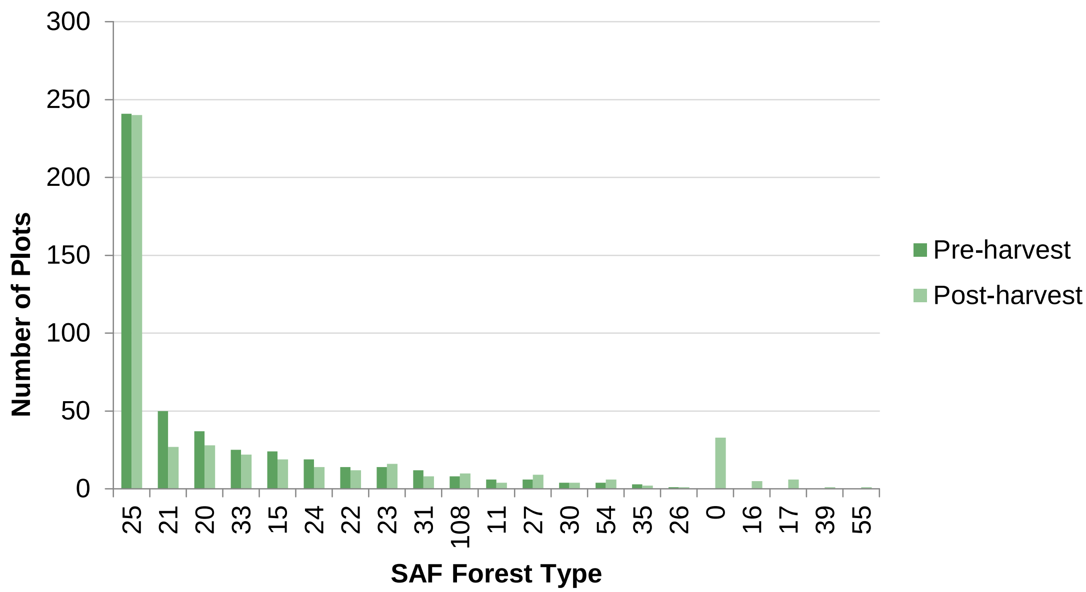
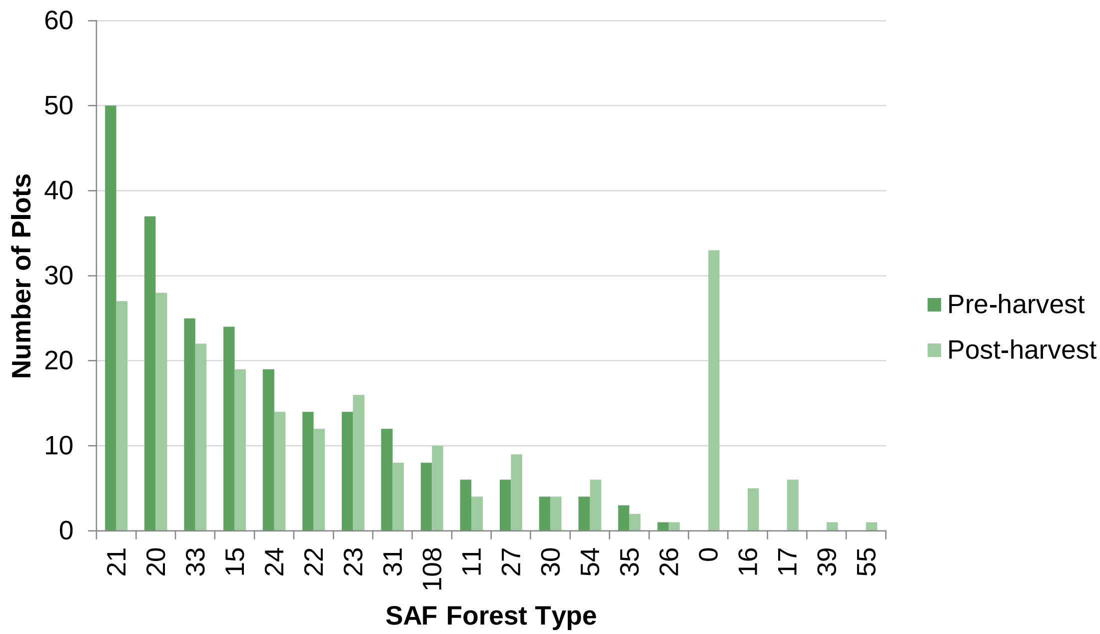


Figure 7-3. Number of plots in each SAF forest type class, pre- and post-harvest, excluding forest type 25 (northern hardwoods), on 78 timber harvesting operations (468 plots) in Vermont, 2012.



Within broader forest type classes[77] notable pre-harvest to post-harvest conversions were from softwood or mixed wood types to hardwood types (Table 7-8). Of 214 mixed wood and softwood plots, 31% (67 plots) were converted to a hardwood or open type. There were only 5 conversions in the opposite direction (hardwood to mixed wood or softwood), or 1% of the total.

Table 7-8. *Pre-harvest to post-harvest changes in broad forest type classes: Number and percent of vegetation plots by pre- and post-harvest forest type on 81 timber harvesting operations[78] in Vermont, 2012.*

Pre-harvest Forest Type to Post-harvest Forest Type	Number of Plots	Percent of Total Plots
Hardwood to:	**272**	
Hardwood	245	50%
Mixed wood	2	<1%
Not Stocked	22	5%
Softwood	3	1%
Mixed wood to:	**72**	
Hardwood	19	4%
Mixed wood	50	10%
Not Stocked	2	<1%
Softwood	1	<1%
Softwood to:	**142**	
Hardwood	19	4%
Mixed wood	2	<1%
Not Stocked	27	6%
Softwood	94	19%
Total	**486**	**100%**

Hardwood and open types increased as a proportion of all plots, while softwood and mixed wood types decreased (Table 7-9, Table 7-10).

Table 7-9. *Pre-harvest forest type class,[79] as a percentage of all timber harvesting operations sampled, on 81 timber harvesting operations in Vermont, 2012.*

Pre-Harvest Forest Type Class	Percent of All Operations
Hardwood	56%
Softwood	29%
Mixed wood	15%
Open	0%
Total	**100%**

[77] "Hardwood" is defined as < 25% softwood, "softwood" as ≥ 65% softwood, and "mixed wood" as 25 to 65% softwood.

[78] All 81 THOs included.

[79] These figures are based on aggregating plots by SAF type on 78 THOs not converted to agricultural land.

Table 7-10. *Post-harvest forest type class,[79] as a percentage of all timber harvesting operations sampled, on 81 timber harvesting operations in Vermont, 2012.*

Post-Harvest Forest Type Class	Percent of All Operations
Hardwood	58%
Softwood	20%
Mixed wood	11%
Open	10%
Total	100%

Close to a third of softwood cover types were converted to one of the three other broad cover types. This may have negative implications where softwood cover types are desired.

The silvicultural practice(s) most often associated with a cover type change were overstory removals/clearcuts or clearings, while partial cuts resulted in softwood conversion about half as often. Conversion of softwood or mixed wood types to hardwood types or open occurred on approximately 14% of all points, and at least one point on 38% of THOs.

Although trends in understory vegetation are unrelated to direct harvest impacts, these results may influence future management planning as they may indicate a further shift from softwood or mixed types to hardwood. Sixty-two percent of all mixed wood plots and 55% of all softwood plots had a hardwood or non-softwood understory, while only 3% of all hardwood plots had a softwood understory. In about half the softwood or mixed stands, softwoods are not the dominant regeneration; and they seldom are in hardwood stands.

Residual Stocking[80]

Stocking guides, prepared by the USDA Forest Service for specific forest types, provide charts that allow foresters to plot the current position of any given stand, using forest inventory data, relative to a pre-established standard. The guides typically provide reference lines labeled A, B, and C, which relate to established stocking goals for even-aged stands. The A line represents a fully stocked stand. The B line represents the suggested residual stocking, and the C line represents minimal stocking (Leak et al. 1987).

For the purposes of the 2012 assessment, residual stocking levels were determined using the mean plot basal area and mean number of trees per acre for the six, variable radius (BAF10) plots taken on each THO, using dominant and co-dominant trees only.[81]

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80 Since pre-harvest data were not available for the THOs assessed, it is not possible to make judgments on the appropriateness of implemented treatments. The results outlined here provide a baseline for future work.

81 Stocking position was calculated using specific formulas for hardwood, mixed wood, and softwood stands. The formulas calculated the A-line basal area reference for a given number of trees per acre, which was then used as the denominator to calculate the stocking position of each plot relative to the A-line reference. A-level was interpreted as 75% to 100% of the

Harvest Method and Stocking Levels

Partial Cutting/Thinning, the most common silvicultural treatment observed, representing 50% of plots, had the highest post-harvest basal area (99 ft^2/acre), or 65% of A-level stocking (Table 7-11).

Table 7-11. *Post-harvest stocking levels by silvicultural treatment on 78 timber harvesting operations in Vermont, 2012.*

Silvicultural Method	Dominant/Co-Dominant Basal Area/Acre (ft^2/acre)	Percent of A-Line[81] (Dominant/Co-Dominant Trees)	Position on USFS Stocking Chart
Partial Cutting/Thinning	99	65%	Above B-line
Group Selection	72	47%	Slightly below B-line
Shelterwood/Seed Tree/Prep Cut	46	30%	At C-line
Strip Cut	25	17%	Below C-line
Overstory Removal/Clearcut	21	19%	Below C-line

Overstory removals/clearcuts (strip and patch), were the second most common treatment with 109 plots, or 23% of all non-conversion plots. Stocking in overstory removals/clearcuts and strip cuts were both well below C-level. Plots regenerating to pioneer types had densities less than 15 ft^2/acre. Residual trees in overstory removals/clearcuts ranged in density from 3 ft^2/acre to 74 ft^2/acre.[82]

Stocking Levels and Regeneration Harvests

Overstory removals/clearcuts in tolerant hardwood, mixed wood, and softwood had considerably higher residual stocking than in intermediate or intolerant hardwood stands (Table 7-12).[83] The silvicultural treatment was classified as a regeneration harvest, in the form of a shelterwood or group selection treatment, on 27% of plots. Residual densities had a similar range in each of these harvest types (from 10 ft^2/acre to 138 ft^2/acre), but group selection treatments resulted in a higher residual stocking on average, 72 ft^2/acre vs. 46 ft^2/acre. Residual stocking levels in regeneration harvests other than clearcuts were evaluated against suggested stocking from NE 603 *'Silvicultural Guide for Northern Hardwood Types in the Northeast'* (Leak et al. 1987). These suggested residual densities, where the goal is regeneration of the stand, are:

- Tolerant hardwood regeneration: residual not less than 60 ft^2/acre
- Intermediately tolerant hardwood regeneration: residual not less than 30 ft^2/acre
- Softwood regeneration: residual not less than 100 ft^2/acre

reference basal area; B-level was 35% to 75% of the reference; and C-level was below 35% of the A-line reference. This measure is used in Table 7-11 through Table 7-16 in this section.

[82] These stocking levels are generally consistent with what would be expected by definition, particularly since the determination of the silvicultural method was made following the cutting. No information on the intended method was collected during the interview process. In treatments such as overstory removal/clearcut, higher basal area measurements were likely a result of randomly located plots that measured patches of saplings/small poles, reserved patches within the treatment area, or were located close to the edge of the treatment area.

[83] The shade–tolerance categories of tolerant, intermediate, and intolerant indicate whether the species can regenerate and persist under conditions of heavy, moderate, or no shade, respectively. Moderate shade is defined as 30 to 70% crown cover. NE-603 Leak et al. (1987).

Hardwood type residual density was within the ranges specified in NE-603, though tolerant hardwoods, on average, were slightly understocked for tolerant hardwood regeneration goals. Mixed wood and softwood stands, on average, were below recommended levels of stocking for sustaining existing softwood regeneration or the establishment of new softwood regeneration (Table 7-12).

Table 7-12. *Post-harvest stocking levels by broad forest type class in regeneration harvests on 78 timber harvesting operations in Vermont, 2012.*

Broad Forest Type	Basal Area of Dominant/Co-Dominant Trees (ft^2/acre)	Trees Per Acre	Mean Stand Diameter (inches)	Percent of A-Line[81] (Dominant/Co-Dominant Trees)
Softwood	83	121	12	37%
Mixed wood	54	92	12	35%
Tolerant hardwood	52	108	10	44%
Intermediate hardwood	42	125	10	28%

Stocking Levels of Acceptable Growing Stock

Post-harvest number of trees per acre, mean stand diameter (MSD), total basal area (BA), and acceptable growing stock (AGS) basal area were summarized for all partial harvests by broad cover type (Table 7-13).

Table 7-13. *Residual stand characteristics by partial harvest silvicultural treatment and broad forest type class on 78 timber harvesting operations in Vermont, 2012.*

Silvicultural Method: Broad Forest Type Class	Basal Area of Live Trees (ft^2/acre)	Basal Area of AGS[70] (ft^2/acre)	Basal Area Dominant/ Co-Dominant Trees (ft^2/acre)	Trees Per Acre Dominant/ Co-Dominant	Mean Stand Diameter (inches)	Percent of A-line[81] of Dominant/ Co-Dominant Trees	AGS as Percent of Total Basal Area
Group Selection							
Hardwood	67	43	63	128	10	53%	64%
Mixed wood	62	43	58	99	12	33%	69%
Softwood	101	77	96	143	12	41%	76%
Treatment Average	**77**	**54**	**72**	**123**	**11**	**42%**	**70%**
Shelterwood/Seed Tree/Prep Cut							
Hardwood	38	21	36	75	11	29%	55%
Mixed wood	62	45	59	102	12	33%	73%
Softwood	70	46	69	121	12	28%	66%
Treatment Average	**57**	**37**	**55**	**99**	**12**	**30%**	**65%**
Partial Cutting/Thinning							
Hardwood	89	53	84	147	11	70%	60%
Mixed wood	102	61	93	131	12	53%	60%
Softwood	147	100	136	165	13	59%	68%
Treatment Average	**83**	**71**	**104**	**148**	**12**	**61%**	**63%**

Limited conclusions can be drawn from these post-harvest data, but the Silvicultural Guide for Northern Hardwood Types in the Northeast (Leak et al. 1987) does provide some insights into the minimum AGS basal area needed for the efficient practice of uneven-aged management in northern hardwood and mixed wood forest type classes. For the purposes of this assessment these guidelines were therefore assumed to be the minimum AGS basal area to be retained following treatments.

The guide suggests minimum AGS basal areas of 40 ft^2/acre and 60 ft^2/acre, for hardwood and mixed wood type classes respectively, when practicing uneven-aged management. If the treatments on sampled THOs and classified as group selection and partial cutting/thinning were assumed to have been intended as uneven-aged treatments,[84] then group selection treatments in the hardwood forest type class and the partial cutting/thinning treatments for both hardwood and mixed wood all had sufficient retained sawlog-quality trees to justify uneven-aged management into the future. The group selection treatments in the mixed wood forest type class, on average, had insufficient retained AGS to justify uneven-aged management into the future.

As noted in the previous section of this report, the northern hardwood guide also provides target residual basal areas for shelterwood cuts, but does not specify AGS stocking levels.

Post-Harvest Stocking and State-wide FIA Data

When compared with statewide FIA data, harvested stands in this assessment had lower stocking (49% vs 63% of A level from FIA) and reduced AGS (54% of total BA vs 78% from FIA). The plots of the most dominant forest type in this assessment and statewide, beech-birch-maple or northern hardwood, had a considerably lower AGS across all THO plots, 40 ft^2/acre vs 71 ft^2/acre for all FIA plots.

Comparison of Stocking: North vs. South[74]

Plots in southern Vermont counties had higher tree density and AGS stocking, and larger mean stand diameters overall and across all harvest types after harvest (Table 7-14) when compared to plots in northern counties. This result suggests a negative impact in regeneration harvests where the residual stand provides less light with more competing vegetation for new seedlings, and a positive impact in thinning with more trees retained for future harvests.

Comparison of Stocking by Ownership Category

Residual density and AGS were lower in hardwood plots located on public land when compared to hardwood plots on private land, while residual density and AGS were considerably higher in softwood and mixed types on public land when compared with plots on private land.

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[84] Classification of the treatment methods employed reflects only the outcome of the treatment. No data were available regarding the intent of the observed treatments.

Table 7-14. *Residual stocking levels by geographic region[74] and silvicultural method on timber harvesting operations in Vermont in 2012.[85]*

Silvicultural Method	Live Basal Area (ft^2/acre)	Basal Area of AGS (ft^2/acre)	Dominant/ Co-Dominant Basal Area (ft^2/acre)	Dominant/ Co-Dominant Trees Per Acre	Mean Stand Diameter (inches)	Percent of A-Line[81] (Dominant/ Co-Dominant)	AGS as Percent of Total Basal Area
North							
Overstory Removal/ Clearcut	15	9	14	39	5	11%	60%
Stripcut	20	10	20	66	7	11%	50%
Group Selection	66	44	64	109	10	37%	66%
Shelterwood / Seed Tree/ Prep Cut	48	26	42	95	11	29%	54%
Partial Cutting/ Thinning	97	59	92	151	11	60%	61%
North Average	**49**	**30**	**46**	**92**	**9**	**30%**	**59%**
South							
Overstory Removal/ Clearcut	31	16	30	51	10	26%	51%
Stripcut	37	19	37	15	21	29%	51%
Group Selection	84	59	79	142	12	57%	70%
Shelterwood / Seed Tree/ Prep Cut	55	36	52	74	12	30%	65%
Partial Cutting/ Thinning	111	71	104	148	12	69%	68%
South Average	**64**	**40**	**60**	**86**	**13**	**42%**	**62%**

[85] Minor math discrepancies are due to effects of rounding over multiple axes.

Comparison of Stocking by Use Value Appraisal Participation

Plots on parcels enrolled in the state's Use Value Appraisal program, on average, had higher density in total and greater density of AGS quality trees, as well as a higher mean stand diameter (Table 7-15).

Table 7-15. *Residual stocking levels by Use Value Appraisal Program (UVA) participation on timber harvesting operations in Vermont in 2012.*[86]

UVA Status	Live Basal Area (ft^2/acre)	AGS Basal Area (ft^2/acre)	Dominant/ Co-Dominant Basal Area (ft^2/acre)	Dominant/ Co-Dominant Trees Per Acre	Mean Stand Diameter (inches)	Dominant/ Co-Dominant Percent of A-Line Stocking[81]	AGS as % Total Basal Area
Eligible But Not Enrolled in UVA (48 plots)	65	40	62	101	9	43%	61%
Enrolled in UVA (354 plots)	75	49	71	116	11	52%	64%
Mean (402 plots)	**70**	**45**	**67**	**109**	**10**	**48%**	**62%**

Comparison of Stocking by Forester Participation

Timber harvesting operations with forester supervision had higher residual AGS levels on average, with slightly larger residual trees than those harvests without forester involvement (Table 7-16).

Table 7-16. *Residual stocking levels by forester involvement (forester involved vs. not involved) on 78 timber harvesting operations in Vermont in 2012.*[87]

Forester Involvement	Live Basal Area (ft^2/acre)	Dominant/ Co-Dominant Basal Area (ft^2/acre)	AGS Basal Area (ft^2/acre)	Dominant/ Co-Dominant Trees Per Acre	Mean Stand Diameter (inches)	Dominant/ Co-Dominant Percent of A-Line[81]	AGS as % Total Basal Area
Involved (420 plots)	79	74	50	121	10.8	51%	63%
Not Involved (66 plots)	54	49	28	72	9.4	39%	52%

Forester-supervised overstory removal/clear cut harvests, had densities approximately 50% lower than on similarly classified harvests with no forester involvement. These lower residual densities more closely followed silvicultural guidelines specifying lower densities for regeneration harvests. In partial cutting/thinnings, forester-supervised harvests tended to have densities classified as "well stocked," with a higher AGS stocking level compared to harvests that did not have forester involvement. THOs without forester involvement and classified as partial cutting/thinning were overstocked with lower AGS stocking.

86 Excludes THOs on public land which, by definition, are not eligible for the UVA program.

87 Agricultural conversions were excluded.

Regeneration

Understory vegetation and browse impacts were evaluated on all plots to predict potential future forest composition, forest type, and to identify potential areas of concern for regeneration. On non-agricultural conversion plots, 47% of plots had a dominant understory vegetation of tree seedlings and/or saplings (Table 7-17). Thirty-two percent of understory plots were dominated by ferns and/or herbaceous plants. Although some fern species (hayscented and New York fern) are known to form dense patches that suppress regeneration, these were not singled out among these vegetation types. Field notes indicate that hayscented and New York fern were the most common fern species in fern-dominated plots. Invasive plants are known to out-compete native species on the forest floor, and 31 plots (7%) had one or more invasive species present.

Table 7-17. *Frequency and percentage of plots by most dominant understory vegetation type on 78 timber harvesting operations in Vermont, 2012.*[87]

Vegetation Type	Number of Plots	Percent of Plots
Seedling/Sapling	221	47%
Fern/Herbaceous	148	32%
Shrubs	38	8%
Invasive Exotic Plant	31	7%
Beech Sprouts	25	5%
None	2	<1%
Unknown	3	<1%
Total	**468**	**100%**

In addition, in regenerating plots (seedling/sapling), 51 (41%) out of a total of 124 plots were expected to have commercial seedlings or saplings as the dominant vegetation in 3 to 5 years. The remaining 73 plots were primarily stocked with non-woody vegetation, beech sprouts, which can favor the creation of a monoculture of beech in the understory, unacceptable growing stock (UGS) seedling/saplings, or non-native plants. Of those regenerating plots in the seedling/sapling class, the most common cover types were intermediate hardwood (36%) and northern hardwood (38%).

In 1990 seedling/sapling and coppice regeneration were combined into one category. Combining these categories in 2012 results in 48% of regenerating plots stocked with tree regeneration, considerably lower than the 89% of regenerating plots in 1990. Several factors may be responsible for this change including: drought, which has a more detrimental effect on sugar maple than on beech from root sprouts; deer or moose browsing pressures; and/or calcium depletion, which at sites reaching critically reduced levels may no longer support the nutrient requirements for sugar maple regeneration, but is adequate for lower-demanding beech (Long et al. 2009). In addition, beech is known to sprout aggressively following disturbance and is highly shade tolerant.

Regeneration at the Regional Level

There were some notable regional deviations from the mean related to regeneration type and composition. Caledonia, Essex, and Orleans county plots had a higher overall percentage of desirable seedling and sapling vegetation. Windham and Windsor counties combined had regeneration that was poorer than average, with ferns, beech sprouts, or invasive plant species being the dominant vegetation type on 55% of plots, and 33% of seedling and sapling regeneration made up of unacceptable growing stock.

Regeneration and Harvest Type

Low residual density treatments (overstory removal/clearcut, strip cut, and group selection) and higher residual density treatments (shelterwood, seed tree, prep cut and partial cutting/thinning) displayed notable differences in dominant understory vegetation. Statistical significance of these differences was not determined and should not be implied.

Treatment areas with low residual densities had a dominant understory of shrubs on 12% of sites. Beech sprouts were the dominant understory in 2% of these treatment sites.

In treatment areas with higher residual densities, the dominant understory vegetation was beech sprouts and shrubs, on 8% and 6% of sites, respectively. Typically, the shrubs were a mix of blackberry and raspberry. Occurrences of invasive plants in higher residual density harvests were lower (4% vs 8% in low residual density harvests), but the occurrence of invasive species in this THO sample was low in general, making it difficult to make solid conclusions.

Regeneration Related to Browse Assessment

Deer and moose browsing impacts, short-term and historical, were evaluated using the Browsing Site Conditions for Managed Northern Hardwoods (VT F&W 2012); a system that considers both current browsing intensity and the sensitivity of the particular site to future browsing impacts (see Appendix E). This system was designed cooperatively by the Vermont Departments of Forests, Parks and Recreation, Fish and Wildlife, and the Woodland Owners Association located in Windham, Vermont. The method examines visible evidence of recent browsing, as well as the composition and condition of understory plants, to determine the level of browsing intensity.

Relationships between browse level and understory vegetation were notable on some plots. In particular, plots where ferns and herbs were the expected dominant vegetation type were more common in areas rated heavy or severe for browse (Table 7-18.)

Table 7-18. *Expected dominant vegetation in 3-5 years by browse level rating on (78) timber harvesting operations in Vermont, 2012.*

Expected Dominant Vegetation (in 3-5 years)	**Browse Level Rating**				
	None-Light	**Moderate**	**Heavy**	**Severe**	**Total**
None	<1%	0%	0%	0%	<1%
Ferns and herbs	28%	31%	44%	38%	32%
Shrubs	11%	6%	11%	0%	8%
Beech Sprouts	5%	6%	3%	0%	5%
Seedlings/Saplings	43%	51%	42%	50%	47%
Non-Native Invasive Plants	11%	5%	0%	13%	7%
Unknown	<1%	0%	0%	0%	<1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Northern hardwoods (sugar maple, beech, yellow birch) were the dominant seedling-sapling type, in plots both fully and partly stocked with seedlings and saplings, at all densities and browse levels with the exception of several plots in softwood stands that had regenerated to softwood species. Unacceptable hardwood (UGS) regeneration was the second most common type at most browsing levels. (Table 7-19).

Table 7-19. *Expected dominant tree regeneration species group in 3-5 years by browse level rating on 78 timber harvesting operations in Vermont, 2012.*

Expected Dominant Tree Species Group (in 3-5 years)	Browse Level Rating			
	None-Light	**Moderate**	**Heavy**	**Severe**
No Commercial Tree Species	3%	3%	0%	0%
White Pine	1%	2%	2%	50%
Spruce-Fir	11%	5%	2%	25%
White Ash, White Birch, Red Maple	12%	16%	5%	0%
Sugar Maple, Beech, Yellow Birch	38%	50%	42%	25%
Other Commercial Hardwood	2%	3%	2%	0%
Mixed Hardwood/Softwood	6%	4%	6%	0%
Unacceptable Growing Stock	27%	18%	42%	0%
Total	**100%**	**100%**	**100%**	**100%**

Projected Seedling Success Related to Browse Level

The moderate browsing level description in *"Browsing Site Conditions for Managed Northern Hardwoods"* indicates likely success for regeneration of most tree species except ashes and oaks. Eighty-five percent of plots were rated as "none to light" or "moderate" browsing sensitivity. For plots where regeneration success was expected, low-level browse areas ("none-light"), made up 34% of the sample plots. Looking at multiple variables, if sites where regeneration success is most likely are those where: a regeneration harvest[88] had occurred; browsing sensitivity was rated none to moderate; and native seedlings, saplings, or rubus species were the dominant understory; then regeneration success is likely in 219 plots, 45% of all plots. Plots with browse levels that would impede or eliminate oak and ash regeneration (moderate to severe browse) totaled 66% of plots, if oak and/or ash seed or sprout sources were present.

The use of post-harvest slash as a seedling protector has been recommended by Joshua Hunn in, *Retention of logging debris to reduce deer browsing and promote forest regeneration* (Hunn 2007). Observations of post-harvest slash indicate that this technique was seldom used on the sampled sites. Where it was retained, results suggest that slash in the >3' category would be most desirable as a seedling protector. On plots rated as heavily browsed, only 5% of plots had slash evenly distributed and greater than 3' in height (Table 7-20). On these sites, most slash was below 3' in height (29%) or was removed from the site (32%). On plots ranked as having severe browsing, most tops were removed from the site (62%), while the remainder of plots left slash on site but lopped it to less than 3' (38%). Other methods of slash retention may be advantageous, but where slash is removed from the site entirely, 62% of sites with

[88] Regeneration harvests in this context included Overstory Removal/Clearcut, Strip Cut, Shelterwood/Seed Tree/Prep Cut and Group Selection.

severe deer browse, seedlings are vulnerable to further browse impact. In other words, browse pressure was heavier on sites without slash.

Table 7-20. *Percent of browse plots by type of slash distribution in plots and browse level on (78) timber harvesting operations in Vermont, 2012.*

Slash Distribution	Browsing Level Rating			
	Severe	**Heavy**	**Moderate**	**None-Light**
Evenly Distributed <3 feet	37.5%	29.0%	25.2%	25.0%
Evenly Distributed >3 feet	0.0%	4.8%	3.8%	11.9%
Evenly Distributed/Tops Intact	0.0%	8.0%	15.1%	13.1%
Piled/Windrowed	0.0%	12.9%	19.3%	11.2%
Removed From Site	62.5%	32.2%	28.1%	26.2%
Unevenly Distributed	0.0%	12.9%	8.4%	2.5%

Down Woody Material

Down woody material (DWM) serves many ecological functions. A wide variety of wildlife species rely on DWM for habitat and nourishment (see Chapter 10). DWM functions to store carbon and nitrogen. Decomposition of DWM replenishes soil nutrients, soil carbon and carbohydrates, and provides substrate and nutrients for fungi, plants, and microorganisms. Structurally, it shades soil to help with forest temperature moderation. Leaving tree tops, some large diameter downed trees, and foliage on site after a timber harvest helps to replenish organic matter content, moisture holding capacity, increase rooting depth, and enhance soil nutrition.

Stand age (usually referred to as stand size class: seedling/sapling, pole size, or sawtimber size) influences the abundance and diameter of DWM. Regenerating stands (seedling/sapling size class) may have remnants of large diameter DWM from past mature forests, but it is more mature stands (sawtimber size class) that would be expected to have larger diameter DWM. Vermont's Forests 2007 (Morin et al. 2011) indicates that 64% of Vermont's Timberland is made up of larger diameter stands, but that the state has a very low percentage of "older" forests. This assessment of THOs should, therefore, reflect higher levels of abundance and diameter of DWM since "large" diameter sawtimber stands are generally those harvested commercially. In spite of the increasing size of trees in Vermont, our forests are relatively young in ecological terms, having become established following agricultural abandonment and/or heavy logging during the 19th and early 20th centuries.

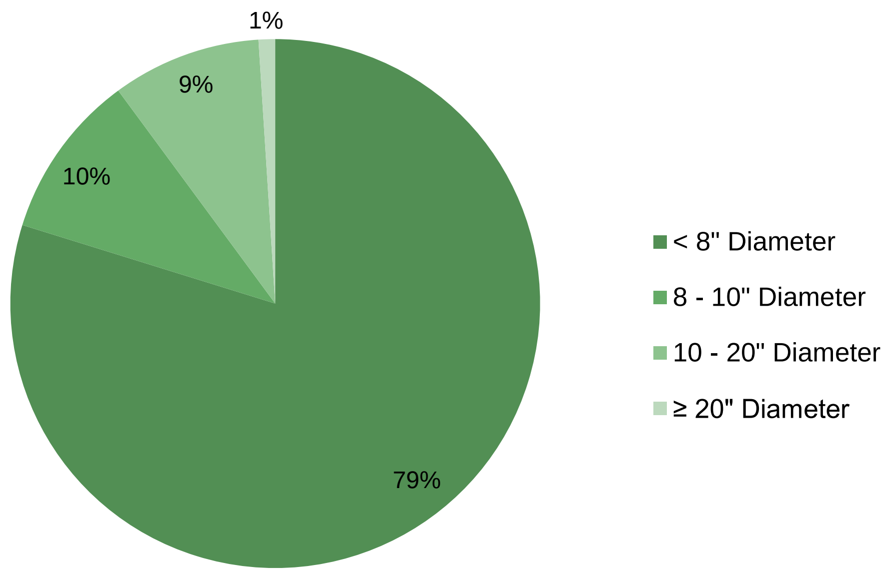
As trees grow, their biomass increases exponentially. Since tree biomass is roughly half carbon, retaining larger diameter trees as down material can have significantly greater benefits than retaining many small diameter trees.

For this survey, we limited measurement of DWM to coarse woody material (CWM), material that is greater than 3 inches in diameter and greater than 3 feet in length. The mean volume of CWM on sampled THOs was 870 ft^3/acre. Of the 465 plots analyzed, 57% of plots had less than the mean for the statewide FIA data (550 ft^3/acre CWM). Several THOs had large amounts of CWM (in excess of 9,000 ft^3/acre) and 21% had volumes greater than 1,200 ft^3/acre (Table 7-21). The size of down material was dominated by pieces less than 8 inches in diameter (79% of pieces), and only 1% of pieces were 20” diameter or greater (Figure 7-4). Nearly half the down wood was in decay classes 1 or 2 (recently down) (Figure 7-5), indicating that while the recent harvest had created new CWM, past harvesting practices may not have favored retention of CWM or the large diameter stems required for recruitment. The statewide FIA data likewise showed a lack of larger diameter down wood (>8” diameter), especially those sizes greater than 20 inches in diameter (Morin et al. 2011).

Table 7-21. *Frequency and distribution of the volume of coarse woody material (CWM) measured on 465 plots*[89] *on 78 timber harvesting operations in Vermont, 2012.*[87]

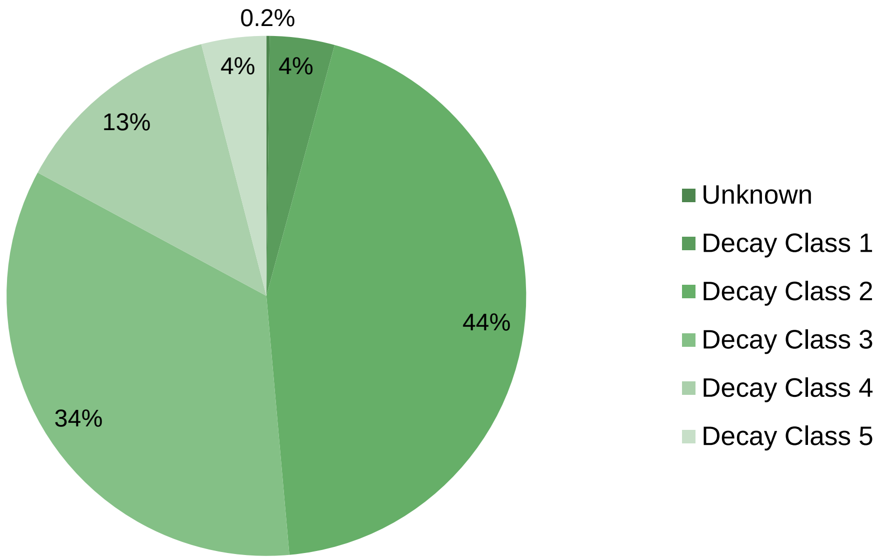
Total CWM Volume (ft^3/acre)	Number of Plots	Percent of Plots
None	75	16%
1-550	191	41%
551-1200	101	22%
>1200	98	21%

Figure 7-4. Distribution of coarse woody material by size class (diameter at sample line intercept) on timber harvesting operations in Vermont in 2012. Shown as percent of pieces by size class.



[89] Three plots were excluded from the analysis due to data errors.

Figure 7-5. Distribution of coarse woody material volume (percent of total volume) according to decay class[90] at time of assessment on timber harvesting operations in Vermont in 2012.



In addition to the FIA data on DWM, several recent studies provide a reference for how much down wood may be desirable when practicing silviculture. Keeton et al. (2011) sampled CWM at 40 northern hardwood sites in the Northern Forest states and found that mature[91] forests (not old growth[92]) with minimal disturbance averaged 1,200 cubic feet per acre of CWM, while old growth forests had nearly 1,800 cubic feet per acre (William S. Keeton, personal communication, Rubenstein School of Environment and Natural Resources, University of Vermont, 2012).

Morin compared Vermont inventory data to previously published work by McGee et. Al. (McGee 1999). McGee reported that old growth northern hardwood stands contained about 332 cubic feet of CWM per acre, greater than or equal to 20 inches in diameter, and 998 cubic feet of CWM between 10 and 20 inches in diameter. By contrast, Vermont's forests, on average, contain 101 cubic feet per acre of CWM greater than or equal to 20 inches in diameter (Morin and Woodall 2012). In addition, the average acre in Vermont's forests contains 201 cubic feet of CWM volume in the 10 to 20 inch diameter class.

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[90] See Data Collection Procedures (Appendix D) for a full description of decay class ratings.

[91] "Mature" forest designation refers to stands that are approximately 80–150 years of age, exhibiting even to multi-aged (two or three age classes) structure. The mature stands originated after logging and human-caused wildfires in the late 19th and early 20th centuries and have had little or no logging since establishment (Keeton et al. 2011).

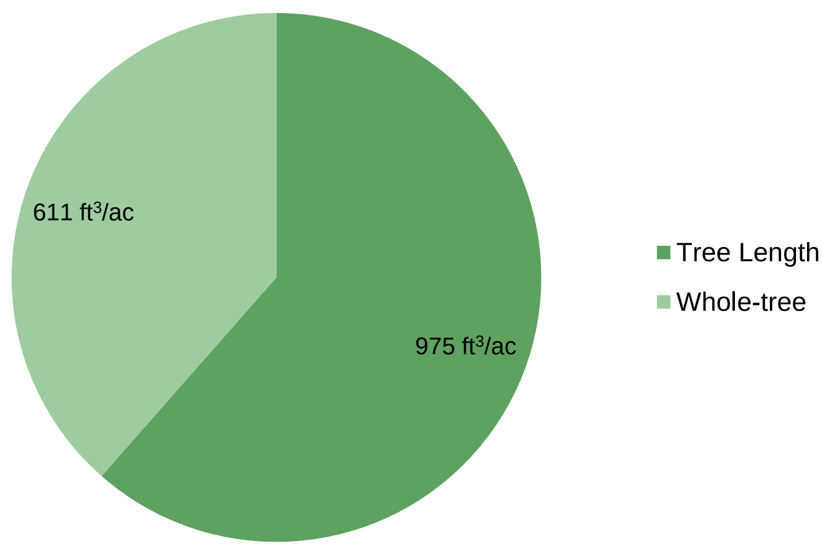
[92] Old-growth is greater than 150 years of age and having complex structure, but encompassing both the vertical diversification and horizontal diversification stages described by Franklin et al. (2002). Old-growth is a stand development condition, and therefore can redevelop in secondary forests (William S. Keeton, personal communication, Rubenstein School of Environment and Natural Resources, University of Vermont, November 29, 2014).

Down Woody Material, Treatment and Harvest Type

There was no substantial difference between silvicultural treatment types and the amount of DWM. The data suggest a difference,[93] however, in the amount of down material left after whole tree removals compared to tree length removals.

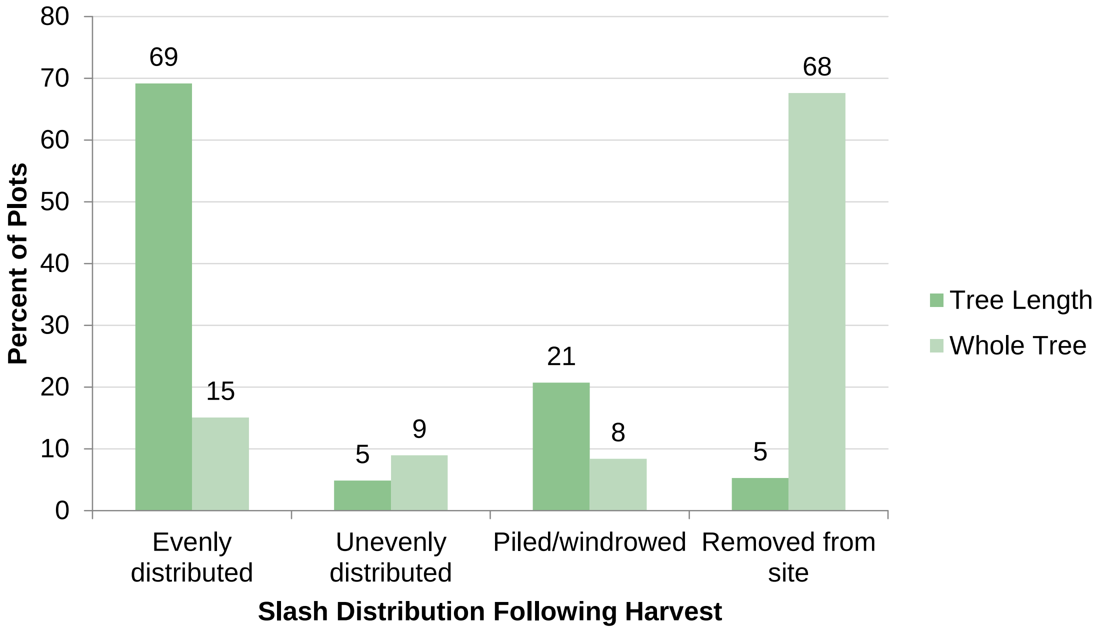
The volume of CWM was higher, and a greater percentage of slash was left onsite, following harvests with tree length removals as compared to whole tree harvests (Figure 7-6, Figure 7-7). On average, tree-length skidding left 975 ft^3/acre of CWM compared to 611 ft^3/acre left from whole-tree skidding. Tree-length skidding methods were also more likely to evenly distribute residual slash (DWM) across the site than where whole-tree skidding methods were used, 69% vs. 15%, respectively (Figure 7-7).

Figure 7-6. Comparison of skidding method and residual volumes of coarse woody material (ft^3/acre) on timber harvesting operations in Vermont, 2012. Note: sites that used multiple skidding methods were excluded from this analysis.



[93] Statistical significance of this difference was not determined.

Figure 7-7. Comparison of skidding methods and fate of residual slash on timber harvesting operations in Vermont, 2012. Note: sites that used multiple extraction methods were excluded from this analysis.



Results Comparison: 1990 and 2012

Direct comparisons of residual stand damage between 2012 and 1990 were not possible. Damage categories were updated for the 2012 assessment based on new studies that defined significant wounds based on effects on tree health and timber quality; size classes measured in 1990 included a “<5 inch DBH class,” which was not repeated in the 2012 assessment; and more thorough damage assessments were made in 2012 using the whole bole, instead of a single stem face as done in 1990.

Unlike 1990, a majority of overstory removal/clearcut harvests observed in 2012 had a low frequency of seedling or sapling regeneration. In 1990 the forest floor on plots that had their overstories removed was occupied primarily by seedlings or coppice 68% of the time, and ferns/herbs/Rubus 8% of the time. In 2012 seedling/sapling/coppice stems were the dominant understory vegetation in 49% of this harvest type, and 45% were occupied by ferns/herbs and Rubus spp.

Residual stocking level results were remarkably similar to 1990 in several ways. Intermediate treatments in most types resulted in adequate residual stocking, while residual stocking in regeneration harvests was less than recommended for mixed wood and softwood types. However, in 2012 it appears residual densities in regeneration harvests overall were often lower than in 1990, with densities more commonly at levels that favor intolerant or intermediate hardwood, rather than tolerant hardwood or softwood regeneration.

CONCLUSIONS

Results of this assessment suggest that regenerating native tree species will be a challenge on a number of the THOs assessed, which will require attention to silvicultural practice, control of competing vegetation, and continued population management of whitetail deer and moose.

> Nearly one third of understory plots were dominated by ferns and/or herbaceous plants, and less than half of plots had a dominant understory of seedlings or saplings. In addition, on plots located in treatment areas likely to be intended to regenerate the stand (overstory removal/clearcut plots) seedlings and saplings were the dominant vegetation on less than one half the plots, down from nearly two thirds of the plots in 1990.

Residual stand damage levels observed during this assessment were similar to, or lower than in 1990, despite the more comprehensive assessment of damage made in 2012.

> Logging damage to residual trees was low, with 88% of sampled trees having no damage and 92% of operations having less than 20% of the residual basal area damaged. Residual tree damage was not extensive in the 2012 assessment, but managed forestland in Vermont is likely to be harvested periodically and damage can accumulate over time. Accumulated damage was not measured in this assessment.

Analysis of the pre- and post-harvest cover types on sampled THOs suggest that, over the long term, many softwood and mixed wood stands may be replaced by hardwoods.

> Changes in composition can be attributed to a number of factors including silvicultural practices, land management history, and accumulated browsing impacts. Mixed wood and softwood stands on assessed THOs were, on average, found to be below recommended levels of stocking for sustaining existing softwood regeneration or the establishment of new softwood regeneration. Natural succession may also be an important factor, particularly in relation to white pine stands (most of which were established on abandoned agricultural lands) transitioning to the hardwood types that likely occupied these sites before European settlement.

Both forester involvement and enrollment in UVA had a positive effect on anticipated silvicultural outcomes. In general, operations with forester involvement led to results that more closely followed established guidelines for post-harvest conditions. Forester involvement and UVA participation resulted in better stocked stands of sawtimber-quality trees in partial cuts, and clearcuts that were silviculturally correct and effective with respect to ensuring regeneration success.

Operations on lands enrolled in UVA and those with forester involvement resulted in higher residual densities and AGS in intermediate treatments, and lower residual densities in clearcuts.

Data related to residual stocking suggest that the Current Use program and the increasing use and influence of foresters appear to be having a positive influence on the quality of forest management practiced.

Harvest operations contributed to the amount of DWM left on sampled THOs, but more effort is needed to increase amounts and sizes of retained down woody material following harvests to help maintain or improve site productivity.

The mean volume of CWM on sampled THOs was considerably higher than the statewide mean reported by FIA, but also much less than volumes considered desirable when practicing silviculture. The majority of CWM was less than 8 inches in diameter, and the new down woody material, some from current harvest operations, represented about half the total CWM. Whole tree harvests (WTH) left measurably less down woody material than tree length harvests, though the mean volumes were slightly higher than the statewide mean. Given that there has been a sizeable increase in WTH operations since the 1990 assessment, these results indicate relatively lower volumes of residual material left to replenish soil productivity where this harvest system is utilized.

RECOMMENDATIONS

The lack of regeneration and the presence of established competing vegetation and/or mid-level shade in many stands suggest a need to carefully apply silvicultural guidelines to ensure more effective regeneration treatments in the future. Current conditions in some stands may require aggressive pre-harvest treatments (mechanical, herbicides, or in combination) to control competing vegetation, and/or site preparation to ensure the establishment of desired regeneration. Silvicultural systems may need to be adjusted to adequately address the increased potential for interfering vegetation.

Longer-term monitoring should be conducted to determine the ultimate success or failure of obtaining desirable regeneration under a variety of conditions.

More focused assessment of softwood and mixed wood stands, managed to perpetuate these forest types, should be conducted to determine the most successful techniques for ensuring successful establishment of softwood regeneration on suitable sites.

The browse sensitivity method of assessing deer and moose browse intensity should be further evaluated and, if needed, refined to better reflect observed and recorded forest and regeneration condition.

Regional differences in regeneration success or potential were significant in some instances and should be used to inform deer and moose population management and silvicultural practice and climate change adaptation.

Develop a single standard for an Acceptable Growing Stock tree, and provide training regarding what constitutes a high quality stem at the regeneration, pole, and sawtimber size class.

Develop guidelines for down woody material retention to ensure adequate amounts and sizes of down material are left on site following harvests.

Future assessments should consider measurement of both recent and pre-existing wounds, as well as noting whether or not the wounded tree was retained to serve as a bumper tree along a skid trail.

Investigate the possibility of aggregating existing data from a variety of sources (public and private) to help provide a statewide data set as a basis of comparison with pre-harvest conditions in future assessments. A subset of basic and consistently defined data on stand density, composition, and quality, as well as regeneration condition, could yield ongoing information to guide practice and policy.

If ongoing assessments of forest management, harvest impacts, and quality are a goal for policy makers and professional foresters, a post-project group should be convened to make recommendations for future assessments.

CHAPTER 8: FOREST SOIL ASSESSMENT

INTRODUCTION

Soil is a fundamental ecosystem component and a foundation of maintaining healthy forests. The objective of forest soil management is to maintain and enhance soil quality, and thereby sustain soil functions and productivity potential.

- *Soil quality, also known as soil health* (USDA-NRCS, web), is defined as the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (Karlen et al. 1997).
- *Soil functions* include regulating the movement of water in the soil; sustaining biological diversity, activity, and productivity; storing and cycling nutrients and carbon; filtering, buffering, degrading, and detoxifying potential pollutants; and providing physical support for terrestrial organisms (USDA-NRCS 2008).

Soil disturbance and the exposure of mineral soil may occur as a result of the use of harvesting equipment. While exposure of mineral soil may be desirable when regenerating certain tree species is a management goal, this disturbance can also result in soil erosion.

DESIGN

The soil assessment completed in 2012 was based on the 1990 assessment, which limited the collection of soil impact data to: the presence or absence of soil erosion; and exposure of bare mineral soil. These conditions were considered the most critical at the time of the 1990 assessment because “Soil disturbance… almost certainly increases the potential for erosion and because it can influence the rate of colonization and species composition of subsequent regeneration on the site” (Newton et al. 1990). Data were collected on three plots located at a pre-determined distance and azimuth from each of the six vegetation data points assessed on each THO.

A more robust set of soil disturbance parameters was selected for measurement for the 2012 assessment based on the Forest Soil Disturbance Monitoring Protocol (Page-Dumroese et al. 2009) developed by the USDA Forest Service. These parameters, chosen for their ability to be measured consistently, efficiently, and economically were: the extent of bare soil; erosion severity; depth of compaction; extent of rutting; and the soil disturbance class.[94] The soil disturbance class provided a cumulative assessment of impacts at each soil data point (Page-Dumroese et al. 2009). Table 8-1 provides a summary of the specific data that were collected at each soil data point and a brief description of the importance of each parameter. It should be noted that the measurement of soil bulk density was considered, but was determined by the project

[94] “Burn severity” is also included in the set of parameters which may be assessed using the rapid assessment protocol, but was not included in the parameters measured.

technical committee to be impractical due to the time required to collect samples, the number of samples to be collected, and the cost of lab analysis. Additional details on data collection procedures may be found in Appendix D.

Table 8-1. *Soil parameters measured on timber harvesting operations in Vermont 2012.*

Parameter	Field data collected	Importance
Extent of bare soil	Visually observed presence/absence of bare mineral soil at the ground surface.	Bare soil lacks the porous, nutrient-rich, organic layer (duff) covering the soil surface. This layer holds moisture, prevents erosion, and provides a substrate for soil organisms. It is important to note that bare soil is, in some cases, desired to prepare a seedbed suitable for regenerating some tree species.
Erosion	Visually observed presence/absence. If present, the type (sheet, rill, gully) and depth class (0-6”, 6-12”, over 12”) of erosion was recorded.	Erosion results in the loss of fertile organic and mineral soil, lowering the soil productivity. These losses are very important, since it can take decades to hundreds of years to rebuild lost topsoil. Erosion can also deliver sediment to nearby streams, degrading water quality.
Compaction	Presence/absence based on a “shovel test,” which consists of pushing a shovel into the ground and noting whether increased resistance can be perceived, in comparison to a nearby area of undisturbed soil. Compaction confirmed using a visual assessment of a soil sample at each point (See Appendix B). If compaction is present, the depth class (0-4”, 4-12”, and over 12”) of compaction was recorded.	Soil compaction results in a loss of soil pore space, decreasing the amount of space for air and water in the soil and making root penetration (growth) more difficult. This can decrease the site productivity for years to decades, depending on the soil characteristics. Compaction typically is the result of heavy logging equipment moving cut logs to a landing. Compaction is usually greatest when the soil is moist, and least when the soil is dry or very wet (saturated).
Rutting	Presence/absence. If present, the depth class (0-6”, 6-12” over 12”) was recorded.	Rutting typically occurs when heavy logging equipment travels over wet (saturated) soils. Rutting may also result in compaction, depending largely on the soil texture and moisture content. Rutting on sloping ground can easily trigger gully erosion.
Soil Disturbance Class (SDC)	The SDC best representing the soil data point was recorded. There were four SDCs, ranging from Class 0 (undisturbed, natural soil conditions) to Class 3 (highly disturbed soils, such as in a skid road). Professional judgment was used to determine the Class. More detailed descriptions and pictures of the SDCs are provided in Appendix B.	The SDC is a way to record the presence and magnitude of bare soil, erosion, compaction and rutting, in one “cumulative” rating. In general, the higher the SDC number the greater the loss in soil quality, productivity, and function. Some of these losses can last decades.

The 2012 assessment parameters were chosen as indicators of direct and indirect timber harvesting impacts to soils, within the harvested area, which may influence site resilience and long-term sustainability (Page-Dumroese et al. 2009). As in 1990, the sampling scheme was intended to be representative of the overall harvested area.

Data on each of the sampled soil parameters were collected at 18 data points in each timber harvest operation (THO) in order to broadly characterize soil disturbance and impacts, in general, across the THO. Three data points were located at pre-determined distances and azimuths from the center of each of the six variable radius vegetative data plots systematically located on each THO. Each soil data point consisted of a six-inch diameter circle on the ground, at the “tip of the boot” of the person collecting data. No adjustment was made when points fell on skid trails or truck roads.

Beyond the presence or absence of a skid trail at the soil points, no additional data related to the cause of a particular condition were noted (detailed information related to the condition of skid trails and truck roads within the THOs was collected in separate assessments and is summarized in Chapter 9 of this report).

RESULTS AND ANALYSIS

General Characteristics

Soil disturbance data were collected at a total of 1,458 points, in the combined 81 THOs. Several points framing the data analysis are:

- Fifty-four of the 1,458 soil data points fell in THOs on lands that were converted to crop or pasture. These data points were excluded from the soil impact assessment because they were no longer forested, and maintenance of forest soil quality and functions were no longer appropriate objectives. As a result, the total number of data points considered in all analyses was 1,404. Each soil point received equal weight in the data analyses, as did each THO.
- The soil results characterize existing soil conditions, on the date that data were collected. Soil disturbance was not characterized prior to, or during harvest.
- All soil disturbances were the direct or indirect result of using heavy equipment used to cut and haul trees to the landing. Skid trails are defined as trails with two or more passes by heavy skidding or forwarding equipment. Skid roads were not differentiated from skid trails; all were identified as skid trails.

Assessment results for each soil resource parameter are presented in the following paragraphs.

Extent of bare soil

Bare mineral soil was observed at 72 of 1,404 data points. Ninety-five percent of points exhibited no bare soil. Bare soil was observed on *at least one* data point in 53% of the THOs. Seventy-five percent of soil points with bare soil were found on skid trails or haul roads.

Erosion

No erosion was observed on 96% (1,347 points) of the points. Sheet erosion (1/4 to 2” in depth) was observed on 3.2% of points (45 points), and rill erosion (less than 6” deep) was observed on 0.8% of points (12 points). No gully erosion was observed on any data points.

Two hundred sixteen data points fell on skid trails (15% of total). Of these points, 48 points were noted to have had erosion present; 38 points exhibited sheet erosion and 10 points were noted to have rill erosion up to 6” deep. As previously noted, no data supporting conclusions as to the cause of this erosion were collected during the forest soil assessment. Additional data regarding erosion occurring on skid trails and truck roads, as well as data on the presence or absence of erosion control structures, can be found in Chapter 9 of this report.

Compaction

Compaction was recorded at 137 of the 1,404 soil data points. Ninety percent of points exhibited no identifiable compaction. Three and three tenths percent of points (47) had compaction to a maximum depth of 4”, 6.2% of points (85) had compaction at 4-12”, and 0.4% of points (5) had compaction greater than 12” deep. Ninety-three percent of points with compaction occurred on skid trails.

Compaction to a maximum depth of 4” is expected to dissipate over the next decade, due to surface freezing and thawing, soil wetting and drying, root penetration, and organism activity (Martin 1988, Donnelly et al. 1991).

Rutting

Rutting was observed at 56 of the 1,404 soil data points. Ninety-six percent of points had no rutting. Of these, 84% (47 points) were located on skid trails and 9 points (16%) were not on skid trails. Eighty-four percent of the 56 points with observed rutting fell on skid trails where the soils were usually moist or wet. Two and six tenths percent of all points (36) had ruts to a maximum depth of 6”, 1% of all points (14) had ruts to 6-12”, and 0.4% of all points (6) had ruts ≥12” deep.

An important concern is that ruts on any slope have the potential to form gullies, causing erosion with the possibility of sediment reaching streams and other bodies of water. Movement of soil from the growing site results in soil depletion, causing adverse impacts to forest health and productivity.

Soil Disturbance

Soil Disturbance Class (SDC) was used to group the type, degree and extent of soil disturbance within the harvested area, into four categories. Disturbance Class 0 represents forested sites in a natural, undisturbed condition; Class 1 has minimal soil disturbance; in Class 2 soil disturbance is common; and Class 3 represents sites with highly disturbed soils.

Ninety-four percent of points were rated as having no or minimal disturbance. Eighty-five percent of soil data points fell in Class 0, 9% were in Class 1, 5% in Class 2, and 2% in Class 3 (Table 8-2).The presence/absence of a skid trail on a soil data point had a strong influence on its SDC. Points with a skid trail often also had compaction, rutting, and/or bare soil.

Table 8-2. *Soil data point frequency and percent by Soil Disturbance Class on 78 timber harvesting operations in Vermont, 2012.*

Disturbance Class	Abbreviated Description	Number and Percent of Soil Data Points
0	***Natural, undisturbed soil conditions –*** No evidence of past equipment No erosion or compaction Forest floor (duff; organic layers) intact	1190 points; 85%
1	***Minimal soil disturbance –*** Wheel tracks or depressions may be evident, but faint or shallow Forest floor mostly present and intact Bare mineral soil is uncommon on the ground surface Soil compaction is shallow (0-4”), but is only slightly greater than under natural conditions	120 points; 9%
2	***Soil disturbance is common –*** Wheel tracks/ruts are evident in the mineral soil The forest floor is partially missing, and bare soil may be exposed Soil compaction is present in the mineral soil to a depth of 4-12” Soil structure is typically platy A typical situation is a light to moderately-used skid trail	71 points; 5%
3	***Soil is highly disturbed –*** Wheel tracks are highly evident, being greater than 4” deep The forest floor is partially or fully gone There is evidence of surface soil removal, gouging, and piling Soil compaction is more than 12” deep Soil structure is platy or massive to a depth of over 12”	23 points; 2%
	Total	1,404 points; 100%[95]

Further Analysis of Soil Disturbance Class

Soil Disturbance Class data was further analyzed to determine whether or not heavily disturbed soil points (SDC 2 or 3) were clustered on a few THOs, or if they were distributed across the sample population. The existence of a majority of the SDC 2 and 3 points on a small number of THOs could suggest that some sites could be experiencing significant negative soil impacts, even though the overall impact to forest soils on sampled sites is low. In order to address this question, a weighted average of SDCs was calculated for each THO. A summary of the weighted average SDCs are shown in Table 8-3. This analysis indicates that there were no THOs with unusually high frequencies of SDC 2 and 3. In other words, there was no single THO, or group of THOs, where soil data points had a high frequency of SDC 2 or 3.

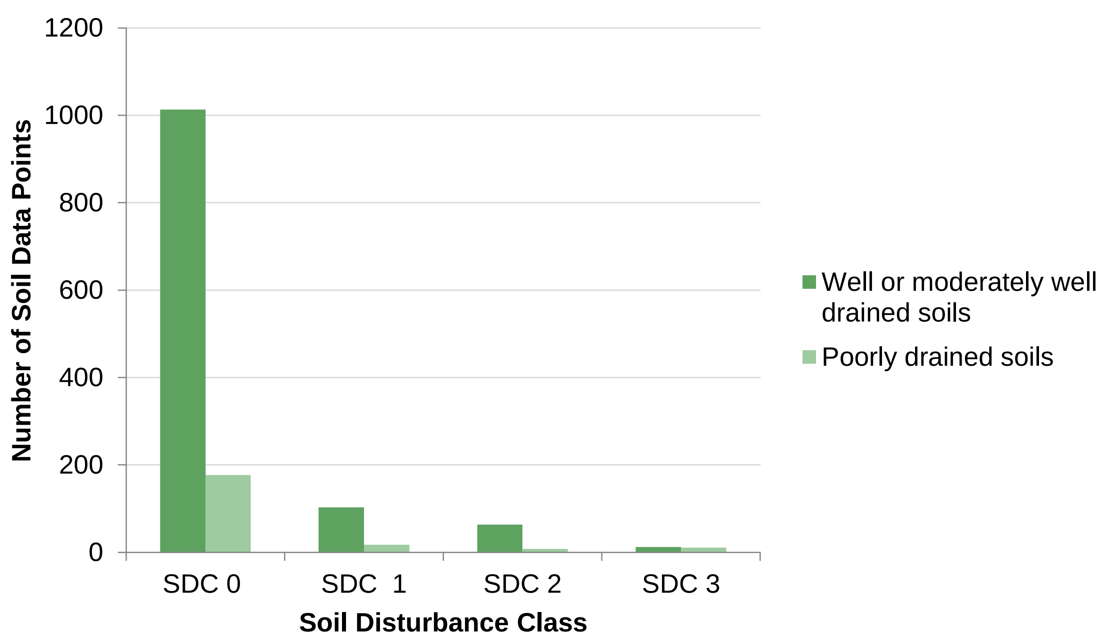
[95] Actual total exceeds 100% due to rounding.

Table 8-3. *Summary of the weighted average soil disturbance classes (SDC) by timber harvest operation for 78 timber harvests in Vermont, 2012.*

	Weighted Average SDC[96]			
	0	**1**	**2**	**3**
Number of THOs, based on the weighted average SDC (78 THOs, total)	64	14	0	0

Soil drainage also has the potential to strongly influence SDC. It is well known that poor soil drainage increases the risk of rutting and exposure of bare mineral soil, which, in turn, leads to higher SDC ratings. Eighty-five percent of soil data points (totaling 1,191 points) were on well-drained or moderately well-drained soils, and 15% (213 points) were on poorly drained soils. Figure 8-1 displays the distribution of data points by SDC. The percentage of soil data points in each SDC that were poorly drained (as opposed to well-drained or moderately well-drained) for SDC 1, SDC 2, and SDC 3 were 14%, 11%, and 48%, respectively. Only the SDC 3 points showed a relative proportion of poorly drained to well-drained or moderately well-drained soils, which were noticeably different than the overall results, indicating that SDC 3 points were more likely to occur on poorly-drained soils. It should be noted that SDC 3 rated points represent less than 2% of the total soil points observed.

Figure 8-1. Distribution of soil data points by soil disturbance class and soil drainage category on timber harvesting operations in Vermont, 2012.



Extent and Soil Disturbance Condition of Skid Trails

Overall, 15% of soil data points fell on skid trails (defined as trails with two or more passes by heavy skidding equipment). There are limited published studies that have

[96] All numbers rounded up or down, to the nearest whole number.

quantified the percentage of harvest areas occupied by skid trails, but one such study reported:

- Skid trails plus landings represented approximately 10% of the total harvest area (Grushecky et al. 2009, from a study in West Virginia).
- The average percentage of harvest areas in skid trails alone was 5.5%, but ranged from 2.1% to 7.5% (Grushecky et al. 2009, from a study in West Virginia). It is important to note, however, that the cited study examined “primary skid roads” only. “Primary skid roads were defined as those constructed with a bulldozer, in contrast with secondary skid roads where logging equipment may have run without prior road construction.” (Provencher et al. 2007).

It is impossible to directly compare results between these studies and this assessment. The 2012 assessment methods did not allow for a calculation of the area of skid trails present and did not differentiate between primary and secondary skid roads and trails.

Examining the level of soil disturbance on skid trails specifically; of the 216 soil points located on skid trails, 20% (44) were in Soil Disturbance Class (SDC) 0, 40% (87) were in SDC 1, 31% (67) in SDC 2, and 8% (18) in SDC 3. Soil Disturbance Class 0 and 1 indicate a natural soil condition or a low level of soil disturbance due to harvest, while SDC 2 and 3 indicate a relatively high level of disturbance. Overall, 7% (94 points) of the 1,404 soil data points were in SDC 2 or 3, indicating major skid trails. It is likely that the skid trails rated as SDC 0 or 1 were secondary or limited use trails.

Skid trails are necessary if trees are to be harvested using conventional harvesting methods, but the presence of roads can reduce soil productivity by increasing soil compaction and reducing the productive land base. The loss may seem to be directly proportional to the area of roads, but in reality it is not a direct relationship because some roads are closed after use and returned to the land base (Grigal 2000). Overall, the SDC data indicate a relatively low level of soil disturbance in the THOs.

Soil Parameters by Equipment Type and Skidding Method

As shown in Table 8-4, cable skidders were used on 33 THOs, grapple skidders on 22 THOs, both were used on 10 THOs, forwarders were used on 5 THOs, and a tractor was used on 1 THO included in the soil assessment. On the remaining THOs some combination of skidding and/or forwarding equipment was used. Operationally, cable skidders use a length of steel cable to winch felled trees to the machine and to hold them for transportation to the landing. As a result, the skidder does not need to drive to each stump. On the other hand, grapple skidders must travel to each felled tree or bunch of felled trees in order to retrieve them. These differences in operational characteristics may lead to differences in the overall area of a THO disturbed by skidding.

Since soil disturbance for SDC 0 and 1 is non-existent or very low, data analysis focused only on SDC 2 and 3. The results in Table 8-4 suggest that the occurrence of SDC 2 and/or 3 rated points on a THO was slightly more likely when the skidding equipment used was a grapple skidder(s) alone than with a cable skidder alone. The very limited number of SDC 2 and/or 3 plots for the other skidding equipment types or combinations makes it impossible to draw meaningful conclusions on their potential impact.

Table 8-4. *Percentage of soil data points rated as Soil Disturbance Class (SDC) 2 and 3 by type of skidding equipment used (where a single type of skidding equipment was used) on 78 timber harvesting operations in Vermont, 2012.*

Type of Skidding Equipment used for harvest	Percent of total soil data points rated SDC 2 or 3	Percent[97] of total soil data points[98] using each equipment type	Number of THOs Using Skidding Equipment Combination[99]
Grapple Skidder	3%	28%	22
Cable Skidder	2%	42%	33
Both Cable and Grapple Skidders	1%	13%	10
Forwarder	<1%	6%	5
Grapple Skidder and Forwarder	<1%	3%	2
Cable and Grapple Skidder and Tractor	<1%	3%	2
Cable Skidder and Forwarder	<1%	1%	1
Cable Skidder and Tractor	0%	1%	1
Forwarder and Tractor	<1%	1%	1
Tractor	0%	1%	1

Soil Disturbance Class rating data were also summarized by “skidding method” (the form in which forest products were transported to the landing) to examine any possible relationship between whole-tree skidding and severity of soil disturbance. Table 8-5 provides a breakdown of the number and percentage of soil data points by soil disturbance class for each skidding method used.

Forty-one percent of all soil data points were associated with THOs that entirely or partially used whole-tree skidding (data highlighted in gray in the above table). Using this subset of data points, the total number of soil data points in each SDC was determined. These data are displayed in Figure 8-2. The data suggest that when whole-tree skidding was used (fully or partially); there was slightly greater soil disturbance. To describe this in another way, 41% of all soil data points were in areas where whole-tree harvesting was used to skid all or part of the forest products on the THO. However, 62% of all SDC 2 data points, and 65% of all SDC 3 data points, fell in THOs where whole-tree harvest skidding methods were used to skid all or a portion of the trees.

[97] Total does not equal 100% due to rounding.

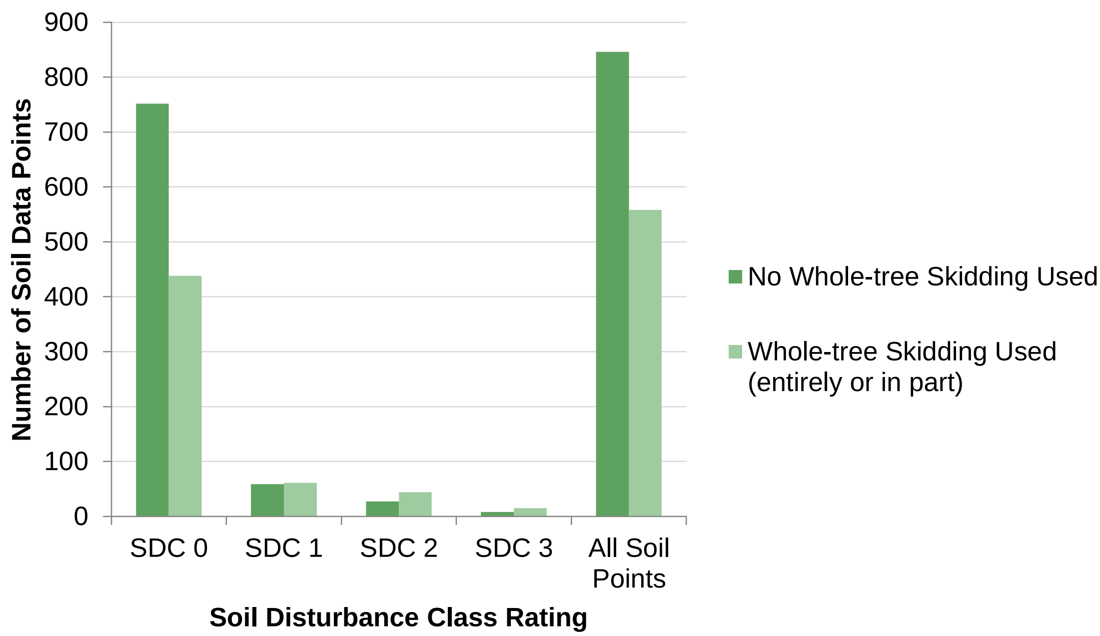
[98] The total number of soil data points is 1,404.

[99] Total number of THOs is 78. Three agricultural conversions were excluded.

Table 8-5. *Number and percentage of soil data points by soil disturbance class and skidding method for 78 timber harvesting operations in Vermont, 2012.*

Skidding Method(s)[100] Used	Number and percent of soil data points in each Soil Disturbance Class (SDC)								
	SDC 0		SDC 1		SDC 2		SDC 3		
	# of points	% of total points (1,404)	# of points	% of total points (1,404)	# of points	% of total points (1,404)	# of points	% of total points (1,404)	Total by Skidding Method (%)
Log length	350	25%	35	2%	9	1%	2	<1%	28%
Tree length (without branches)	354	25%	20	1%	16	1%	6	<1%	28%
Tree length (without branches), Log length	48	3%	4	<1%	2	<1%	0	0%	4%
Whole-tree (with branches)	377	27%	60	4%	38	3%	11	1%	35%
Whole-tree (with branches), Log length	30	2%	1	<1%	2	<1%	3	<1%	3%
Whole-tree (with branches), Tree length (without branches)	31	2%	0	0%	4	<1%	1	<1%	3%
Total	**1190**	**85%**	**120**	**7%**	**71**	**5%**	**23**	**1%**	**100%**

Figure 8-2. Soil point distribution by Soil Disturbance Class rating and skidding method[100] on 78 timber harvests in Vermont, 2012.



[100] Skidding Method refers to the form in which trees were moved from the stump to the landing.

Relationship to Primary Ownership and UVA Status to Soil Conditions

Table 8-6 examines the relationships between land ownership, Use Value Appraisal Program participation status, and occurrence of SDC 2 and 3 rated points. However, the percentage of SDC 2 and 3 rated points is so low that is it not reasonable to make meaningful conclusions about relationships.

Table 8-6. *Frequency and percentage of all soil data points rated as SDC 2 or 3 by ownership category and Use Value Appraisal (UVA) Program participation on 78 timber harvesting operations in Vermont, 2012.*[101]

Ownership and UVA Status	Percent of all THOs	Number and percent of soil data points rated SDC 2 or 3			
		SDC 2		SDC 3	
		# of soil data points	Percent of total (n=1,404)	# of soil data points	Percent of total (n=1,404)
Public	12%	7	<1%	3	<1%
Private					
Enrolled in UVA	73%	48	3%	16	1%
Eligible but not enrolled in UVA	10%	11	1%	2	<1%
Not eligible due to tract size	5%	5	<1%	2	<1%
Total	100%	71	5%	23	2%

Table 8-7 presents the same data, but as a percentage of only those soil data points rated SDC 2 or 3. Public land and land enrolled in the UVA Program both showed a lower incidence of SDC 2 and 3 occurrences proportional to the percentage of THOs. Only those parcels not enrolled in the UVA program showed a larger than proportional number of points in the more heavily disturbed classes. Here again, the small number of points in these categories makes drawing any conclusions from these data unreliable.

Table 8-7. *Frequency and percentage of the subset of soil data points rated as SDC 2 or 3 by ownership category and Use Value Appraisal (UVA) Program participation on 78 timber harvesting operations in Vermont, 2012.*[101]

Ownership and UVA Status	Percent of all THOs	Number and percent of soil data points rated SDC 2 or 3 (Percentages reflect only data points rated SDC 2 or 3)			
		SDC 2		SDC 3	
		# of soil data points	Percent of SDC 2 & 3 (n=94)	# of soil data points	Percent of SDC 2 & 3 (n=94)
Public	12%	7	7%	3	3%
Private					
Enrolled in UVA	73%	48	51%	16	17%
Eligible but not enrolled in UVA	10%	11	12%	2	2%
Not eligible due to tract size	5%	5	5%	2	2%
Total	100%	71	76%	23	24%

[101] Three agricultural conversions were excluded.

Results Comparison: 1990 and 2012

The monitoring methods used in 1990 were significantly different than those used in 2012, so a direct comparison of data cannot be made. In fact, in 2012 a conscious decision was made to not replicate the 1990 data collection methods because of the development of improved methods since the last assessment.

CONCLUSIONS

Based on the sampled harvest operations, the observed impacts to forest soils within harvested stands from timber harvesting operations were minimal.

> On 95% of soil data points sampled in the 2012 Assessment no mineral soil was exposed; no signs of erosion were observed on 96% of points; 90% of points showed no signs of soil compaction, and 96% of points showed no signs of rutting.
>
> Four Soil Disturbance Classes were used to describe the type, degree, and extent of soil disturbance at each sample point. Disturbance Class 0 represents forested sites in a natural, undisturbed condition; Class 1 has minimal soil disturbance; in Class 2 soil disturbance is common; and Class 3 represents sites with highly disturbed soils. Ninety-four percent of points were rated as having no or minimal disturbance. Eighty-five percent of soil data points fell in Class 0, 9% were in Class 1, 5% in Class 2, and 2% in Class 3.
>
> No single THO or group of THOs were found to have had a high frequency of highly disturbed soils.

Based on the sampled harvesting operations, the presence or absence of a skid trail was the factor most commonly associated with negative impacts on forest soils.

> While the overall number of soil data points exhibiting negative impacts to forest soils is limited, it is clear that the majority of these impacts were associated with skid trails. Seventy-five percent of points with bare soil, 84% of points with erosion, 93% of points exhibiting compacted soils, and 84% of points with rutting noted occurred on skid trails.

RECOMMENDATIONS

Limit the construction of new skid trails as much as possible and re-use existing skid trails if they meet AMPs guidelines and are otherwise properly designed and located. Existing skid trails typically have soils that are already compacted. Re-use limits the creation of new areas of compaction.

Ensure proper installation of AMPs to keep erosion to a minimum. This also protects soil productivity.

On sensitive or wet sites, conduct harvest operations in winter, when skid roads and landings are frozen, and/or covered with a thick layer of snow. This minimizes rutting, compaction, creation of bare soil, and erosion.

CHAPTER 9: WATER QUALITY

INTRODUCTION

Forests play a vital role in providing clean water. Compared to other land uses, forests generally produce high-quality water, especially when the ecosystems are healthy and functioning properly. However, timber harvesting, like many other land uses, can directly and indirectly impact water quality by affecting how water infiltrates into the soil or flows through an area; by causing direct discharges into streams; and by changing environmental conditions in or near waterbodies. An intact forest floor, which is composed of wood and leaf litter, humus and fibrous roots, is the most important element of the forest that helps to keep water clean. Because forest soils are often highly porous and permeable, rainwater can infiltrate into the soil freely (Stuart and Edwards 2006), reducing the potential for erosion and stream sedimentation. The construction and use of roads, trails, and log landings necessary to timber harvesting operations may:

- Reduce soil permeability. This can occur any time the forest floor is disturbed, removed, compacted, or otherwise damaged.
- Increase soil erosion. The opportunity for soil to be carried away by runoff increases greatly when mineral soil is exposed or fill is used. Erosion reduces tree growth and can pollute water.
- Divert water flow. Roads and trails can intercept and redirect water moving over or through the soil. When water volume and velocity increase, there is a greater chance that it will form a channel and start eroding soil. Sometimes harvesting has been known to cause streams to erode a new channel by blocking the stream's flow with logs or debris.
- Concentrate water flow. Roads, trails, and log landings can collect and channel runoff, creating rills or gullies. In these situations, water erodes and transports exposed soil in its path.

The *Acceptable Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont* are preventative measures that help control soil erosion and protect water quality. They are designed to minimize the effects of logging on natural hydrologic functions of forests. They can absorb or disperse runoff, retain soil nutrients, filter sediment, prevent fluctuations in water temperature and contribute organic material to surface waters. The AMPs are intended and designed to protect water quality by preventing discharges of mud, petroleum products, and woody debris (logging slash) from entering streams and other bodies of water during logging, while protecting streambank vegetation and the natural flow of water in streams to minimize risks to water quality.

Evaluating direct and indirect water quality impacts from timber harvesting operations, and compliance with AMPs and Vermont's wetland rules, were the major objectives of the water quality portion of this assessment.

DESIGN

Each timber harvesting operation (THO) was evaluated for compliance with existing statutes, rules, and regulations, as well as for impacts on water quality. Only those obvious lingering effects to water quality that result from conditions such as sedimentation, logging slash in streams, and petroleum spills were evaluated.

In general, field data collection followed the same methodology and data recording procedures used in the Impact Assessment of Timber Harvesting Activity in Vermont (Newton et al. 1990). A general description of these methods is found below and detailed descriptions of the data collected and collection methods can be found in Appendix D of this report.

Stream Crossings

All stream crossings encountered while assessing truck roads, skid trails, streams, and while navigating between vegetation plots were evaluated. Crossings on roads associated with the THO were evaluated even if not within the THO (i.e., truck roads or skid trails outside the harvested area but clearly part of the operation).

For the purposes of determining if a stream crossing existed, a “stream” had to have defined banks and a gravel bottom. For the purposes of the assessment, a permanent stream had to have water present during the driest part of the summer. Streams not meeting this criterion were considered intermittent.

Data collection at stream crossings included: compliance with AMPs; presence and degree of sedimentation and logging debris at stream crossings; stream crossing structure type and hydraulic capacity;*[102] and suitability for aquatic organism passage.*

Assessment of the hydraulic capacity of stream crossing structures (bridges and culverts) included determination of bankfull width and depth of the stream to calculate the opening size required for several flood event cycles.

Streams and Other Waterbodies

One stream or waterbody (excluding wetlands, which were assessed using a different protocol) was evaluated if it fell entirely or in part within the harvested area of the THO.

Data collection along streams and waterbodies included evaluations of: recommended and actual protective strip width; percent forest canopy cover along the stream;* stream condition* and likely cause;* and extent of slash present in the stream channel.*

Truck roads

One truck road was examined on each THO, if present, from a landing to the public road or for ½ mile, whichever was less. Compliance with AMPs, soil drainage, and type and extent of erosion, if present, were assessed.

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[102] Attributes identified with an asterisk (*) were not considered during the 1990 Assessment or utilized different procedures.

Skid Trails

One main skid trail was evaluated on each THO. If several choices existed, the trail with the most potential for impact was chosen. Compliance with AMPs, soil drainage, and type and extent of erosion, if present, were assessed.

Landings

All landings associated with a THO were evaluated separately. If the study team was unable to distinguish the location of the landing, or if it was being utilized for another purpose (such as a house site or had been restored to agricultural use) it was not evaluated. Each landing was evaluated to determine soil drainage, type and extent of erosion, and compliance with AMPs.

Wetlands and Vernal Pools

Wetlands and vernal pools were identified through the use of the Agency of Natural Resources Vermont Significant Wetlands Inventory Map. All mapped wetlands and vernal pools within, or adjacent to, the THO were evaluated, as were any unmapped wetlands that were encountered while evaluating other resource attributes.

Evaluations were designed based on Vermont wetland rules* and included noting presence or absence of: rutting in or adjacent to the wetland; harvesting in the wetland; and road construction or expansion within the wetland.

Several important procedures and assumptions should be noted:

- Stream temperature and turbidity were evaluated during the 1990 assessment, but these measures were not repeated during the 2012 assessment, as recommended by the Advisory Committee.
- When faced with the choice of several potential skid trails or streams to investigate, the preference was always to locate the sample at the site that was expected to have been the most severely impacted by the harvest operation. This protocol was consistent with the methods used in the 1990 assessment.
- For the purposes of this assessment, a stream was defined as having defined banks and a defined stream bed.
- Several unusual storm events could have had an impact on the assessment of roads, streams, stream crossing structures, and stream condition on the sampled THOs. The most severe of these, Tropical Storm Irene, is known to have had a severe impact on streams throughout the state. As a result, data collection methods allowed field crews to distinguish between changes in stream condition observed to be related to logging (e.g., slash or crossing structures left in streams) and those resulting from flood events (e.g., severe scouring and bank erosion) while assessing stream condition.
- Each of the 81 timber harvesting operations was evaluated for compliance with 17 of the 24 Acceptable Management Practices (Vermont Department of Forests, Parks and Recreation 1987). Six of the AMP's apply <u>only</u> to the active phase of a

timber harvesting operation and were not evaluated in this assessment. One AMP (AMP 12) pertains to close-out of temporary truck roads after logging (removing culverts and temporary stream crossing structures, installing waterbars, and stabilizing erosion-prone areas with seed and mulch). No temporary truck roads were encountered during this study, thus no evaluation of temporary truck roads occurred.

RESULTS AND ANALYSIS

Results are presented by all observations made across all operations that had a stream crossing, a stream, or other associated waterbody.

Stream Crossings

Stream crossings are the dominant feature where truck roads and skid trails contribute to sediment discharge into waterbodies. One hundred forty-seven stream crossings were evaluated on 52 timber harvesting operations. There were no stream crossings to evaluate on 36% of timber harvesting operations (29 operations). All stream crossings evaluated were associated with a timber harvesting operation, but some were not within the harvest area, e.g., stream crossings on truck roads or skid trails providing access to the harvest area.

Sedimentation Associated with Stream Crossings

One hundred forty-seven stream crossings were evaluated for evidence of sedimentation within one chain (66 feet) downstream of the stream crossing site. Evidence of sedimentation was classified in three broad categories; (1) natural streambed conditions prevalent - no sedimentation; (2) thinly coated streambed; and (3) plumes, thick deposits.

Overall, 78% of crossings were rated as “natural streambed conditions prevalent - no sedimentation” (115 observations). Twenty-two percent of stream crossings showed evidence of sedimentation (32 observations); 8 crossings on perennial streams and 24 on intermittent streams. Four percent of all crossings evaluated showed evidence of thick deposits of sediment (6 observations) (Figure 9-1, Table 9-1).

Figure 9-1. Percentage of stream crossings by sedimentation level at 147 stream crossings on timber harvesting operations in Vermont, 2012.

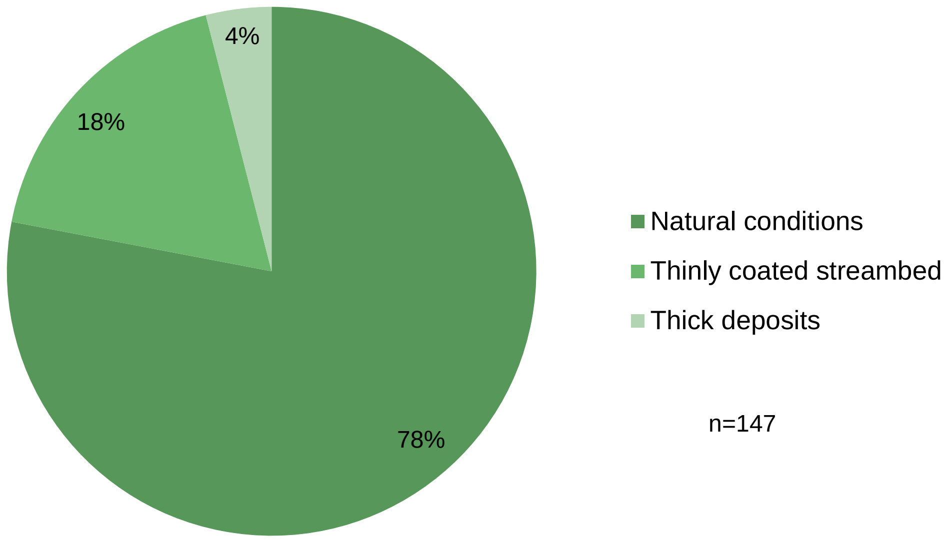


Table 9-1. *Frequency of sedimentation level observed at stream crossings by stream type on 52 timber harvesting operations in Vermont, 2012.*

Level of Sedimentation	**Stream Type** Intermittent (Number)	**Stream Type** Perennial (Number)	**Totals**
Thinly Coated Streambed	19	7	26
Plumes/thick deposits	5	1	6
Total Number of Crossings with Observed Sedimentation	**24**	**8**	**32**

Stream Crossing Structure Types Associated With Sedimentation

The majority of the observed and documented sediment at stream crossings was associated with culverts and in instances where structures had been removed (Table 9-3). Twenty-three percent of the culverts (10 observations) and 14% of removed crossing structures (10 observations) assessed showed evidence of sedimentation.

Eight of the 10 culverts where sedimentation was observed were classified as perched culverts.[103] Plunge pools had formed at the culvert outlets resulting in bank scouring. The other 2 culverts were undersized. Undersized culverts will increase stream flow velocity through the culvert and also cause bank scouring. Both of these situations result in increased inputs of sediment into the stream channel.

[103] A perched culvert is defined as one where the outlet end is at an elevation above the streambed, allowing the water to fall and scour a pool in the streambed. Scour pools result in sedimentation downstream as the streambed is eroded.

Table 9-2. *Frequency and percent of stream crossings by structure and road type on 52 timber harvesting operations in Vermont, 2012.*

Structure Type	Permanent Truck Road	Skid Trail	Total	Percent of Total Crossings
Culvert	31	13	44	29%
Ford	2	3	5	5%
Bridge	4	3	7	5%
Log Ford	0	13	13	9%
Brush	0	8	8	5%
Structure Removed	7	63	70	47%
Total	**44**	**103**	**147**	**100%**

Table 9-3. *Frequency and percent of sedimentation observed at stream crossings by structure and severity on 52 timber harvesting operations in Vermont, 2012.*

Structure Type	Level of Sedimentation		Total	Percent of Total Crossings
	Thinly coated	Plumes, thick deposits		
Culvert	9	1	10	7%
Ford	1	0	1	<1%
Log Ford	5	1	6	4%
Brush	2	3	5	3%
Structure Removed	9	1	10	7%
Total	**26**	**6**	**32**	**22%**

Nine of the 10 removed stream crossing structures where sedimentation was observed were on skid trails, and in all but one instance, the severity of observed sedimentation was classified as "thinly coated stream bed."

Sedimentation associated with removed structures cannot be attributed directly to lack of AMP compliance. There was no apparent soil erosion from the road surface that would contribute to sediment reaching streams at any of the crossings. Approaches were stable and had re-vegetated. In a number of instances it appeared that streambed disturbance associated with the removal of the crossing structure, as required by the AMPs, was at least in part responsible for the discharge of sediment.

Logging Slash Associated with Stream Crossings

Logging slash left in a stream or other waterbody constitutes a discharge under Vermont's water quality statutes. The amount of logging slash or woody debris remaining in stream channels[104] at crossings was documented for each of the 147 crossings evaluated. Conditions were classified as "Natural" (no logging slash or woody debris present) at 75% of the stream crossings (110 observations). At 25% of stream crossings assessed, the extent of logging slash or woody debris present was classified as "moderate" or "blocking or altering stream flow" (37 observations). Six crossings were on perennial streams and 31 crossings were on intermittent streams (Table 9-4).

[104] Categories of slash or woody debris present at crossings were defined as follows: Natural (logging debris and slash absent); Moderate (logging debris or slash present, but not blocking or altering stream flow); Blocking or altering stream flow (sufficient woody debris present to alter stream flow at the crossing site).

Table 9-4. *Frequency and percent of stream crossings with logging slash or woody debris left in stream channels by extent observed on 52 timber harvesting operations in Vermont, 2012.*

Extent of Slash or Woody Debris Present[104]	Number	Percentage
Natural	110	75%
Moderate	25	17%
Blocking/Altering Streamflow	12	8%
Total	**147**	**100%**

Stream Crossing Structure Types Associated With Logging Slash or Woody Debris

Stream crossing structure types associated with logging slash left in stream channels are summarized in Table 9-5. Where logging slash associated with the crossing was noted, it was most commonly associated with crossings where structures were identified as “removed” (9% of all crossings), followed by “log fords” (7% of all crossings), and “brush” crossings (5% of all crossings).

Table 9-5. *Frequency and percent of stream crossings with moderate or blocking levels of logging slash or woody debris left in stream channels by structure type and extent of debris observed on 52 timber harvesting operations in Vermont, 2012.*

Structure Type	Extent of Slash or Woody Debris Present[104]		Total	Percent of Total Crossings
	Moderate	Blocking/Altering Stream flow		
Culvert	5	0	5	3%
Ford	1	0	1	<1%
Log Ford	3	7	10	7%
Brush	4	4	8	5%
Structure Removed	12	1	13	9%
Total	**25**	**12**	**37**	**25%**

Logging slash or woody debris was blocking the stream channel at 4 of the 8 brush crossings, and 7 out of the 10 log ford crossings. In 55% of instances (6 crossings), the stream crossing structure had not been removed upon completion of logging. Both log fords and brush crossings are considered acceptable practices for temporary stream crossing structures under certain conditions. The AMPs require removal of all temporary structures and restoration of the stream channel upon completion of logging, and state that streams and all bodies of water shall be kept free of slash and other logging debris.

The amount of logging slash or woody debris observed at 12 of the 13 crossings was rated as “moderate” where the structures had been removed. Without knowing what types of structures had been in place during logging, it’s impossible to determine all of the factors that may have led to woody debris being left in the stream channel. Slash or woody debris sufficient to block the stream channel was recorded for one crossing site. Excessive amounts of woody debris can alter the natural course of flow, resulting in soil erosion and presenting a barrier to fish passage.

Streams and Other Waterbodies

Thirty-three (41%) of harvesting operations had no associated waterbodies. Forty-eight timber harvesting operations that had a waterbody either within, or partially within the harvest area were evaluated. Two hundred fifty-five observations[105] on 12.75 miles of streams and other waterbodies were made to evaluate dominant condition and likely cause, amount of logging slash left in the waterbody, forest canopy cover along the waterbody, and a number of evaluations related to AMP compliance[106] were made on the 48 THOs. Ninety observations were made on intermittent streams, 159 on perennial streams, and 6 on a pond (Table 9-6).

Table 9-6. *Frequency and percent of waterbody observations by type of waterbody evaluated on 48 timber harvesting operations in Vermont, 2012.*

Waterbody Type Evaluated	Number	Percentage
Intermittent	21	44%
Perennial	26	54%
Pond	1	2%
Total	**48**	**100%**

<u>Logging Slash Associated with Streams and Other Waterbodies</u>

Two-hundred fifty-five observations were made on 48 streams and other waterbodies to document the amount of logging slash left in the waterbody as a result of harvesting activities. The amount of logging slash observed in each stream segment was recorded in one of the three following categories: 0-100 cubic feet; 100-200 cubic feet; and more than 200 cubic feet.[107] Two-hundred thirty (90%) of observations for logging slash in waterbodies were in the 0-100 cubic foot category; nineteen (8%) of observations were in the 100-200 cubic foot category, and six (2%) of observations were in the category greater than 200 cubic feet (Table 9-7). Thirty-three or 69% of operations had logging slash recorded in the 0-100 cubic foot category; ten or 21% of operations had logging slash recorded in the 100-200 cubic foot category, and five or 10% of operations had logging slash recorded in the category greater than 200 cubic feet. Spatial distribution of logging slash by stream segment was not determined. The presence of logging slash by observation was greater in perennial streams than that for intermittent streams (63% compared to 36%). AMP 8 states that “Streams and all bodies of water shall be kept free of slash and other logging debris.”

[105] For each selected stream, the starting point was determined at an elevation just above or below the operation. Observations were made at four-chain (264 foot) intervals, either to the end of the stream or for 0.5 mile, whichever was less.

[106] Observations related to AMP compliance (e.g., protective strip evaluations, protective strip entries by machinery, and occurrences of skidding in the stream) are reported in Appendix C.

[107] The amount of logging slash present was estimated for each four-chain segment (264 feet) of stream evaluated. Each stream segment evaluated was counted as one observation. The categories used to document the amount of slash in a stream segment were chosen to correspond to those established for the US Forest Service BMP Monitoring Protocol and differed from the protocols used during the 1990 assessment. They are not tied to any biological impact index, but were merely chosen as a means to visualize the volume of slash.

Table 9-7. *Frequency of waterbody observations by type of waterbody and amount of logging slash observed on 48 timber harvesting operations in Vermont, 2012.*

Waterbody Type	Quantity of Logging Slash Observed per Stream Segment			Total
	0-100 ft^3	100-200 ft^3	> 200 ft^3	
Intermittent Streams	84	3	3	90
Perennial Streams	140	16	3	159
Pond	6	0	0	6
Percent of Total Observations	**90%**	**8%**	**2%**	**100%**

Dominant Condition of Streams and Other Waterbodies

Two-hundred fifty-five observations were made on 48 streams and other waterbodies to document dominant condition of the stream or waterbody. Dominant condition was rated as natural condition,[108] moderate,[109] or natural condition disrupted.[110] The presence or absence of both logging debris/slash and sediment were taken into consideration in determining dominant condition of the stream or waterbody. This approach differed from the procedures used in the 1990 assessment, which evaluated only sedimentation, and therefore the results are not comparable.

Sixty-seven percent of observations (170) were rated as natural condition. An additional 11% (29 observations) rated as moderate or natural condition disrupted were assumed by the field observers to have been caused by naturally occurring events[111] such as 2011 flood events, including Tropical Storm Irene. Alteration of natural conditions by flood events was characterized by observations of significant stream bank erosion and braided channels by the field observers. Nineteen of the “natural condition disrupted/naturally occurring event” rated observations occurred on two THOs. The field observers noted that impacts attributable to Tropical Storm Irene and other flood events were primarily limited to a small number of the operations included in this assessment.

The dominant condition was rated as moderate or natural condition disrupted due to logging on 22% of segments (56 observations) (Figure 9-2).

The dominant condition was altered from natural conditions (all causes) at 33% (85 observations) of all observations. Dominant condition was recorded as moderate at 45 observations; 37 due to logging and 8 due to natural occurrences. Dominant condition was recorded as disrupted at 40 observations; 19 due to logging and 21 due to natural occurrences. Dominant condition was altered from natural conditions more in perennial streams than in intermittent streams; 55% compared to 39%.

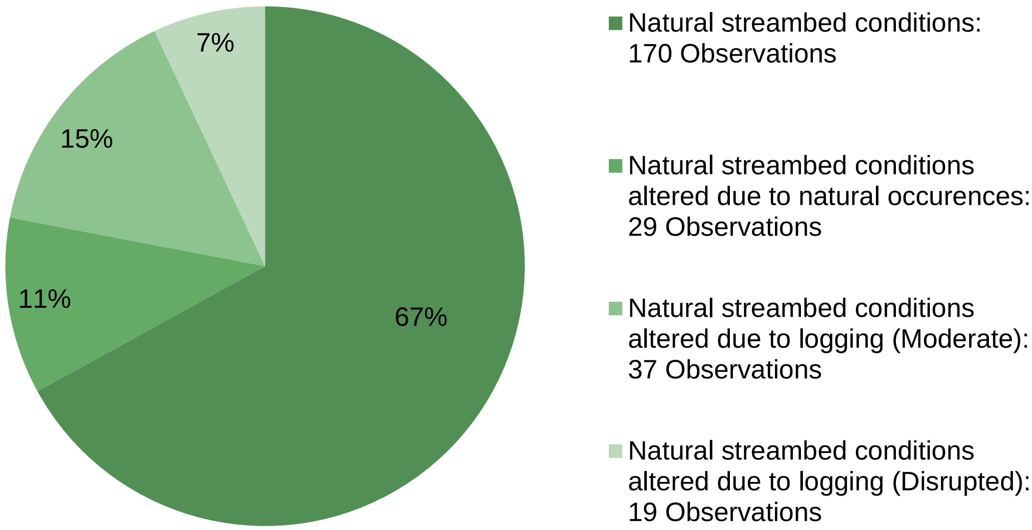
[108] Natural condition: clean adjacent rocks, stable, little sediment, natural stream location, no plumes, no alluvial fans.

[109] Moderate: thinly coated streambed, logging debris or slash present, but not blocking or altering stream flow.

[110] Natural condition disrupted: adjacent rocks coated with sediment, active bank cutting, heavy sedimentation, stream relocated, many plumes and alluvial fans, logging debris or slash blocking or altering stream flow.

[111] Data collection methods allowed field crews to indicate the probable cause of the dominant condition (natural or logging caused) to distinguish between changes in stream condition related to logging (e.g., slash or crossing structures left in streams) and those resulting from flood events (e.g., severe scouring and bank erosion).

Figure 9-2. Percent of stream observations by dominant streambed condition rating and cause on 48 timber harvesting operations in Vermont, 2012.



Petroleum Spills

Proper storage, handling, and use of hazardous materials are critical to protect water quality during timber harvesting operations.

Presence or absence of the evidence of petroleum spills was recorded while assessing log landings and at stream crossings. Refueling and storage of logging equipment on landings makes them the most likely areas on a harvesting operation for a petroleum spill to occur. Evidence of spills was noted at stream crossings because of concentrated use by logging machinery and the proximity of water.

There was no evidence of petroleum spills or other hazardous materials at any of the stream crossings evaluated. Evidence of a petroleum spill was observed at one log landing. No portion of the landing was located in a protective strip and the landing had been graded, with water diversions installed.

Hydraulic Capacity of Bridges and Culverts

All bridges and culverts left in place after logging[112] were evaluated to determine if the structure size opening was adequate to accommodate expected stream flow for a 1-3 year, 10-year, and 25-year flood event following the process outlined in the Maine Forest Service publication “Best Management Practices for Forestry: Protecting Maine’s Water Quality” (Maine Dept. of Conservation 2004).[113] The purpose of this observation

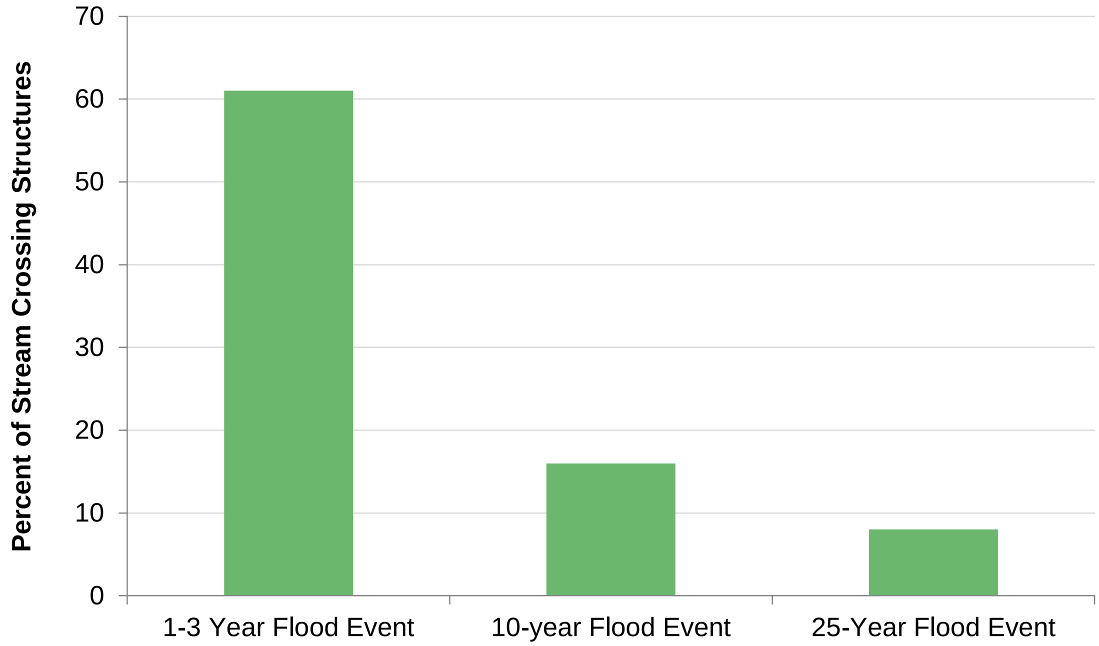
[112] Because this was a post-harvest assessment, all in-place stream crossing structures encountered were considered permanent structures; therefore they were evaluated to provide an indication of hydraulic capacity (their ability to move water) for both short-term and long-term flood events.

[113] This field method for determining structure size for different flood frequencies was chosen because it relies upon the physical

was not to determine AMP compliance, but to provide an indication of the hydraulic capacity of the stream crossing structures under current conditions and their ability to withstand flood events.

The evaluation of structure size openings indicated that 61% of all structures (7 bridges and 24 culverts) were adequately sized to accommodate a 1-3 year flood event; 16% of all structures (2 bridges and 6 culverts) were adequately sized to accommodate a 10-year flood event; and 8% of all structures (1 bridge and 3 culverts) were adequately sized to accommodate a 25-year flood event (Figure 9-3)

Figure 9-3. Percent of stream crossing structures that met hydraulic capacity recommendations by flood event category on timber harvesting operations in Vermont, 2012.



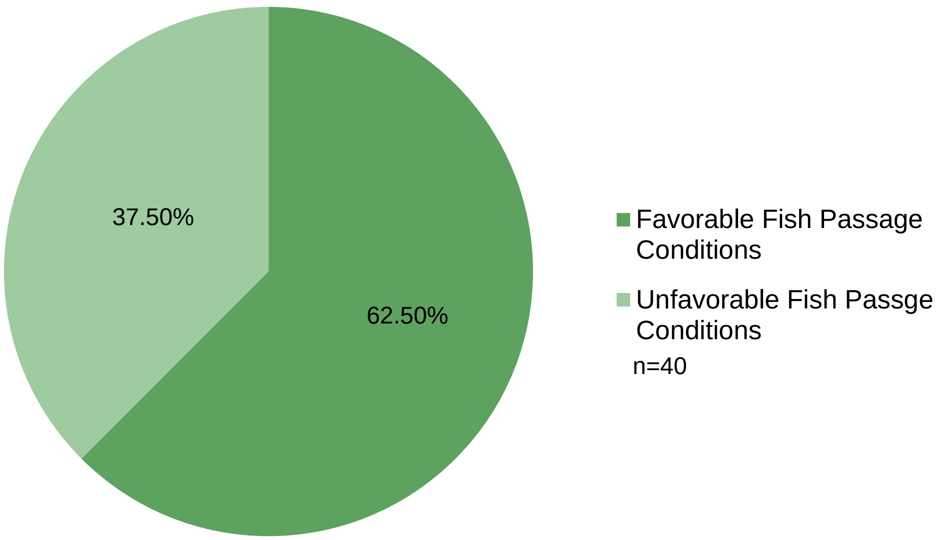
Fish Passage

Fish Passage was evaluated for 40 stream crossings where it was determined that the stream could support fish at that particular location. All stream crossing types (structures and methods) were included in this assessment, including temporary streams crossings and where the structure was removed. It is important to note that fish passage, unlike many of the water quality attributes addressed previously in this chapter, is not addressed by the AMPs.

Conditions for fish passage were favorable at 62.5% of the sites examined (25 observations) (Figure 9-4). Natural streambed conditions and absence of barriers to fish passage characterized these sites.

characteristics of stream channels that can be easily identified and measured on-site (bankfull width and average stream channel depth). Field indicators were used for determining cross sectional area of the stream channel where stream crossing structures were located; bankfull width (width of the stream at normal high water) x (average depth of the stream channel at normal high water).

Figure 9-4. Percent of stream crossing structures suitable for fish passage on timber harvesting operations in Vermont.



Closed-bottom structures where natural streambed substrate material was not present or not continuous on the inside bottom of the structure, closed-bottom structures with perched outlets and pole or slash fords were deemed as unfavorable for fish passage. Unfavorable conditions were documented at 37.5% of the sites examined (15 observations).

Streamside Protective Strips[114]

The AMPs state that "a protective strip"[115] shall be left along streams and other bodies of water in which only light thinning or selection harvesting can occur so that breaks made in the canopy are minimal and a continuous cover is maintained." The actual width of the protective strip required is determined by the slope of the land between a skid or truck road and the bank of a stream or other waterbody (Table 9-8).

Two hundred forty-two observations were made on 45 THOs to evaluate streamside protective strips along streams and other waterbodies; 81 observations on intermittent streams, 155 observations on perennial streams, and 6 observations on a pond.

[114] It is important to note that data on protective strips were collected during both the waterbody assessment and the skid trail/truck road assessments (see Data Collection Procedures, Appendix D). Results from both evaluations are reported below separately. Where multiple roads and or streams were present, protocol dictated choosing the most potentially impacted stream, and the truck or skid trail with the most potential for impact independently. The streams and roads/trails chosen for evaluation may or may not have been associated with one another, so each evaluation must be viewed independently.

[115] "Protective strip" and "streamside buffer" are used here as interchangeable terms.

Table 9-8. *Protective strip width guide: From Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont (Table 4); 1987.*

Slope of Land Between Roads or Landings and Stream Banks or Lake Shores	Width of Strip Between Roads or Landings and Stream (Feet along surface of ground)
0-10%	50'
11-20%	70'
21-30%	90'
31-40%[116]	110'

Shading along streams and protective strip width[117]

Percent canopy cover[118] along streams and other waterbodies averaged 85%, with a median value of 91%. Continuous cover was maintained adjacent to open water on all operations. Residual stocking in the protective strip was not determined.

Protective strip width was adequate or more than adequate at 60% of the total observations (145 observations). Thirty-eight percent (18) of the operations met AMP protective strip width requirements[119] 100% of the time. Four operations had less than adequate protective strip widths for all measurements taken.

Logging near streams and other waterbodies

No machine entries within 25 feet were recorded on 78% of observations (198 observations). Forty-four percent of operations (27 operations) had no machine entries that disturbed the soil within 25 feet of streams or other waterbodies.

Truck roads and skid trails within the protective strip[120]

The AMPs state that truck roads and skid trails be located outside of protective strips with the exception of stream crossings.

Protective strips associated with truck roads met or exceeded recommended widths on 95% of the observations. Five operations had portions of truck roads located within a protective strip.

[116] Add 20 feet for each additional 10% slope.

[117] Percent slope was measured at each observation point to determine recommended protective strip width. Actual protective strip width was determined by measuring the distance from the top of the stream bank, as defined by the normal high water mark, to the nearest road or trail, unless the canopy had been removed in that particular portion of the harvest area. In those cases, where all or the majority of dominant overstory trees were removed, protective strip width was measured to the edge of the harvested area.

[118] Percent canopy cover was measured at the top of the stream bank as defined by the normal high water mark along streams, using a densiometer for each observation.

[119] Protective strip width was deemed to be "inadequate" if it was not the full width recommended in Table 9-8 on both sides of the stream.

[120] Results in this section are from the evaluation of truck roads and skid trails. See Appendix D for protective strip evaluation procedures associated with roads and skid trails.

Protective strips associated with skid trails met or exceeded recommended widths on 96% of the observations. Twelve operations had portions of skid trails located within a protective strip.

Log landings within the protective strip

Eighty-six percent of log landings observed were located outside of protective strips. Log landings on 16% of the operations (11 operations) or 14% of the total number of landings evaluated were at least partially located within the protective strip. There were fourteen landings on 11 different operations where a portion of the landing was located within the protective strip, requiring seeding and mulching.[121] Seventy percent of the landings (7 observations) or 60% of the operations (6 operations) where log landings were partially located within a protective strip were seeded and mulched. In each case, surface erosion type was documented as sheet or rill.

Truck Roads

Permanent truck roads were evaluated for soil drainage and surface erosion type as well as compliance with AMPs. Results of AMP evaluations can be found in the *Existing Statutes Compliance* section of this chapter. One hundred forty-two observations were made on 11.8 miles of truck road (Table 9-9). Thirty-two operations had permanent truck roads that were evaluated. There were no truck roads associated with the remaining operations because they were either accessed by public roads or there was no evidence of a truck road, such as in the case of land conversions.

Table 9-9. *Frequency and percent of permanent truck road observations (segments) by soil drainage class on 32 timber harvesting operations in Vermont, 2012.*

Soil Drainage Class	Number of Observations	Percent of Observations
Well Drained	97	68%
Moderately Well Drained	44	31%
Poorly Drained	1	1%
Total	**142**	**100%**

Soil drainage was favorable for the construction of truck roads on 11.5 miles of the 11.8 miles of truck roads evaluated. These soils were classified as being moderately well-drained or well-drained. There was only one operation that had a 132-foot section of road constructed where it was determined that soil drainage was poor.

Truck roads were also evaluated for surface erosion type.[122] Sixty-nine percent of observations were rated as “none to sheet erosion” (Table 9-10) the least severe

[121] Property boundaries, physical constraints, and locations of existing infrastructure can sometimes determine and restrict the location of log landings, resulting in portions of log landings being located within a protective strip. As a result, the AMPs address this situation: AMP 24 states that “areas of exposed soil within the buffer or protective strip along streams and other waterbodies shall be stabilized by seeding and mulching…”

[122] Each 8-chain segment of truck road, or observation, was rated based on the most severe erosion type observed anywhere on that segment. In most cases, ratings were based on short sections or small areas that were eroding.

category, as the most advanced surface erosion type. There was no erosion classified as marked gully erosion or advanced gully erosion observed on any truck roads.

Table 9-10. *Percent of permanent truck road observations (segments) by soil erosion type rating on 32 timber harvesting operations in Vermont, 2012.*

Most Severe Erosion Type Observed	Percent of Observations
None to sheet	69%
Rill up to 6 inches deep	27%
Initial Gully: 6-12 inches deep	4%
Marked Gully: 12-24 inches deep	0%
Advanced Gully: greater than 24 inches deep	0%

Skid Trails

One major skid trail[123] on each operation was chosen for evaluation of soil drainage, erosion, and AMP compliance. Results of AMP evaluations can be found in the *Existing Statutes Compliance* section of this chapter.

Six-hundred forty observations were made on 22.6 miles of skid trails. Skid trails were evaluated on 76 operations. Five operations did not have skid trails to evaluate: three were agricultural conversions and the other two were small clearcuts of 10 and 8 acres in size. There were no discernable skid trails on these five operations.

Seventeen and six-tenths miles (78%) of the total length of skid trails evaluated had favorable soil drainage. These soils were classified as “moderately well-drained” or “well-drained” (Table 9-11). To avoid excessive rutting, it’s important to locate skid trails where soil drainage is favorable.

Table 9-11. *Frequency and percent of skid trail observations (segments) by soil drainage class on 76 timber harvesting operations in Vermont, 2012.*

Soil Drainage Class	Number of Observations	Percent of Observations
Well Drained	119	18%
Moderately Well Drained	382	60%
Poorly Drained	140	22%
Total	**641**	**100%**

Soil drainage was unfavorable (poorly drained) for the location of skid trails on 5 miles (22%) of the total length of skid trails evaluated. Gully erosion (greater than 6 inches deep) was observed on four of these 13 operations. Rutting can be minimized on poorly drained soils by utilizing tree tops and limbs to “brush-in” or armor skid trails, or by restricting operations to times when the ground is frozen during winter months.

[123] If several choices existed, the trail judged to have the most potential for impact was chosen.

Seventy-four percent of observations were rated as having “none to sheet” erosion[124] as the most severe surface erosion type encountered (Table 9-12) with 20% of observations rated as “rill up to 6” deep.” There was no advanced gully erosion observed.

Fifty-eight percent of skid trail segments (observations) were observed to have fewer waterbars and other drainage structures installed than recommended in Table 1 of the AMPs (Table 9-12). When installation of waterbars as required in Table 1 of the AMPs was summarized by operation, 61% of the THOs did not meet the standard.

Table 9-12. *Percent of skid trail observations (segments) by soil erosion type rating on 76 timber harvesting operations in Vermont, 2012.*

Most Severe Erosion Type Observed	Percent of Observations
None to sheet	74%
Rill up to 6 inches deep	20%
Initial Gully: 6-12 inches deep	5%
Marked Gully: 12-24 inches deep	1%
Advanced Gully: greater than 24 inches deep	0%

Log Landings

One hundred-two log landings were evaluated on 69 timber harvesting operations for surface erosion type and AMP compliance. General statistical information with respect to size and numbers of landings is summarized in Table 9-13. Results of AMP evaluations can be found in the *Existing Statutes Compliance* section of this chapter.

Table 9-13. *Size and number of landings per THO for 69 timber harvesting operations in Vermont.*

Size (acres)		Landings/THO	
Mean:	0.5	Mean:	1.47
Median:	0.3	Median:	1.00
Range:	0.1 – 2.0	Range:	1 - 7

Twelve operations did not have landings that could be evaluated because they were not discernable, 3 operations were land use conversions from forest to agriculture, and the other 9 operations had landings located in agricultural fields, pastures, or non-forested openings.

To determine if necessary grading and draining had been conducted, log landings were evaluated for existing surface erosion (Table 9-14). Eighty-three percent of landings (85) evaluated exhibited “none to sheet” erosion. “Rill erosion up to 6” deep” was

[124] These categories were combined to allow comparison with the 1990 assessment. The 1990 report explains the combination of the “no apparent erosion” and “sheet erosion” categories by explaining that as roads re-vegetated in the growing season(s) following the harvest, it became increasingly difficult to distinguish between them, and the categories were combined in the report. During the 2012 assessment, data were collected separately for these two categories of erosion severity and combined for reporting purposes.

observed on 14% of landings (14); “initial gully erosion from 6-12” deep” was observed on 2 landings; “marked gully erosion, 12–24” deep” was observed on 1 landing. “Advanced gully erosion” was not observed on any of the landings evaluated.

Table 9-14. *Frequency of log landings by soil erosion type rating on 69 timber harvesting operations in Vermont, 2012.*

Most Severe Erosion Type Observed	Number of Log Landings
None to sheet	85
Rill up to 6 inches deep	14
Initial Gully: 6-12 inches deep	2
Marked Gully: 12-24 inches deep	1
Advanced Gully: greater than 24 inches deep	0

Eighty-six percent of all landings (88 observations) and 87% of operations (60 operations) had landings that were graded and water diversions had been installed. Sixty-two percent of landings (63 observations) were also seeded and mulched. The remaining 38% of landings (39 observations) were not seeded and mulched or the observer was unable to determine their status.

Landings were located on gentle slopes between 0-5% grade on 71% of the operations (49 operations), or 63% of the total number of landings evaluated (64 observations). Thirty-eight landings were located on slopes between 6-15% and no landings were located on slopes greater than 15%.

Landings were located on well-drained or moderately well-drained soil 90% of the time. One landing was located in a wetland and was operated under frozen conditions. This is an allowed use under the Vermont Wetland Rules.

Existing Statutes Compliance

Each timber harvesting operation was evaluated for compliance[125] with applicable Acceptable Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont for truck roads, skid trails, log landings, and streams and other waterbodies (Table 9-15, Table 9-16, Table 9-17,Table 9-18). Additional details regarding compliance with AMPs can be found in Appendix C of this report.

[125] Compliance data calculated from the sample population size (“n” value) are presented and have been arranged to summarize both compliance by frequency of observations and also by frequency of operations. If one observation was not in compliance on an operation, for the AMP being assessed, then the operation was deemed to be out of compliance with that AMP. Comparisons were not made to determine level of partial AMP compliance by operation. The comparison across the columns in the tables below provides an indication of the level of distribution of any particular metric (observation) across many operations versus its concentration on a smaller number of operations: a higher level of compliance by operation, suggests more concentration of the non-compliance data in a smaller number of operations.

Permanent Truck Roads

Table 9-15. *Compliance with the Acceptable Management Practices (AMPs) pertaining to truck roads on timber harvesting operations in Vermont, 2012.*

AMP Evaluated	Level of AMP Compliance by Observation (Percent)	Level of AMP Compliance by Operation (Percent)
AMP 1. Steep pitches greater than 10% on permanent truck roads shall not exceed 300 feet in length.	n=142 88%	n=32 69%
AMP 2. Road surfaces on permanent truck roads shall be adequately drained with culverts and broad-based dips and spaced at intervals according to Table 1 in the AMPs where conditions permit.	100%	100%

Skid Trails

Table 9-16. *Compliance with the Acceptable Management Practices (AMPs) pertaining to skid trails on timber harvesting operations in Vermont, 2012.*

AMP Evaluated	Level of AMP Compliance by Observation (Percent)	Level of AMP Compliance by Operation (Percent)
AMP 5. Short steep sections up to 20% grade are permissible but shall not exceed 300 feet in length.	n=641 94%	n=76 72%
AMP 19. Ruts shall be filled and smoothed if they offer any potential for gullying.	n=641 95%	n=76 78%
AMP 20. Waterbars shall be installed at proper intervals according to Table 1 in the AMPs.	Avg. 42%	Avg. 39%

Post-harvest use of transportation networks (truck roads and skid trails) by recreational vehicles was not determined to have been an important factor in reduced AMP compliance or increased soil erosion for this assessment. The1990 assessment noted that post-harvest recreational use of roads and trails was common and that closeout techniques used at the time were insufficient to withstand this use.

Streams and Other Waterbodies

Table 9-17. *Compliance with the Acceptable Management Practices (AMPs) pertaining to streams and other waterbodies on timber harvesting operations in Vermont, 2012.*

AMP Evaluated	Level of AMP Compliance by Observation (Percent)	Level of AMP Compliance by Operation (Percent)
AMP 8. Streams and all bodies of water shall be kept free of slash and other logging debris.[126]	-	-
AMP 9. Truck road crossings of all permanent streams shall be over a bridge or culvert.	n=37 92%	n=23 59%
Streams may be forded by skid trails only where streambeds have stable beds and approaches.	n=3 100%	n=3 100%
AMP 10. Logging activities shall be kept out of stream channels.	n=255 98%	n=48 92%
AMP 11. Turn-ups or broad-based dips shall be used before a truck road or skid trail crosses a stream.	n=147 30%	n=52 8%
AMP 13. Stream crossings shall be made at right angles where possible.	n=147 88%	n=52 73%
AMP 14. Except for the necessary construction of stream crossings, a protective strip shall be left along streams and other bodies of water in which only light thinning or selection harvesting can occur. Width of the protective strip shall be in accordance with Table 4 in the AMPs.	n=242 60%	n=48 38%
Log transport machinery must remain outside a 25-foot margin along streams or other waterbodies.	n=255 78%	n=48 44%
AMP 21. All non-permanent structures shall be removed from streams and the channel restored.	n=92 76%	n=49 57%
AMP 22. Following the close of operations, all approaches to streams shall be stabilized, seeded, and mulched.	n=70 53%	n=45 38%

[126] Data collection procedures and coding related to deposition of logging slash in streams and other waterbodies did not allow for comparison to AMP 8 and are therefore not reported here.

Log Landings

Table 9-18. *Compliance with the Acceptable Management Practices (AMPs) pertaining to log landings on timber harvesting operations in Vermont, 2012.*

AMP Evaluated	Level of Compliance by Observation (Percent)	Level of Compliance by Operation (Percent)
AMP 15. Log landings shall be located on level or gently sloping stable ground.	n=102 63%	n=69 71%
AMP 16. Log landings shall not be located in protective strips.	n=102 86%	n=69 87%
AMP 23. Log landings shall be graded and water diversions installed as needed to prevent sedimentation.	n=102 80%	n=69 77%
AMP 24: Areas of exposed soil within the protective strip along waterways shall be seeded and mulched.	n=14 50%	n=11 55%

Silvicultural Activities in Vermont Wetlands

Timber harvesting operations were evaluated for compliance with Vermont Wetland Rules (Vermont Agency of Natural Resources 2010).

Silvicultural activities in wetlands remain an 'Allowed Use' under the wetland rules as long as certain conditions are followed. Silvicultural activities, as defined in the Vermont Wetland Rules, mean those activities associated with the sustained management of land for silvicultural purposes including the planting, harvesting, and removal of trees.

Compliance with Vermont's Wetland Rules

Twenty-three wetlands and their associated buffers were evaluated for timber harvesting impacts on 21 operations. Eleven wetlands are Class II significant wetlands as mapped on the Vermont Significant Wetlands Inventory Maps. The other 12 were unmapped wetlands. Class II significant wetlands ranged in size from 1.1 acres to 33.9 acres, and averaged 7.2 acres.

A total of 99 observations were made along the boundaries and encircling each of the wetlands evaluated. Harvesting was conducted within wetlands on 5 operations – an allowed use under the Vermont Wetland Rules.

Residual crown canopy in all wetland buffers evaluated averaged 71% with a median value of 85%. A landing on one operation was located in a wetland under frozen conditions - an allowed use under the Vermont Wetland Rules.

Presence or absence of several conditions that would indicate potential negative impacts to wetlands were recorded for each observation and are detailed below. Timber harvesting impacts to wetlands were observed on two of the twenty-one operations where wetlands were evaluated.

- <u>Excessive rutting that alters natural hydrology</u>

No excessive rutting was observed on 85% of observations for wetlands assessed. Excessive rutting was documented in 2 wetlands, both on the same operation. Rutting was documented on 9 out of the 15 observations made – an excessive amount that would impact natural hydrology and prevent re-establishment of wetland vegetation.

- Excessive amount of brush or corduroy in skid trails or truck roads that alters grade or natural hydrology

  Excessive use of brush and/or corduroy[127] was noted on 1% of observations. Natural hydrology was altered by an excessive amount of brush in an approximate 20-foot length of skid trail on a single operation.

- Sediment entering a wetland

  There were no observations of sediment entering a wetland.

- Filling a wetland

  There were no truck roads located through wetlands. No filling occurred as a result. An excessive amount of brush was used in a skid trail on one operation and was thus considered to be fill.[128]

Results Comparison: 1990 and 2012

Impacts to Water Quality from Timber Harvesting Operations

Results of this assessment suggest reduced negative impacts to water quality, as compared to the 1990 report findings in several areas. The three categories of impacts listed in Table 9-19 show improved conditions on timber harvesting operations from 1990 to 2012 for those measures where data are comparable. The data contained in this table were calculated and are expressed in the same manner and format as in the 1990 report.

A direct comparison of dominant condition/sedimentation levels of streams and other waterbodies and the extent of logging slash left in waterbodies was not possible due to differences in data collection methodology for the 2012 assessment. A complete description of these differences is provided in the Streams and Other Waterbodies section of this chapter. Comparisons of compliance with specific AMPs were also not possible due to the lack of documentation of procedures used to calculate the percentage of compliance for each attribute in the 1990 assessment report.

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[127] Excessive use of brush and/or corduroy was defined, for the purposes of the assessment, as an amount sufficient to alter the hydrology of the wetland and/or to affect the ability of the wetland to re-vegetate and return to natural conditions.

[128] This refers to the same operation where excessive brush used on a 20-foot length of skid trail altered the natural hydrology of the wetland.

Table 9-19. *Comparison of logging related impacts to water quality for timber harvesting operations in Vermont, 1990 and 2012.*

Description of Impact	Percent of All Operations					
	No Waterbody Evaluated		Water Quality Impacted[129]		Water Quality Not Impacted[130]	
	2012	1990	2012	1990	2012	1990
Stream crossing sedimentation	36%	37%	26%	36%	38%	27%
Logging slash at stream crossings	36%	37%	32%	35%	32%	28%
Petroleum spills	36%	3%	0%	4%	93%	64%

Evaluation and Comparison of Stream Crossings

Types of stream crossings used in timber harvesting operations: The results of the 2012 assessment showed substantial improvements in stream crossing practices on timber harvesting operations compared to 1990 (Table 9-20). The 1990 report indicated that fording streams was a common practice and 50% of all stream crossings were fords, mostly located on skid trails. The 1990 report also indicated that 10% of temporary stream crossing structures were recorded as “structure removed” compared to 47% in 2012.

Table 9-20. *Percent of total stream crossing structures used by structure type on timber harvesting operations in Vermont, 1990 and 2012.*

Stream Crossing Structure Type	Percent of Total Structures	
	2012	1990
Culvert	30%	24%
Ford	5%	50%
Bridge	5%	4%
Log Ford	9%	10%
Other/Brush	5%	<1%
Structure Removed	47%	10%

Levels of logging slash observed at stream crossings: Results of the 2012 assessment indicate a lower percentage of stream crossings on timber harvesting operations were impacted by logging slash (Table 9-21). Results also showed a lower incidence of logging slash at levels capable of blocking or altering stream flow at crossings, than that reported in 1990.

For Table 9-21 through Table 9-22, frequency and percentage were calculated based upon the total number of THOs evaluated, whether or not there was a stream crossing associated with the operation. This methodology was consistent with that used for the 1990 assessment and allows for comparison of results. The calculations also reflect THOs with multiple stream crossings and different levels of logging slash observed. For

[129] “Percent Water Quality Impacted” represents the percentage of all THOs with feature that were impacted.

[130] “Percent Water Quality Not Impacted” represents the percentage of all THOs with feature that were not impacted.

example, a THO has three stream crossings that were evaluated. One crossing had no slash, one crossing had moderate slash, and one crossing had slash that was blocking/altering streamflow. This THO would be recorded three times for each of the three categories of logging slash. Because of the way the calculations were made, percentages do not add up to 100 percent.

Table 9-21. *Frequency and percent of stream crossings with logging slash left in stream channels by slash level observed on timber harvesting operations in Vermont, 1990 and 2012.*

Amount of logging slash at stream crossings[104]	2012		1990	
	Frequency[131]	Percentage[132]	Frequency	Percentage
Natural	44	54%	41	53%
Moderate	21	26%	17	22%
Blocking/Altering stream flow	8	10%	15	19%
No stream crossings	29	36%	29	37%

Level of sedimentation observed at stream crossings: Results of the 2012 assessment indicate a larger percentage of stream crossings on timber harvesting operations that were not impacted by sediment when compared with results from 1990 (Table 9-22).

Table 9-22. *Frequency and percent of sedimentation at stream crossings by sedimentation level observed on timber harvesting operations in Vermont, 1990 and 2012.*

Level of Sedimentation at stream crossings	2012		1990	
	Frequency[131]	Percentage[132]	Frequency	Percentage
Natural	45	56%	40	51%
Thinly coated streambed	18	22%	22	28%
Plumes, thick deposits	5	6%	11	14%
No stream crossings	29	36%	29	37%

CONCLUSIONS

Results of this assessment, suggest a lower incidence of negative impacts to water quality, as compared to the 1990 report findings. Improvements were noted for presence of sediment and logging slash at stream crossings and a lower frequency of petroleum spills.

Overall, 78% of crossings were rated as “natural streambed conditions prevalent - no sedimentation.”

No logging slash was observed at 75% of stream crossings assessed.

[131] Frequency sums the number of occurrences of a specified condition across all stream crossing points. More than one stream crossing, and therefore multiple conditions, may occur on a single THO.

[132] The Percentage calculation uses Frequency in the numerator and the total number of THOs in the denominator – 78 for 1990 and 81 for 2012. This calculation allows comparisons to be made between the two assessments. Since the denominator is all THOs, Percentage will not equal 100%.

There was no evidence of petroleum spills or other hazardous materials at any of the stream crossings evaluated. Evidence of a petroleum spill was observed at one log landing on an operation.

The assessment results suggest that stream crossing practices have improved and that culverts were the most commonly used structure type for crossing streams on the assessed timber harvesting operations. However, most of the culverts left in place following logging were not adequately sized to handle long-term flood events.

The 1990 report indicated that fording streams was the most common stream crossing practice and that 50% of all stream crossings were fords, mostly located on skid trails. During the 2012 assessment only 5% of crossings were classified as fords. While AMPs allow the use of fords on skid trails under certain conditions, there is an elevated risk for streambed disturbance and sedimentation when compared with the use of other crossing types.

The 1990 report also indicated that 10% of temporary stream crossing structures were recorded as “structure removed,” compared to 47% in 2012.

Evaluation of structure size openings indicated that 61% of all structures were adequately sized to accommodate a 1-3 year flood event; 16% of all structures were adequately sized to accommodate a 10-year flood event; and 8% of all structures were adequately sized to accommodate a 25-year flood event. Because these structures were still in place following sale close-out, they must be considered permanent and therefore, most are undersized and at high risk to wash-out during flooding events.

AMP compliance was high for streamside protective strips, truck roads, and log landings.

Residual crown closure along streams and other waterbodies averaged 85%.

Protective strip width was adequate or more than adequate (as outlined in AMPs Table 4) at 60% of the total observations on streams. Thirty-eight percent of operations met protective strip width requirements 100% of the time. Continuous cover was maintained adjacent to open water on all operations.

No machine entries within 25 feet of streams were recorded on 78% of observations.

Protective strips met or exceeded recommended widths on 95% of the observations associated with truck roads and 96% of the observations associated with skid trails.

Truck roads were adequately drained with properly spaced culverts and broad-based dips at 100% of observations. Steep pitches, greater than 10%, did not exceed 300 feet in length on 88% of observations.

Eighty-six percent of landings were located outside streamside protective strips and 83% of landings evaluated were rated as having erosion limited to “none to sheet erosion.”

There was a high level of compliance with the Vermont Wetlands Rules on timber harvesting operations.

Twenty-three wetlands and their associated buffers were evaluated for timber harvesting impacts on 21 operations. Timber harvesting impacts to wetlands occurred on 2 of the 21 operations evaluated.

Findings from this assessment indicate that 22% of stream crossings showed evidence of sedimentation and represented the principal source of sediment associated with the timber harvesting operations observed.

Of the 147 stream crossings evaluated, 32 showed evidence of sedimentation as a result of logging. This is less than reported in the 1990 assessment (28% of crossings in 2012 vs. 42% of crossings in 1990).

Twenty-eight temporary stream crossing structures (19% of total) were still in place after logging. They included seven culverts, thirteen log fords, and eight brushed-in crossings. Culverts and removed structures were noted to be the most common stream crossing “structures” associated with sedimentation at crossings (14% of all stream crossings).[133]

Measures intended to divert runoff from skid trails and truck roads on approaches to stream crossings, such as incorporating turn-ups or installing broad-based dips, were not applied on 70% of stream crossings evaluated.

Thirty-seven stream crossings, where temporary structures were removed had seeded and mulched approaches (53%), and 21 (30%) did not. There was no visual evidence of seeding and mulching at 11 other crossing sites (16%) and field investigators were unable to determine if the practice was implemented.[134]

Numbers of waterbars observed on skid trails were below levels recommended by the AMPs.

The number of waterbars and other drainage structures installed on skid trails according to spacing requirements in Table 1 of the AMPs averaged 42% of the required number by observation (segment) and 39% of the required number by operation.

[133] Sedimentation observed where structures were removed cannot be attributed directly to lack of AMP compliance. The streams affected were apparently flushing out sediment due to streambed disturbance during logging and from removal of the stream crossing structure. Therefore, it can be concluded that this is an ephemeral condition, whereas sediment inputs associated with undersized culverts and those with perched outlets will linger until corrective action is taken.

[134] There was no observable soil movement resulting in sedimentation at 90% of the stream crossings evaluated and in many cases, the approaches had re-vegetated naturally to forbs, grasses, and sedges.

Seventy-four percent of observations were rated as having “none to sheet” erosion as the most severe surface erosion type encountered on skid trails.

RECOMMENDATIONS

Direct and enhance efforts to reduce sedimentation associated with temporary stream crossings on logging operations by:

- promoting and increasing the use of portable skidder bridges through education, outreach, and program delivery.
- providing guidance and training for choosing the appropriate type of temporary stream crossing structure, as allowed in the AMPs, based upon stream characteristics.
- providing guidance and training regarding specific techniques for stabilizing approaches to temporary stream crossings within the stream buffer on skid trails.

Provide technical guidance and training for installing and sizing permanent bridges and culverts on perennial streams to improve flood resiliency and reduce sedimentation.

Continue efforts to develop the second edition of the AMP manual. The next edition will provide enhanced guidance to help attain a higher level of AMP compliance and protection of water resources.

Continue to provide AMP training to loggers through the Logger Education to Advance Professionalism (LEAP) Program and other education providers.

Continue to provide AMP technical assistance to loggers and landowners through the AMP Monitoring Program administered by FPR.

Explore potential funding opportunities for conducting AMP effectiveness and evaluation monitoring of logging operations using the USDA Forest Service State & Private Forestry Northeastern Area protocol – Best Management Practices (BMPs) Implementation and Effectiveness for Protection of Water Resources (Welsch et al. 2007).

Support regional research efforts that examine the effectiveness and cost of implementing water quality Best Management Practices on logging operations.

Explore the feasibility of starting a program in Vermont that provides incentive financing to loggers to reduce non-point source pollution risk on timber harvests, using the Maine Forestry Direct Link Loan Program as a model.

CHAPTER 10: WILDLIFE HABITAT

INTRODUCTION

Wildlife species vary in their habitat requirements and sensitivity to disturbances, and timber harvesting can have positive, negative, or neutral impacts on wildlife habitat. Indeed, a particular operation may improve habitat for some species, while reducing habitat for others. For example, a harvest designed to improve habitat for ruffed grouse and other early successional-dependent species would likely reduce habitat for forest interior songbirds.

Since it is impossible to make lists of all wildlife species that are helped or harmed by each operation, this assessment considers potential impacts to a variety of coarse-scale and fine-scale habitat features. Coarse-scale features include those, such as habitat blocks and natural communities, which are not necessarily associated with particular wildlife species. These features provide an indication of some overall characteristics of the landscape in and around harvest operations. Fine-scale features include those, such as deer wintering areas, vernal pools, or standing dead trees, which are necessary biological requirements for a single species or suite of species. Disturbance of these fine-scale features could result in the loss of the associated species from the local landscape.

The features used in these analyses were selected in order to compare results with the 1990 assessment, for their importance to wildlife, and for their ability to be meaningfully assessed within the scope of this project. Many other factors are commonly used to provide a more complete picture of the relative quality of wildlife habitat, but were beyond the scope of this assessment. The habitat components addressed in this assessment are not presented as the only measures of wildlife habitat, but rather as a broad set of indicators.

DESIGN

In practice, three levels of data collection were used in evaluating the effects of timber harvests. First, interviews with a contact person for each operation indicated whether a conscious effort was made to incorporate wildlife considerations into the harvest plan, such as by the involvement of a wildlife biologist or inclusion of special contract provisions for wildlife.

A second level of data was obtained from several sample plots in each timber harvest operation. These plots included six vegetation plots in each operation, as well as additional plots taken to survey for abundance of coarse woody material of sizes most desirable for wildlife habitat (see Appendix D for a full description of field survey methods). These data were used to evaluate the post-harvest forest composition and structure, which has a strong influence on the distribution of wildlife.

Finally, spatial data for the 81 operations were overlaid with several state-wide data sets for important habitat features: deer wintering areas, vernal pools, rare natural communities, and habitat blocks. These analyses provided some indication of the frequency with which harvesting may affect the first three feature types, while the habitat block data allowed some analysis of landscape context.

It should be noted that while all 81 THOs are included in much of this analysis, three THOs were conducted for the purpose of conversion of forest to agricultural land.

RESULTS AND ANALYSIS

Characteristics of Timber Harvesting Operations

An interview was conducted with a person knowledgeable about the timber harvest; questions were asked related to the involvement of natural resource professionals in the timber harvest planning and implementation.

Professional foresters were consulted on 86% of all timber harvesting operations (70 operations); wildlife biologists/ecologists were consulted on 16% of the 81 THOs (Table 10-1). Ten of the THOs occurred on public land where involvement of wildlife biologists was likely required, therefore biologist involvement in THOs on private land occurred at a lower rate.

Table 10-1. *Characteristics of 81 timber harvesting operations (THOs) in Vermont that may indicate wildlife management considerations, 2012.*

	Number of THOs
Public or private land?	
Private	71
Public	10
Total	**81**
Enrolled in UVA?	
No	22
Yes	59
Total	**81**
Natural resource professional consulted?	
AMP Forester	4
Ecologist	1
Other	6
Stream alteration engineer	1
Wildlife biologist	11
None	58
Total	**81**
Professional forester involved?	
No	11
Yes	70
Total	**81**
Special provisions in contract?	
Wildlife habitat	12
Wildlife habitat not expressly noted	69
Total	**81**

There are likely several reasons why wildlife biologists may not have been consulted more often in private forest land management, but since the reasons for the decision were not included in the interview, it is impossible to speculate what those reasons were. On 15% of THOs (12 operations), contacts reported that special provisions for wildlife were included in harvesting contracts. This may be an under-representation of operations that actually addressed wildlife habitat concerns, as the question specifically asked about “special” provisions and not those that may be considered “standard” in a contract.

Changes in Habitat Structure

Snag Presence

Standing dead trees, also known as snags, are used by many wildlife species, providing important feeding, nesting, and denning sites. Published research and guidelines vary somewhat in recommended post-harvest snag densities, but many suggest that post-harvest forests in New England should have a minimum of 4-5 snags per acre that are 15” diameter breast height (DBH) or larger, and that one of these should be 18-20” DBH or larger, in order to support a variety of snag-using wildlife species (Forest Guild Biomass Working Group 2010, Bryan 2007, Flatebo et al. 1999, Weber 1986).

Ninety-three percent of the 81 THOs (75 operations), had residual snags that were observed in the sample plots. The mean residual snag density on these 75 THOs appears to be well below published recommendations (Table 10-2). On average, an estimated 3 snags larger than 10” DBH per acre were found on post-harvest THOs in hardwood forests, one of which was larger than 15”. Mixed-wood and softwood forests had lower snag densities. The majority of the retained snags were smaller than 15” DBH, and essentially no snags 25” DBH or larger were present.

Table 10-2. *Mean number of snags (hard and soft) > 10” diameter breast height (dbh), per acre, post-harvest, by pre-harvest forest cover type class on 75 timber harvesting operations with residual dead trees >10” dbh in Vermont, 2012.*

DBH Class (1” categories)	Mean Number of Snags per Acre		
	Hardwood	**Mixed wood**	**Softwood**
10 to 14	2.53	0.38	1.46
15 to 24	0.71	0.11	0.22
over 24	0.03	0.02	0.03
Total	**3.27**	**0.51**	**1.71**

While snags are generally not present in adequate numbers for wildlife, this is not necessarily interpreted as a direct negative impact of the most recent harvesting activity. It may be a result of a combination of the average age of Vermont’s forests and previous harvesting activities that has resulted in a low abundance of snags overall. The lack of pre-harvest data makes definitive conclusions on harvesting impacts to snag densities impossible.

Coarse Woody Material

Coarse woody material has been shown to provide important wildlife habitat. Biodiversity in the Forests of Maine: Guidelines for Land Management (Flatebo et al. 1999) states that downed woody material, snags, and cavity trees are important shelter, resting, nesting, denning, foraging, perching, displaying, and basking sites for 20% of bird, 50% of mammal, 44% of amphibian and 58% of reptile species in Maine.

An analysis was conducted to determine the number of coarse woody material pieces (CWM) by diameter class and whether the pieces were hollow or sound (not hollow) (Table 10-3). The dataset used in this analysis includes CWM measurements from 468 fixed-radius plots (THOs that resulted in agricultural conversions were excluded).

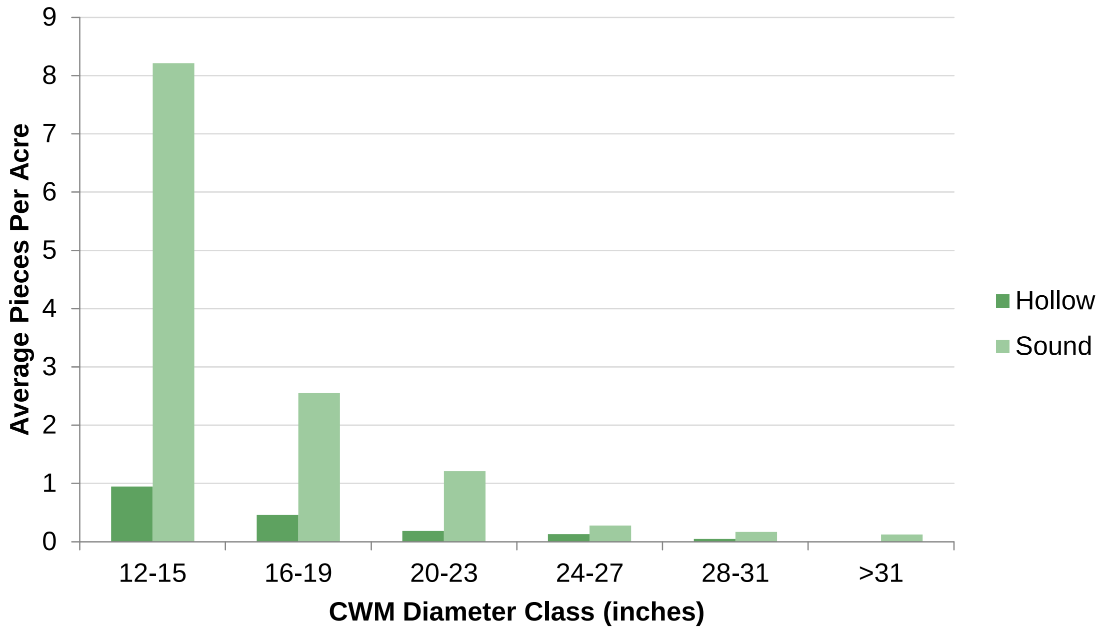
Table 10-3. *Number of pieces of coarse woody material per acre, by diameter class and condition on 78 timber harvesting operations in Vermont, 2012.*

Diameter Class	Condition	
	Sound	Hollow
12”-19”	10.72	1.41
20” and larger	1.96	0.51

Approximately 64% of the sampled CWM pieces were in the 12- to 15- inch diameter class and the number of pieces decreased with increasing diameter (Figure 10-1). According to USDA Forest Service, Forest Inventory and Analysis (FIA) data, on a statewide basis, distributions of CWM by diameter class also decrease with increasing diameter (Morin et al. 2011). The majority of the pieces on sampled THOs were sound (i.e., not hollow), but the percent of logs that were hollow generally increased with increasing diameter.

CWM pieces 12-inches and greater in diameter were present on 41% of plots, and pieces 20-inches and greater in diameter were present on 9% of plots. The abundance of large coarse woody material on the sampled plots is similar to statewide estimates from the FIA program across nearly all diameter classes greater than 12 inches. However, the number of pieces is nearly three times greater in the 16-19 inch class than FIA estimates. As noted in Chapter 7 (Timber Quality and Productivity), about half of the coarse woody material appeared to have been left by the most recent harvest. Together, these data suggest that timber harvesting has the potential to improve certain aspects of habitat for some wildlife species at least in the short term.

Figure 10-1. *Distribution of hollow and sound coarse woody material (CWM), by diameter class, on 78 timber harvesting operations in Vermont, 2012.*



Silvicultural Practices and Changes in Habitat Structure

Different silvicultural practices result in different types of wildlife habitat, thus the overall mix of silvicultural practices can be a broad indicator of post-harvest habitat diversity. Changes in habitat structure resulting from timber harvesting operations can range from minimal (light individual-tree selection harvest) to extreme (large clearcut). Partial cutting/thinning has the potential to benefit wildlife species that favor the multi-layered, diverse structure of a more mature forest, while clearcuts and shelterwood harvests benefit those species that prefer forest edges and early-successional habitat. Group selection harvests, depending on the specific size of the groups and overall area harvested, can provide a mix of early and late successional habitat patches. The resulting mosaic of habitat conditions produced by group selection harvesting is much like that maintained by fine-scale natural disturbances (William S. Keeton, personal communication, Rubenstein School of Environment and Natural Resources, University of Vermont).

On the 81 THOs analyzed for this assessment, many types of forest harvesting practices were used, resulting in a wide variety of residual stand structures (Table 10-4). Approximately 33% of plots were harvested using the overstory removal/clearcut, strip cut, or shelterwood/seed tree/prep cut methods; these areas likely had conditions that resulted in initiation of regeneration and improved early successional habitat. Approximately 63% of plots were harvested using partial cutting/thinning or other partial harvest methods; these areas likely had conditions that minimally impacted forest structure and existing habitat.

Table 10-4. *Silvicultural methods used on 81 timber harvesting operations in Vermont, 2012.*

Silvicultural Method	Percent of Harvested Area (from Table 3-3)	Percentage of Plots
Patial Cutting/Thinning	49%	48%
Overstory Removal/Clearcut	29%	22%
Shelterwood/Seed Tree/Prep Cut	17%	11%
Group Selection	6%	15%
Stripcut	1%	1%
Other[135]	1%	4%

Some of the most obvious impacts a timber harvest will have on a wooded landscape are changes to forest composition and understory vegetation (Table 10-5).

Table 10-5. *Expected dominant vegetation (3-5 years after cutting) on 486 survey plots on 81 timber harvesting operations in Vermont, 2012.*

Expected Dominant Vegetation Type	Number of Plots	Percentage of Plots
None[136]	20	4.12%
Ferns, herbs	148	30.45%
Shrubs, Rubus	38	7.82%
Tree coppice	25	5.14%
Seed/saplings	221	45.47%
Non-native, invasive	31	6.38%
Unknown	3	0.62%
Total	**486**	**100.00%**

While the short-term changes to a forest (i.e., creation of early successional, young forest) are often the focus when considering wildlife needs, it is also important to account for the long-term impacts to forest composition, structure, and condition. If a harvest does not result in conditions that favor adequate regeneration of native species, the long-term wildlife habitat value of the forest will be reduced. Data on regeneration is addressed at length in Chapter 7 (Timber Quality and Productivity) but two points are worth mentioning here:

First, evidence of “heavy” or “severe” browsing by white-tailed deer and moose was noted at 15% of THO sample plots (excluding agricultural conversions), and 50% of plots had evidence of “moderate” browse impacts. Browse pressure can favor plant species such as hay-scented fern, which is not browsed and which inhibits the regeneration of tree species. In addition to causing long-term compositional changes in the forest (with resulting effects on songbirds, amphibians, and many other wildlife species dependent on complex forest structure), a lack of understory regeneration can eventually reduce the capacity of the forest to support deer or moose.

[135] Silvicultural method “other” represents 3 agricultural conversion THOs.

[136] Eighteen of the 20 plots with an expected vegetation type in 3-5 years of “None” were agricultural conversions.

Second, non-native invasive plant species were found to be the expected dominant understory at 7% of THO plots sampled. The presence of these species cannot be attributed as a direct impact of the harvest; however, any disturbance (e.g., creating canopy gaps or soil disturbance) that takes place in proximity to non-native, invasive species has the potential to promote the spread of these undesirable species. Once a forest is dominated by non-native species, it provides lower habitat quality for many native wildlife species (see for example, Schmidt and Whelan 1999). The data from this assessment are cause for concern, but they also suggest that invasive plant species may not yet be well established on the majority of THOs sampled.

Spatial Analysis

The following analyses used digital mapping software to compare locations of the THOs with specific habitat features (see Chapter 2 for a full description of digital analysis methods). All of these analyses are new to this effort, and were not conducted in the 1990 assessment.

Deer Wintering Areas

Deer wintering areas (DWAs), which are typically dense softwood forests that limit snow accumulations on the ground and provide thermal cover, are essential habitat for white-tailed deer. The Vermont Department of Fish and Wildlife maintains a digital map of deer wintering areas and has outlined specific habitat management recommendations aimed at maintaining or improving the functions of DWAs.

Twenty-one percent of the 81 operations (17 operations) overlapped with mapped deer wintering areas. The area of DWA that fell within each of these operations ranged from 3.5 to 76 acres, with a mean of 24 acres.

Since "perpetuating shelter" or maintaining softwood cover is the number one management goal for DWAs (Reay et al. 1990), plot data from these 17 operations was used to assess whether harvesting was changing softwood or mixed-wood plots into hardwood plots. Of the 102 total plots, 57 were identified as having softwood or mixed-woods cover types pre-harvest.[137] Eighty-four percent of the 57 plots (48 plots) had no change in cover type post-harvest. Of the 16% of plots (9 plots) that did change from softwood or mixed-wood cover to another type, eight transitioned to hardwood cover. (The remaining plot was classified as "open"). Overall in the THOs, 31% of softwood and mixed plots were converted to a hardwood or open cover type (see Chapter 7, Timber Quality and Productivity). Conversion of softwood plots in THOs associated with DWAs, then, is occurring at just half that frequency, indicating that the presence of mapped DWA in the THO may be resulting in more softwood cover retained.

Vernal Pools

Vernal pools provide important habitat for many species of amphibians, as well as some invertebrates. In addition to the pool itself, upland forest within 600 feet of the pool is essential habitat for amphibians (Faccio 2003, Semlitsch 1998). Thus, this analysis

[137] As noted in previous chapters of this report, pre-harvest cover types were estimated by field crews utilizing observations of both residual trees and stumps. See Appendix D, Data Collection Procedures.

considers potential impacts to vernal pools and their surrounding upland forest (sometimes called the “life zone”).

This assessment draws on the Vernal Pool Mapping Project,[138] a statewide inventory of verified and potential vernal pools. The dataset includes 909 field-verified vernal pools and an additional 1,557 potential vernal pools identified only from remote sensing. Data analysis from the Vernal Pool Mapping Project indicates roughly an 80% success rate in field verification of these potential pools. Pools are mapped digitally as 600-foot radius circular polygons centered on pool locations. The 600-foot radius is designed to capture the upland “life zone” around the pool. For the purposes of this assessment, “overlap with a vernal pool” includes overlap with the pool itself and/or the life zone.

Of the 81 THOs, three operations overlapped with field-verified vernal pools or their life zones. One of these operations had two pools in close proximity, so a total of four pools were feasibly affected by timber harvesting. An additional three operations overlapped with potential vernal pools. One of these operations overlapped three potential pools, resulting in a total of five potential vernal pools that might be affected.

The proximity of vernal pools and timber harvest operations does not in itself indicate impact. Special provisions in the harvest layout and contract could minimize or prevent impacts. Without such considerations, however, there is a reasonable possibility of negative impacts. The results of this analysis suggest that cases where vernal pools are in proximity to harvesting are not common, but may be frequent enough to warrant more detailed investigation into whether impacts are occurring.

Rare Natural Communities

Because of their rarity on the landscape, rare natural communities disproportionately contribute to biological diversity, often supporting plant and animal species not found in more common settings (Thompson and Sorenson 2005).

The Vermont Department of Fish and Wildlife’s Natural Heritage Database tracks all known, ecologically viable examples of rare natural communities. A total of 612 records of rare natural communities (those ranked “S1” or “S2”), were drawn from the database to use in this analysis. While this is not a complete index of every occurrence (new occurrences of rare natural communities are discovered and recorded regularly), it does represent the best understanding of their distribution in Vermont.

None of the THOs overlapped with a known occurrence of a rare natural community.

Habitat Blocks

Habitat block data was drawn from Sorenson and Osborne (data not yet published, but available upon request from the Vermont Department of Fish and Wildlife), which identified all areas of contiguous forested habitat without fragmentation[139] in Vermont.

[138] A collaborative project led by the Vermont Center for Ecostudies and Arrowwood Environmental, along with other contributors. Funded by State Wildlife Grants, and with technical support from the VT Agency of Natural Resources. The dataset used in this analysis is identical to that released in 2013 as part of the VT ANR BioFinder Project (Vermont ANR 2013).

[139] Fragmentation is defined as “dividing land with naturally occurring vegetation and ecological processes into smaller and smaller areas as a result of roads, land clearing, development, or other land uses that remove vegetation and create physical barriers to species’ movement and ecological processes between previously connected natural vegetation” (Sorenson and Osborne,

Their work identified over 4,000 habitat blocks greater than 20 acres, and assigned each block a score based on biological function and physical diversity, called the "ecological importance score." Examples of the factors used in scoring included size of the block, the block's role in large-scale wildlife movement corridors, presence of rare species, and presence of exemplary aquatic features. For the purposes of this assessment, all habitat blocks 25 acres or larger were considered, using the minimum forest parcel size eligible for UVA enrollment.

Two important results emerged from this analysis. First, the mean size of habitat blocks that included one or more THOs is significantly larger than the mean size of all habitat blocks (14,046 vs. 1,165 acres, unpaired t-test, $p<0.0001$). This is not surprising, as larger areas of contiguous forest are likely more viable locations for timber harvests. The smallest habitat block that included one of the studied THOs is approximately 70 acres. The largest habitat block that included one of the studied THOs is over 150,000 acres, and is the largest habitat block in the state.

Second, the mean ecological importance score for habitat blocks that included one or more THOs is significantly better than the mean score for all habitat blocks (unpaired t-test, $p<0.0001$). This suggests that timber harvesting is occurring in forest blocks with high ecological value in Vermont, but does not indicate whether this harvesting is resulting in positive or negative impacts to the overall ecological quality of the forest block.

Results Comparison: 1990 and 2012

Characteristics of Timber Harvesting Operations 1990-2012

Several of the characteristics of sampled THOs remained steady between the 1990 and 2012 assessments. Private forest land accounted for 88% of sampled THOs in 2012 vs. 85% in 1990; wildlife biologists were known to have been consulted in 14% of THOs in both 2012 and 1990; contract provisions for wildlife were found on 15% of sampled THOs in 2012 vs. 17% in 1990.

Several changes are more substantial: Use Value Appraisal enrollment on THOs increased from 40% in 1990 to 73% in 2012; professional forester involvement increased from 77% in 1990 to 86% in 2012. These numbers are likely to have been influenced by the source of data for the assessment sample, with the majority of THOs reported by the professional forestry community, but are also consistent with the documented and substantial increase in UVA participation since 1990.

Wildlife Practices 1990-2012

Due to a lack of detailed information on the methods used to evaluate evidence of wildlife practices in the 1990 study, it was, for the most part, not possible to conduct a point-by-point comparison. When quantitative comparisons were not possible, a qualitative comparison is included below.

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unpublished). Timber harvesting is generally not considered to fragment a landscape if the harvested area is allowed to regenerate as forest and is not maintained as a permanent opening.

- Snags

  The 1990 assessment reported that "12% of the trees tallied on 468 plots were classified as either soft snags (7%) or hard snags (5%)." An identical analysis using plot data from this study found that snags were tallied in almost exactly the same proportions: 11.5% of residual trees tallied were classified as soft snags (6.5%) or hard snags (5%). Given that this percentage was not suitable to meet most published wildlife requirements (see above) the comparison suggests that adequate snag retention or creation is a longstanding challenge in managed forests.

- Deer wintering areas

  The 1990 assessment reported, based on field observations, that 19 of 78 operations (24%) had residual cover that appeared suitable as deer wintering area (DWA) cover and one additional operation where softwood cover was removed. This assessment found that 17 of 81 operations (21%) overlapped with mapped deer wintering areas, and plot data from those 17 operations indicated that in most cases (84% of plots) softwood cover was retained.

Silvicultural Practices and Changes in Habitat Structure 1990-2012

Silvicultural Methods

A comparison of silvicultural methods used between the current assessment and the 1990 assessment, using plot observations, can be found in Table 10-6. Timber harvesting is generally not considered to fragment a landscape if the harvested area is allowed to regenerate as forest and is not maintained as a permanent opening.

Table 10-6. *Comparison of silvicultural methods used on timber harvesting operations in Vermont, 1990 and 2012.*

Practice	% Plots 2012	% Plots 1990
Partial Cutting/Thinning	48%	49%
Overstory Removal/Clearcut	22%	16%
Group selection	15%	7%
Shelterwood/seed tree/prep cut	11%	27%
Strip cut	1%	0%
Other	4%	0%

Habitat Structure

The following changes were found in expected dominant vegetation 3-5 years after harvest: A majority of overstory removal/clearcut harvests observed in 2012 had a low frequency of seedling or sapling regeneration. In 1990 the forest floor on plots on which overstories had been removed was occupied primarily by seedlings or coppice 68% of the time, and ferns/herbs/Rubus 8% of the time. In 2012 seedling/sapling/coppice stems were the dominant understory vegetation in 49% of this harvest type, and 45% were occupied by ferns/herbs and Rubus spp. Non-native/invasive species were found on 7% of plots (not noted in the 1990 assessment).

CONCLUSIONS

The indicators used in this assessment showed no conclusive evidence that the THOs sampled in this assessment caused substantial negative or positive impacts to wildlife habitat features that were studied. This does not mean that impacts did not occur, but rather that any impacts to these features could not be detected in a single, post-harvest assessment. None of the locations of the timber harvesting operations overlapped with a known occurrence of a rare natural community.

Many types of forest harvesting practices were used on the THOs assessed, resulting in a wide variety of residual stand structures, providing habitat for a variety of species.

One area of concern identified in this report is the possible loss of deer wintering habitat over time.

> While in 84% of cases softwood cover was retained on vegetation plots located in or adjacent to mapped deer wintering areas that were determined to have been softwood or mixed-wood cover types preharvest, 16% of plots had been converted to another cover type postharvest (9 plots out of 57 total plots).

A complete review of all aspects of timber harvest impacts to wildlife habitat features was not possible within the scope of this assessment, particularly with respect to dead and downed wood, and vernal pools, in part due to the lack of pre-harvest data. The condition of some post-harvest wildlife habitat features may have been the result of pre-harvest forest condition, rather than harvest operations.

> On average, an estimated 3 snags larger than 10” DBH per acre were found on post-harvest THOs in hardwood forests, well below published recommendations. The majority of the retained snags were smaller than 15” DBH, and essentially no snags 25” DBH or larger were present. The lack of pre-harvest data makes conclusions on harvesting impacts to snag densities impossible.
>
> The abundance of large coarse woody material on the sampled plots is similar to statewide estimates from the FIA program across nearly all diameter classes greater than 12 inches, but lack of pre-harvest data makes definitive conclusions on harvest operation impacts impossible.
>
> Results suggest that cases where vernal pools are in proximity to harvesting are not common, but may be frequent enough to warrant more detailed investigation into whether impacts are occurring.

On the landscape scale, this assessment found that sampled timber harvests typically occurred in larger-than-average areas of unfragmented forest. Timber harvesting is generally not considered to fragment a landscape if the harvested area is allowed to regenerate as forest and is not maintained as a permanent opening.

RECOMMENDATIONS

Conduct additional study on the relationship between timber harvesting and the following wildlife habitat features: mast trees, snag and den trees, coarse woody debris, vernal pools, invasive species, and forest habitat blocks.

Increase outreach to encourage retention and creation of snag trees, cavity trees, coarse woody material, and the retention of trees for recruitment as future snags or coarse woody debris.

Encourage foresters, loggers, and other natural resource professionals to take advantage of all available information to assist in identifying important wildlife habitat features when planning timber harvesting operations.

Continue outreach efforts to educate foresters, loggers, landowners, and the public about possibilities for incorporating wildlife habitat considerations into timber harvest operations.

Encourage enrollment in programs such as the Use Value Appraisal "Ecologically Significant Treatment Areas" (ESTAs) or USDA Farm Bill programs, where appropriate, to provide financial incentives for private landowners to manage for significant natural communities or wildlife habitats, respectively.

LITERATURE CITED

Allen, D.C., Molloy, A.W., Cooke, R.R., Lachance, D., and C. Barnett. 1995. *North American Maple Project Seven Year Report.* Joint report by the USDA Forest Service State & Private Forestry, and the Canadian Forest Service, US Gov't Printing Office 1997-505-401. 57 pp.

Benson, R.E., and J.R. Ullrich. 1981. *Visual Impacts of Forest Management Activities: Findings on Public Preferences*. USDA Forest Service Research Paper INT-262. Ogden, UT. 14 pp.

Block, N.E., and V.A. Sample. 2001. *Industrial Timberland Divestitures and Investments: Opportunities and Challenges in Forestland Conservation*. Pinchot Institute for Conservation. Washington D.C., USA. 58 pp.

Brighton, D., Fidel, J., and B. Shupe. 2010. *Informing Land Use Planning and Forestland Conservation Through Subdivision and Parcelization Trend Information.* Vermont Natural Resources Council, Montpelier, VT. 67pp.

Brown, T. C., and T. C. Daniel. 1986. Predicting scenic beauty of timber stands. *Forest Science*. 32(2):471-487.

Brush, R.O. 1979. The attractiveness of woodlands: perceptions of forest landowners in Massachusetts. *Forest Science*. 25:495–506.

Bryan, R.B. 2007. *Focus Species Forestry: A Guide to Integrating Timber and Biodiversity Management in Maine*. Maine Audubon Society: Falmouth, ME.

Butler, B. J. 2008. *Family Forest Owners of the United States, 2006*. General Technical Report NRS-27. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 72 pp.

De Geus, R. 2011. *Vermont Forest Resource Harvest Summary.* Vermont Department of Forests, Parks & Recreation, Montpelier, VT. 5 pp. Available online at: http://www.vtfpr.org/util/documents/rpt10.pdf

Donnelly, J. R., Shane, J. B., and H. W. Yawney. 1991. Harvesting Causes only Minor Changes in Physical Properties of an Upland Vermont Soil. *Northern Journal of Applied Forestry*. 8(1):33-36.

ESRI. 2006. *Modeling archaeological sensitivity in Vermont with GIS.* ArcNews Online, Spring 2006. Available online at: http://www.esri.com/news/arcnews/spring06articles/modeling-archaeological.html

Faccio, S.D. 2003. Postbreeding emigration and habitat use by Jefferson and spotted salamanders in Vermont. *Journal of Herpetology*. 37(3):479–489.

Flatebo, G., Foss, C, Pelletier, S. 1999. *Biodiversity in the Forests of Maine: Guidelines for Land Management*. UMCE Bulletin #7147, University of Maine Cooperative Extension.

Forest Guild Biomass Working Group. 2010. *Forest Biomass Retention and Harvesting Guidelines for the Northeast*. Forest Guild, Santa Fe, NM. 17pp. Available online at: www.forestguild.org/publications/research/2010/FG_Biomass_Guidelines_NE.pdf

Foster, D.R., and J.D. Aber, editors. 2004. *Forests in Time: The Environmental Consequences of 1,000 Years of Change in New England.* Yale University Press, New Haven, Connecticut, USA. 477 pp.

Franklin, J.F., Spies, T.A., Van Pelt, R., Carey, A.B., Thornburgh, D.A., Rae Berg, D., Lindenmayer, D.B., Harmon, M.E., Keeton, W.S., Shaw, D.C., Bible, K. and J. Chen. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. *Forest Ecology and Management*. 155:399-423.

Frieswyck, T.S., and A.M. Malley. 1985. *Forest Statistics for Vermont, 1973 and 1983*. Resource Bulletin NE-87. USDA Forest Service, NE Forest Experiment Station. 102pp.

Grigal, D. F. 2000. Effects of Extensive Forest Management on Soil Productivity. *Forest Ecology and Management*. 138(1):167-185.

Grushecky, S. T., Spong, B. D., McGill, D. W., and J. W. Edwards. 2009. Reducing Sediment from Roads in West Virginia Using Fiber Mats. *Northern Journal of Applied Forestry*. 26(3):118-121.

Hoffman, R.E. and J.F. Palmer. 1996. *Silviculture and Forest Aesthetics Within Stands.* The New York Center for Forest Research and Development, Pub. #2. State University of New York, College of Environmental Sciences and Forestry, Syracuse, NY.

Hull, R.B., Buhyoff, G.J., 1986. The scenic beauty temporal distribution method: an attempt to make scenic beauty assessments compatible with forest planning efforts. *Forest Science*. 32: 271–286.

Hunn, J.R., 2007. *Retention of logging debris to reduce deer browsing and promote forest regeneration*. Honors thesis, Cornell University, Ithaca, NY. 22 pp.

Karlen, D.L., M.J. Mausbach, J.W. Doran, R.G. Cline, R.F. Harris, and G.E. Schuman. 1997. Soil quality: a concept, definition and framework for evaluation. *Soil Sci. Soc. Am. J*. 61:4-10.

Keeton, W.S., Whitman, A.A., McGee, G.C., and C.L. Goodale. 2011. Late-Successional Biomass Development in Northern Hardwood-Conifer Forests of the Northeastern United States. *Forest Science*. 57(6): 489-505.

Keeton, William S. personal communication. Rubenstein School of Environment and Natural Resources, University of Vermont, November 29, 2014.

Keeton, William S. personal communication. Rubenstein School of Environment and Natural Resources, University of Vermont, 2012.

Kelley, R.S. 1996. *Photographic Guide to Selected Defects Associated with Sugar Maple Logging Wounds.* Vermont Department of Forests, Parks & Recreation.

Kelley, R.S., Lackey, J., Smith, E.L., and B. Frament. 2002. *The Health of Vermont's Hardwood Resource: 1985-2001.* Vermont Department of Forests, Parks and Recreation.

Leak, W.B., Solomon, D.S., and P.S. DeBald. 1987. *Silvicultural Guide for Northern Hardwood Types in the Northeast.* Research Paper NE-603. USDA Forest Service, Northeastern Forest Experiment Station, Broomall, PA . 36pp.

Leon, B.H., and J. G. Benjamin. 2012. *A Survey of Business Attitudes, Harvest Capacity and Equipment Infrastructure of Logging Businesses in the Northern Forest*. School of Forest Resources, University of Maine, Orono, ME. 36 pp.

Long, R.P., S.B. Horsley, R.A. Hallett, and S.W. Bailey. 2009**.** Sugar maple growth in relation to nutrition and stress in the northeastern United States. *Ecological Applications*. 19(6):1454-1466.

Maine Department of Conservation, Maine Forest Service. 2004. *Best Management Practices for Forestry: Protecting Maine's Water Quality*. 93 pp.

Martin, W. C. 1988. Soil Disturbance by Logging in New England – Review and Management Recommendations. *Northern Journal of Applied Forestry*. 5(1):30-34.

McGee, G.G., Leopold, D.J., and R.D. Nyland. 1999. Structural Characteristics of old-growth, maturing, and partially cut northern hardwood forests. *Ecological Applications.* 9(4):1316-1329.

Morin, R. S., and C. W. Woodall. 2012. *Vermont's Forest Resources, 2011*. Res. Note. NRS-141. US Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, PA: 4pp. Available online at: http://www.nrs.fs.fed.us/pubs/40781

Morin, R.S., Barnett, C.J., Brand, G.J., Butler, B.J., De Geus, R., Hansen, M.H., Hatfield, M.A., Kurtz, C.M., Moser, W.K., Perry, C.H., Piva, R., Riemann, R., Widmann, R., Wilmot, S., and C.W. Woodall. 2011. *Vermont's Forests 2007*. Resource Bulletin NRS-51 U.S. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, PA. 56 pp.

Moser, M., Hyman, J., and F. Schmidt. 2008. *Looking Ahead: Vermonters' Values and Concerns:* Full Report. Center for Rural Studies. College of Agriculture and Life Sciences, University of Vermont. Burlington, VT. 57 pp. Available online at: http://www.uvm.edu/crs/reports/2008/CFV_Full_Report.pdf

North East Forester's Association (NEFA). 2014. *The Economic Importance of Vermont's Forest-Based Economy 2013.* North East State Forester's Association, Concord, NH. 16 pp.

Newton, C.M., Brynn, D.J., Capen, D.E., Clausen, J.C., Donnelly, J.R., Shane, Jr., J.B., Thomas, P.A., Turner, T.L., and J.E. Vissering. 1990. *Impact Assessment of Timber Harvesting in Vermont*. School of Natural Resources, University of Vermont. Burlington, VT. 144 pp.

Page-Dumroese, D.S., Abbott, A., and T. Rice. 2009. *Forest Soil Disturbance Monitoring Protocols.* Volume 1, Rapid Assessment. Gen. Tech Report WO-82a; USDA-Forest Service. 31 pp.

Page-Dumroese, D. S., Abbott, A., and T. Rice. 2009. *Forest Soil Disturbance Monitoring Protocols.* Volume 2, Supplementary Methods, Statistics and Data Collection. Gen. Tech Report WO-82b; USDA-Forest Service. 64 pp.

Patey, R.C., and R.M. Evans. 1979. Identification of scenically preferred forest landscapes. In Elsner, G.H. and R.C. Smardon, technical coordinators. Proceedings of our national landscape: a conference on applied techniques for analysis and management of the visual resource [Incline Village, NV, April 23-25, 1979.] Gen. Tech. Rep. PSW-GTR-35. Berkeley, CA. Pacific Southwest and Range Exp. Stn., Forest Service, US Department of Agriculture. pp 532-538.

Peebles, G. 2008. *Stewardship Guide for Historic and Archeological Resources on Forest lands – Recommended Best Practices for Protecting Vermont's Historic and Archeological Resources on Forest Land.* Vermont Division of Historic Preservation. Agency of Commerce and Community Development. 11 p.

Provencher, M.A., McGill, D.W. and S.T. Grushecky. 2007 Timber Harvesting Characteristics on Forest Stewardship Properties and Non–Forest Stewardship Properties in Central West Virginia. *Northern Journal of Applied Forestry*. 24(4):265-270.

Reay, R., Blodgett, D., Burns, B., Weber, S., and Frey, T. 1990. *Management Guide for Deer Wintering Areas in Vermont*. Vermont Departments of Fish and Wildlife, and Forests, Parks and Recreation. 35 pp.

Ribe, R.G. 1989. The aesthetics of forestry: what has empirical preference research taught us? *Journal of Environmental Management*. 13:55–74.

Ribe, R.G. 1990. Understanding the aesthetic perception of northern hardwood forests: toward a general model of scenic beauty in deciduous forests. *Landscape Journal*. 9:86–101.

Ribe, R.G. 2009. In-stand scenic beauty of variable retention harvests and mature forests in the U.S. Pacific Northwest: the effects of basal area, density, retention pattern and down wood. *Journal of Environmental Management*. 91:245-260.

Schmidt, K.A. and C.J. Whelan. 1999. Effects of exotic Lonicera and Rhamnus on songbird nest predation. *Conservation Biology*. 13:1502-1506.

Schroeder, H.W., Gobster, P. H., and R. Frid. 1993. *Visual quality of human-made clearings in central Michigan conifers.* Research Paper NC-313. St. Paul, MN. U.S.D.A Forest Service, North Central Forest Experiment Station. 9 pp.

Semlitsch, R.D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding amphibians. *Conservation Biology.* 12:1113-1119.

Sendak, P.E., and D.F. Dennis. 1989. *Vermont's Use-Value Appraisal Property Tax Program: A Forest Inventory and Analysis*. Res.Pap. NE-627. USDA Forest Service, Northeastern Forest Experiment Station. Broomall, PA. 68 pp.

Shigo, A.L. 1966. *Decay and discolorization following logging wounds on northern hardwoods.* Res. Pap. NE-47: USDA Forest Service; Northeast Forest Experiment Station, Upper Darby, PA. 43 pp.

Shigo, A.L. 1982. Tree Health. *Journal of Arboriculture*. 8(12):311-316.

Steinman, J. 2004. *Forest health monitoring in the northeastern United States.* NA-TP-01-04: USDA Forest Service; Northeastern Area State and Private Forestry, Newtown Square, PA. 46 pp.

Stuart, G.W., and P.J. Edwards. 2006. Concepts about Forests and Water. *Northern Journal of Applied Forestry*. 23(1): 11-19.

Thompson, E.H., and E.R. Sorenson. 2005. *Wetland, Woodland, Wildland. A Guide to the Natural Communities of Vermont.* University Press of New England, Hanover, NH.

University of Vermont. 2009. *Archaeological Precontact Site Sensitivity Analysis and GIS Mapping for the Vermont Agency of Natural Resources: Bird Mountain WMA.* University of Vermont Consulting Archaeology Program, University of Vermont, Burlington, VT. 8 pp.

USDA Forest Service. 2009. *Forest Stewardship Program National Standards and Guidelines.* US Department of Agriculture, Forest Service, State & Private Forestry, Washington, DC. 10 pp.

Available online at:
http://www.fs.fed.us/cooperativeforestry/library/fsp_standards&guidelines.pdf

USDA-Natural Resource Conservation Service. Sept. 2008. *Soil Quality Physical Indicators: Selecting Dynamic Soil Properties to Assess Soil Function*. Soil Quality Technical Note #10. 5 pp.

Vermont Agency of Natural Resources. 2013. *BioFinder*. Available online at: http://biofinder.vt.gov/

Vermont Agency of Natural Resources. 2013. *Natural Resources Atlas*. Vermont Agency of Natural Resources, Montpelier, VT. Available online at: http://anrmaps.vermont.gov/websites/anra/

Vermont Agency of Natural Resources. 2010. *Vermont Wetland Rules*. Vermont Agency of Natural Resources, Montpelier, VT. 34 pp.

Vermont Department of Fish and Wildlife (VT F&W). 2012. *Deer Doing Damage to Land Managed for the Production of Marketable Forest Products.* Vermont Department of Fish & Wildlife, Montpelier, VT. 15pp. Available online at:
http://vtfishandwildlife.com/library/Reports_and_Documents/Fish_and_Wildlife/Deer_Damage_Working_Group_Legislative_Report.pdf

Vermont Department of Forests, Parks and Recreation. 1987. *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*. Vermont Department of Forests, Parks & Recreation, Montpelier, VT. 50pp. Available online at:
http://www.vtfpr.org/watershed/ampprog.cfm

Vermont Natural Resources Council. 2013. *Exploring Sprawl: Economic, Social, and Land Use Trends Related to Sprawl in Vermont. Issue 6.* Vermont Natural Resources Council, Montpelier, VT. 10 pp.

Vermont Natural Resources Council. 2014. *Historic Settlement Patterns.* Available online at:
http://vnrc.org/resources/smart-growth-resources/historic-settlement-patterns/

Vodak, M.C., Roberts, P.L., Wellman, J.D., and G.J. Buhyoff. 1985. Scenic impacts of eastern hardwood management. *Forest Science*. 31:289–302.

Weber, S. 1986. *Non-Game Forest Habitat Management Guidelines*. Vermont Department of Fish and Wildlife.

Welsch, D., Ryder, R. and T. Post. 2007. *Best Management Practices Field Guide – Implementation and Effectiveness for Protection of Water Resources*. NA-FR-02-06. USDA Forest Service. Northeastern Area State and Private Forestry, Newtown Square, PA. 140 pp.

Widmann, R.H., and T.W. Thomas. 1988. *Forest-land owners of Vermont – 1983.* Resource Bulletin NE-102. US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. Broomall, PA. 89 pp.

Woodall, C.W., and V.J. Monleon. 2008. *Sampling Protocol, Estimation, and Analysis Procedures for the Down Woody Material Indicator of the FIA Program.* Gen. Tech. Rep. NRS-22. USDA Forest Service, Northern Research Station, Forest Inventory and Analysis Program, Newtown Square, PA. 68 pp.

GLOSSARY

AGS (Acceptable growing stock): an acceptable growing stock tree (AGS) is a commercial species less than rotation age with relatively good vigor, containing no pathogens that may result in the death or serious deterioration before rotation age, and which contains or has the potential of producing merchantable sawtimber of USFS grade 3 quality or better (USFS grading standards available in Appendix F).

AMP (Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont): Regulations promulgated under the authority of Chapter 47 of Title 10 of the Vermont Statutes Annotated, Water Pollution Control, which became effective on August 15, 1987. The AMPs are intended and designed to prevent discharges of mud, petroleum products, and woody debris (logging slash) from entering streams and other bodies of water during logging and to otherwise minimize the risks to water quality.

AMP Forester: VT Department of Forests, Parks & Recreation forester responsible for inspecting operations upon any complaint (from the general public or elsewhere) that sediment is entering the water course, or that some other possible violation has taken place. After the initial inspection, the AMP forester will revisit the operation to ensure that all necessary work is completed and that the AMPs are in place upon sale closeout.

Basal area: the cross-sectional area of all stems of a species or all stems in a stand measured at breast height and expressed per unit of land area.

Benthic community: Aquatic insects consisting of the immature stages of mayflies, stoneflies, caddisflies, dragonflies, blackflies, and the adult and immature snails, aquatic worms, crayfish, beetles and true bugs and other dwellers that inhabit the region of the waterbody on, or in the sediment.

Broad-based dip: A drainage structure, usually used on truck roads where grades are under 8 percent. They are specifically designed to divert surface runoff from the truck road into a vegetated area while vehicles maintain normal travel speeds.

Browse: any woody vegetation consumed, or fit for consumption, by livestock or wild animals, mainly ungulates. Wildlife will forage or graze on the buds, stems, and leaves of woody growth.

Buffer: a vegetation strip or management zone of varying size, shape, and character maintained along a stream, lake, road, recreation site, or different vegetative zone to mitigate the impacts of actions on adjacent lands, to enhance aesthetic values, or as a best management practice.

Chain: a unit of measure equal to 66 feet.

Clear cut: a silvicultural treatment in which the residual stand maintains less than 25% crown closure in the overstory.

Cull: any item of production, e.g., trees, logs, lumber, or seedlings, rejected because it does not meet certain specifications of usability or grade; logs that are rejected, parts of logs deducted in measurement, or the deduction made from gross timber volume because of defects.

Densiometer: A device used to estimate the density of the forest canopy and expressed as percent of crown closure.

Dieback: the progressive dying from the extremity of any part of a plant. Dieback may or may not result in the death of the entire plant.

Erosion: The detachment and transportation of soil particles by wind or water.

Ford: A submerged stream crossing where the streambed may need to be reinforced to bear intended traffic.

Forestland: (As defined by USDA Forest Service, Forest Inventory and Analysis) Land that is at least 10 percent stocked with trees of any size, or that formerly had such tree cover, and is not currently developed for a nonforest use.

Group selection: a silvicultural method resulting in a residual stand composed of open patches ranging in size from 1/20 acre to 2 acres.

Heavy cut: a harvest leaving a residual stocking level of acceptable growing stock below the C-line as defined by the United States Department of Agriculture silvicultural stocking guides for the applicable timber type.

High grade: the removal of the most commercially valuable trees, often leaving a residual stand composed of trees of poor condition or species composition. High grading may have both genetic implications and long-term economic or stand health implications.

Hydraulic capacity: The ability of a stream crossing structure (bridge or culvert), to convey flow from one side of a roadway to the other based upon flood frequency and the anticipated amount of discharge.

Landing: a cleared area in the forest to which logs are yarded or skidded for loading onto trucks for transport.

Live crown ratio: the ratio of crown length to total tree height (crown length of a standing tree is the vertical distance from the tip of the leader to the base of the crown, measured to the lowest live whorl or to the lowest live branch, excluding epicormics).

Mast: the fruit of trees and plants considered as food for livestock and certain kinds of wildlife. Hard mast is the fruits or nuts of trees such as oak, beech, and hickories; soft mast includes the fruits and berries from plants such as raspberry, blackberry, apple, and cherry.

Mean stand diameter: (of a group of trees, crop, or stand): quadratic mean diameter, the diameter corresponding to their mean basal area.

Other forest land: (as defined by FIA) commonly found on low-lying sites or high craggy areas with poor soils where the forest is incapable of producing 20 cubic feet per acre.

Partial cutting/thinning: a silvicultural method that maintains over 75% crown closure in the overstory.

Perched culvert: a culvert positioned with the outlet end at an elevation above the streambed allowing the water to fall and scour a pool in the streambed.

Protective strip (streamside buffer): A strip of land adjacent to streams and other bodies of water where forest management practices are modified to protect water quality as well as riparian and aquatic habitat.

Reconnaissance: a preliminary inspection or survey of a forest or range area to gain general information (e.g., timber volumes) useful for future management.

Regeneration: seedlings or saplings existing in a stand; the act of renewing tree cover by establishing young trees naturally or artificially; regeneration usually maintains the same forest type and is done promptly after the previous stand or forest was removed. Regeneration may be natural (natural seeding, coppice, or root suckers), or artificial (direct seeding or planting).

Reserved forest land: (as defined by FIA) land withdrawn from timber utilization through legislation or administrative regulation.

Residual tree (stand) damage: refers to logging related damage (wounding, limb or stem breakage, bending, and root damage) to remaining trees following a timber harvesting operation.

Residual stand: a stand composed of trees remaining after any type of intermediate harvest.

Salvage cutting: the removal of dead trees or trees damaged or dying because of injurious agents other than competition, to recover economic value that would otherwise be lost.

Sedimentation: Soil that has been eroded from the land surface and is transported and deposited in streams or other bodies of water.

Shade tolerance: the capacity of trees to grow satisfactorily in the shade of, and in competition with, other trees.

Shelterwood: a silvicultural method that is characterized by crown closure of 25% to 74% in the overstory.

Silvics: the study of the life history and general characteristics of forest trees and stands, with particular reference to environmental factors, as a basis for the practice of silviculture.

Silviculture: the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.

Slash: treetops and branches left on the ground after logging.

Snag: a standing, generally unmerchantable, dead tree from which the leaves and most of the branches have fallen. For wildlife habitat purposes, a snag is sometimes regarded as being at least 10 inches in diameter at breast height and at least 6 feet tall; a hard snag is composed primarily of sound wood, generally merchantable, and a soft snag is composed primarily of wood in advanced stages of decay and deterioration.

Stand: a contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable unit.

Stocking: an indication of growing space occupancy relative to a pre-established standard. Common indices of stocking are based on percent occupancy and basal area.

Streamside buffer (protective strip): A strip of land adjacent to streams and other bodies of water where forest management practices are modified to protect water quality as well as riparian and aquatic habitat.

Succession: the gradual supplanting of one community of plants by another. The sequence of communities is called a sere or seral stage.

Timberland: (as defined by FIA) unreserved forest land that meets the minimum productivity requirement of 20 cubic feet per acre per year.

UGS (unacceptable growing stock): an unacceptable growing stock tree (UGS) is a tree (mature or immature) that will not grow or prospectively meet AGS standards primarily because of roughness, poor form, or non-commercial species. (USFS grading standards available in Appendix F).

Waterbar: A mound of soil excavated across the width of a skid trail or truck road to divert water from side ditches and road surfaces into a vegetated area.

Woody (logging) debris: pieces of wood and trees left on a harvest after logging, which may include, but is not limited to tree tops and brush. In the context of stream crossings, woody debris can also include stems and poles used to construct stream crossings but left in place following sale close-out.

APPENDICES

A. VT DHP Precontact Predictive Model Form

B. Soil Disturbance Class and Soil Compaction Rating Examples

C. Acceptable Management Practices (AMP) Compliance

D. Data Collection Procedures

E. Browsing Site Conditions for Managed Northern Hardwoods

F. AGS/UGS Definitions

G. Crown Health Measurements

Appendix A: VT DHP Precontact Predictive Model Form

VERMONT DIVISION FOR HISTORIC PRESERVATION

Environmental Predictive Model for Locating Precontact Archeological Sites

Project Name________________________________County______Town_________
DHP No. ______________ Map No. ____________Staff Init. ________ Date________
Additional Information____

Environmental Variable	Proximity	Value	Assigned Score
A. RIVERS and STREAMS (EXISTING or RELICT):			
1) Distance to River or Permanent Stream (measured from top of bank)	0- 90 m 90- 180 m	12 6	_____
2) Distance to Intermittent Stream	0- 90 m 90-180 m	8 4	_____
3) Confluence of River/River or River/Stream	0-90 m 90 –180 m	12 6	_____
4) Confluence of Intermittent Streams	0 – 90 m 90 – 180 m	8 4	_____
5) Falls or Rapids	0 – 90 m 90 – 180 m	8 4	_____
6) Head of Draw	0 – 90 m 90 – 180 m	8 4	_____
7) Major Floodplain/Alluvial Terrace		32	_____
8) Knoll or swamp island		32	_____
9) Stable Riverine Island		32	_____
B. LAKES and PONDS (EXISTING or RELICT):			
10) Distance to Pond or Lake	0- 90 m 90 -180 m	12 6	_____
11) Confluence of River or Stream	0-90 m 90 –180 m	12 6	_____
12) Lake Cove/Peninsula/Head of Bay		12	_____
C. WETLANDS:			
13) Distance to Wetland (wetland > one acre in size)	0- 90 m 90 -180 m	12 6	_____
14) Knoll or swamp island		32	_____
D. VALLEY EDGE and GLACIAL LAND FORMS:			
15) High elevated landform such as Knoll Top/Ridge Crest/ Promontory		12	_____
16) Valley edge features such as Kame/Outwash Terrace**		12	_____

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17) Marine/Lake Delta Complex**		12	_____
18) Champlain Sea or Glacial Lake Shore Line**		32	______
E. OTHER ENVIRONMENTAL FACTORS:			
19) Caves /Rockshelters		32	_____
20) [ ] Natural Travel Corridor [ ] Sole or important access to another drainage [ ] Drainage divide		12	_____
21) Existing or Relict Spring	0 – 90 m 90 – 180 m	8 4	_____
22) Potential or Apparent Prehistoric Quarry for stone procurement	0 – 180 m	32	_____
23)) Special Environmental or Natural Area, such as Milton acquifer, mountain top, etc. (these may be historic or prehistoric sacred or traditional site locations and prehistoric site types as well)		32	_____
F. OTHER HIGH SENSITIVITY FACTORS:			
24) High Likelihood of Burials		32	_____
25) High Recorded Site Density		32	_____
26) High likelihood of containing significant site based on recorded or archival data or oral tradition		32	_____
G. NEGATIVE FACTORS:			
27) Excessive Slope (>15%) or Steep Erosional Slope (>20)		- 32	_____
28) Previously disturbed land as evaluated by a qualified archeological professional or engineer based on coring, earlier as-built plans, or obvious surface evidence (such as a gravel pit)		- 32	______

** refer to 1970 Surficial Geological Map of Vermont

Total Score:

Other Comments :

0- 31 = Archeologically Non- Sensitive
32+ = Archeologically Sensitive

-over-

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Appendix B: Soil Disturbance Class and Soil Compaction Rating Examples

Soil Disturbance Class (SDC) 0:
Natural, undisturbed soil conditions.

Soil Disturbance Class (SDC) 1:
Minimal soil disturbance. The skid trail is barely discernible and was probably used for only a few passes during deep snow conditions. Duff on the forest floor remains intact and undisturbed.

Soil Disturbance Class (SDC) 2:
Obvious compaction and bare soil on a skid road.

Soil Disturbance Class (SDC) 3:
Gully erosion, bare soil, and rutting greater than one foot deep in a skid road.

Compaction greater than 4" deep, typical of SDC 2. Note the "platy" soil structure, which replaced a more natural porous structure. Compaction slows root growth and downward water movement in the soil.

A former agricultural soil that now supports a forest. This soil is porous, allowing for free movement of water, air, and organisms in the soil. It also has an organic layer made up of decomposing twigs, leaves, and needles. This soil profile would be typical of SDC 0 or 1.

Appendix C: Acceptable Management Practice (AMP) Compliance

Compliance data calculated from the sample population is presented below and has been arranged to summarize both compliance by frequency of observations and also by frequency of operations. If one observation was not in compliance on an operation for the AMP being assessed, then the operation was deemed to be out of compliance with that AMP. Analysis was not performed to determine level of partial AMP compliance by operation.

Truck Roads

AMP 1: *Steep pitches greater than 10% on permanent truck roads shall not exceed 300 feet in length.*

> There were 142 observations on 32 operations. Out of 142 observations, 88% (125) observations and 69% (22) operations had grades under 10 %.

AMP 2: *Road surfaces on permanent truck roads shall be adequately drained with culverts and broad-based dips and spaced at intervals according to Table 1 in the AMPs where conditions permit.*

> All operations met or exceeded the recommended number of drainage structures according to Table 1 in the AMPs.

Skid Trails

AMP 5: *Short steep sections up to 20% grade are permissible but shall not exceed 300 feet in length.*

> There were 641 skid trail segments evaluated on 76 operations. Out of 641 segments evaluated, 94% (605) segments and 72% (55) operations had grades up to 20% and under 300 feet in length.

AMP 19: *Ruts shall be filled and smoothed if they offer any potential for gullying.*

> There were 640 segments of skid trails evaluated on 76 operations. Out of 640 segments evaluated, 96% (611) segments and 78% (59) operations did not exhibit gully erosion as a result of rutting.

AMP 20: *Waterbars shall be installed at proper intervals according to Table 1 in the AMPs.*

> Skid trails were evaluated on 76 THOs. For the total length (22.6 miles) of skid trails evaluated, 42% (684) of the 1,607 recommended drainage structures according to Table 1 in the AMPs were in place and functioning properly to divert runoff[140]. Percent compliance by THO was calculated and then averaged across all THOs to arrive at 39% compliance by THO.

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[140] This represents an average for the total length (22.6 miles) of skid trails examined on the 76 THOs and is expressed as percent compliance by observation. Each skid trail examined was considered as one observation.

Streams and Other Waterbodies

AMP 8: *Streams and all bodies of water shall be kept free of slash and other logging debris.*

Data collection procedures and coding related to deposition of logging slash in streams and other waterbodies did not allow for comparison to AMP 8 and are therefore not reported here.

AMP 9: *Truck road crossings of all permanent streams shall be over a bridge or culvert.*

There were 20 operations with permanent truck roads and stream crossing structures in place on permanent streams. Structures were in place on 37 stream crossings. Fifty-nine percent (22) of the operations had culverts and/or bridges in place. Three operations had pole fords or open ford crossings. Ninety-two percent (34) of stream crossing structures on permanent truck roads had culverts and/or bridges.

Streams may be forded by skid trails only where streambeds have stable beds and approaches.

Three operations had ford crossings (one each) on skid trails, all with stable beds and approaches.

AMP 10: *Logging activities shall be kept out of stream channels.*

Two hundred fifty-five observations were made on 48 timber harvesting operations that had an associated waterbody. There were 5 observations of skidding in streams on 4 operations.

AMP 11: *Turn-ups or broad-based dips shall be used before a truck road or skid trail crosses a stream.*

One hundred forty-seven stream crossings were evaluated on 52 operations. Eight percent (4) of operations had turn-ups or broad-based dips installed on approaches to <u>all</u> stream crossings. Turn-ups or broad-based dips were installed on 30% (44) of stream crossings.

Thick deposits of sediment were observed on 6 of the 147 crossings. Four of these 6 cases were attributed to the fact that log fords or brushed-in crossings had not been removed upon completion of the operation.

Overall, approaches to stream crossings were generally stable and in many cases skid trail crossings had re-vegetated. It should be noted that compliance for this AMP may have been greater if the same protocol was used as in the 1990 assessment. In the 1990 assessment, turn-ups and broad-based dips were recorded, if found within 2 chains (132 feet) of the stream crossing and a minimum of 25 feet from the stream crossing. In the 2012 assessment, turn-ups and broad-based dips were recorded only if they were located within the protective strip width guidance as described in the AMPs. Recommended protective strips according to the AMPs are 50 feet for slopes up to 10 percent; 70 feet for slopes 11-20 percent; 90 feet for slopes 21-30 percent and 110 feet for slopes 31-40 percent.

AMP 13: *Stream crossings shall be made at right angles where possible.*

One hundred forty-seven stream crossings were evaluated on 52 operations. Seventy-three percent (38) of operations had stream crossings that were at a right angle to the stream. Eighty-eight percent (129) of stream crossing observations were at a right angle to a stream.

AMP 14: *Except for the necessary construction of stream crossings, a protective strip shall be left along streams and other bodies of water in which only light thinning or selection harvesting can occur. Width of the protective strip shall be in accordance with Table 4 in the AMPs.*

It's important to first note the field methodology used for measuring protective strip widths. Protective strip width was determined by distance from the stream to the nearest road or trail unless the canopy had been removed in that particular portion of the harvest area. In the case of regeneration harvests, where all or the majority of dominant overstory trees were removed, protective strip width was measured to the edge of the harvest area – that is, unless a road or trail was encountered first – then it was measured to the road or trail.

Two hundred forty-two observations were made on 48 operations that had an associated waterbody. Compliance for this AMP is based on protective strip width. Thirty-three percent (16) of operations met protective width requirements 100% of the time. Four operations had <u>less than adequate</u> protective strips at all measurements taken. All operations had a protective strip associated with a stream or other waterbody where continuous cover was maintained adjacent to open water. Residual stocking in the protective strip was not determined. Protective strip widths were adequate or more than adequate at 71% (171) of the observations. Residual canopy cover along streams and other waterbodies averaged 85%, with a median value of 91%.

Log transport machinery must remain outside a 25 foot margin along streams or other waterbodies.

Two hundred fifty-five observations were made on 48 timber harvesting operations that had an associated waterbody. Forty-four percent (21) of the operations had no machine entries within 25 feet of streams and other waterbodies. No entries were recorded on 78% (198) of observations.

AMP 21: *All temporary structures shall be removed from streams and the channel restored.*

There were 92 temporary stream crossings on skid trails and temporary truck roads on 49 operations. To determine compliance for this AMP, structures were considered to be temporary if they were log fords, brushed-in crossings, or undersized culverts. Also included were sites where structures had been used during logging but were removed prior to the assessment (70 sites). There were no undersized bridges. Twenty-eight temporary structures were still in place, which should have been removed upon close-out. They included 7 culverts, 13 log fords, and 8 brushed-in crossings. Open ford crossings on skid trails were considered to be in compliance with AMP 21 since there is no physical structure in place to cause blockage or alteration of flow in the stream channel. Of the 14 culverts on stream crossings on skid trails and temporary truck roads, 7 were undersized and should have been removed, and thus were considered to be temporary.

Fifty-seven percent (28) of operations had removed all temporary stream crossing structures. Seventy-six percent (70) out of the 92 temporary structures were removed.

AMP 22: *Following the close of operations, all approaches to streams shall be stabilized, seeded, and mulched.*

This AMP pertains to temporary structures that are removed upon close-out of an operation. There were 35 operations and 69 stream crossings that had structures removed. Forty-nine percent (17) of operations where structures had been removed, had seeded and mulched approaches to stream crossings; 57% (20) of operations did not, and 23% (8) of operations were undetermined (no visual evidence of seeding and mulching).

Fifty-four percent (37) of stream crossing observations where temporary structures were removed had seeded and mulched approaches; 30% (21) did not, and 16% (11) were undetermined (no visual evidence of seeding and mulching).

Approaches were stable on 67% (30) of the operations that had stream crossing structures removed and 90% (62) of the stream crossings evaluated. Field investigators noted that in many of these cases, the approaches had re-vegetated naturally to forbs, grasses, and sedges.

<u>Log Landings</u>

AMP 15: *Log landings shall be located on level or gently sloping stable ground.*

One hundred-two landings were evaluated on 69 timber harvesting operations. Landings were located on gentle slopes between 0-5% grade on 71% (49) of the operations or 63% (64) of the total number of landings evaluated. Thirty-eight landings were located on slopes between 6-15% and no landings were located on slopes greater than 15%. Landings were located on well-drained or moderately well-drained soil 90% of the time.

One landing was located in a wetland and was operated under frozen conditions. This is an allowable use under Vermont's Wetlands regulations.

AMP 16: *Log landings shall not be located in protective strips.*

One hundred-two landings were evaluated on 69 timber harvesting operations. Log landings on 16% (11) of the operations or 14% (14) of the total number of landings evaluated were at least partially located in the protective strip of a stream or waterbody.

The AMPs address constrained landing locations that may result in portions of a landing being located within a protective strip: AMP 24 states that areas of exposed soil within the protective strip along streams and other waterbodies be seeded and mulched.

AMP 23: *Log landings shall be graded and water diversions installed as needed to prevent sedimentation.*

To determine if necessary grading and draining had been conducted, log landings were evaluated for existing surface erosion. Eighty-six percent (88) of landings and 87% (60) of operations had landings that were graded and diversions installed. Sixty-two percent (63) of landings were also seeded and mulched. The remaining 38% (39) of landings were not seeded and mulched or it could not be determined. Gully erosion was observed on 4% (4) of all landings evaluated. No advanced gully erosion was observed.

Appendix D: Data Collection Procedures

Data collection procedures are divided into three sections: general data, interview data, and site inspection data. Most of the data is self-explanatory to the experienced field forester. Items requiring additional clarification are described further under the appropriate section. Item numbers below refer to individual data fields.

I. GENERAL DATA

1. Operation number – the first two digits represent the county and the final two digits represent the assigned operation number.

2. County –

3. Town –

4. Interview Person Type – person answering interview questions.
   1. Landowner
   2. State forester
   3. County forester
   4. Federal forester
   5. Company forester
   6. Logger
   7. Consultant
   8. Other
   9. Unknown

5. Ownership type – indicates the ownership of the parcel on which the harvest occurred.
   1. State
   2. Federal
   3. Town (municipal)
   4. NIPF (Non-Industrial Private Forest)
   5. Industrial (Industrial land was defined as being owned by a company with primary forest product processing facilities.)
   6. Other

6. Primary Objective for Timber Harvesting Operation (THO) –
   1. Silviculture (refers to vegetative manipulation for such purposes as timber production, recreation, aesthetics, hazard tree reduction, sugarbush management, and wildlife habitat improvement)
   2. Agricultural conversion (refers to land cleared of trees for conversion to fields or pasture)
   3. Development (refers to land converted from forest use to housing, commercial or industrial development)
   4. Other (includes such descriptions as liquidation, increasing light to house, and generate income)
   5. Unknown

7. Month –

8. Day –

9. Year –

10. Weather during past 24 hours –
    1. No rain
    2. Light rain
    3. Rain
    4. Heavy rain

Silvicultural Method %: (The percent of the THO treated by individual silvicultural methods). These data were estimated by the field crew following completion of the on-the-ground assessment of each harvest. The classification was based on direct observations of residual crown closure along with the use of recent aerial photography. The availability of aerial photos taken during 2012, along with the site visit and systematic “cruising” of the THO made it possible to accurately determine the harvest method based on the intensity of the harvest. Silvicultural methods were defined as follows:

11. % Overstory Removal/Clearcutting - (Less than 25% crown closure)

12. % Strip Cutting (strips removed alternating with strips retained or regen)

13. % Group Selection (patches 1/20-2 acres)

14. % Shelterwood, Seed Tree, Prep. Cut (25-74% crown closure)

15. % Individual Tree Selection/Thinning (≥ 75% crown closure)

16. % Other: Specify_______________________________________

    Sum of the percent of Silvicultural Methods must total 100% for each THO.

17. Size Class Diversity – An overall characterization of the diversity and interspersion by stand size classes and stand acreage.
    1. 30+ acres per general size class patch,
    2. moderate,
    3. 5 acres or less per patch

18. Contextual Land Use (Using GIS) – Summary description of the land uses in the general vicinity of the THO.

Wildlife Practices Evident – wildlife habitat management practices which were observed during the field assessment. These were not systematically surveyed, simply noted when observed.

19. Apple Tree Release
20. Aspen Regeneration
21. Mast Production
22. Deer Winter Area Management
23. Snag and Den Trees

II. **INTERVIEW DATA** - Interviews of landowners or another person knowledgeable of the sale were conducted by phone, US mail, e-mail, and in person. Maps of the operation indicating the sale area and any other pertinent information (landing sites, truck roads, skid trails, cultural or historic sites, etc) were requested during the interview. Permission to conduct the on-site assessment was also requested. If permission was denied, another operation in the same county was randomly selected.

1. Was property enrolled in UVA at time of harvest?
2. Is the property third party certified? – includes Tree Farm, Sustainable Forestry Initiative, Forest Stewardship Council
3. Total Contiguous Acreage in Ownership – all acreage in the ownership even if the ownership extended beyond town/county boundaries. For State and Federal lands, this included all acreage in the management unit (block, etc).
4. Approximate total acres in Timber Harvesting Operation -
5. Was a professional forester involved in the timber harvesting operation? ("Professional Forester" was defined as a person eligible for SAF membership at any level.) If yes, what type?
    1. State lands
    2. County
    3. Private consultant
    4. Federal
    5. Company
    6. Unknown
6. Was another Natural Resource Professional involved in the Timber Harvesting Operation? If yes, what type?
    1. Wildlife biologist
    2. Ecologist
    3. Stream alteration engineer
    4. Other (specify)
    5. AMP Forester

7. Is there a written forest management plan for the property?
8. Was there a written contract between the landowner and the logger?
9. If a forester was involved with the timber harvesting operation, was the forester involved with the contract negotiations?
10. If there was a written contract, did the contract include special provisions? If yes, did they include provisions related to… (indicate all that apply)
    1. Archeological & historical resources
    2. Rare, threatened & endangered species
    3. Water quality
    4. Aesthetics
    5. Wildlife habitat
    6. Recreation
    7. Harvest timing
    8. Invasive plants
    9. Slash/ residuals
    10. Protection of physical sites
    11. Bridge building
    12. Trail construction
    13. Apple tree release
    14. Other
11. How were trees designated for removal?
    1. Forester marking
    2. Forester verbal
    3. Written prescription
    4. Row thinning
    5. Diameter limit
    6. Perimeter marked
    7. Logger's choice
    8. Other (specify)
12. Who was responsible for laying out (locating) skid trails?
    1. Forester
    2. Logger
    3. Landowner
    4. Pre-existing
    5. Other (specify)
13. Who was responsible for designating the landing site?
    1. Forester
    2. Logger
    3. Landowner
    4. Pre-existing
    5. Other (specify)

14. Who was responsible for the close-out of the sale?
    1. Forester
    2. Logger
    3. Landowner
    4. Other (specify)

15. What was the total duration of the timber harvesting operation from the time of start until the time of close-out?
    1. 1-3 months
    2. 3-9 months
    3. 9-18 months
    4. >18 months
    5. Unknown

16. How were the trees felled? (choose all that apply)
    1. Hand felling
    2. Feller buncher (no processor)
    3. Processor head (Cut-to-Length)
    4. Combination
    5. Unknown

17. What type of skidding equipment was used? (choose all that apply)
    1. Horse
    2. Cable skidder
    3. Grapple skidder
    4. Forwarder
    5. Tractor
    6. Other (specify)
    7. Unknown

18. In what form were trees moved to the landing site? (choose all that apply)
    1. Whole tree (with branches)
    2. Tree length (without branches)
    3. Log length
    4. Other (specify)

19. What products were harvested from this timber harvesting operation? (choose all that apply)
    1. Roundwood (logs, pulp, firewood)
    2. Chips
    3. Other (specify)

20. What was the primary goal for this timber harvesting operation?
    1. Income
    2. To satisfy a management plan
    3. Agricultural conversion
    4. Development

5. Recreation
6. Wildlife habitat
7. Aesthetics
8. Other (specify)
9. Timber trespass

21. Were the goals met? 1) Yes, 2) No

III. **SITE INSPECTION DATA** –

On site data were collected three different ways.

1. Point Sampling (with number of data points per THO)
    1. 6 Vegetation Plots (variable radius 10 factor prism)
    2. 6 Course Woody Material(CWM) - wildlife fixed radius points
    3. 18 Soil sample points

2. Line Sampling
    1. CWM-carbon (18 24’ transects)
    2. Truck Road (most used, up to ½ mile)
    3. Skid Trails (most used, up to 1/3 mile)
    4. Stream or Surface Water Boundary (most impacted up to ½ mile)

3. General Observations (observations made of all known occurrences)
    1. Landings
    2. Stream Crossings
    3. Vernal Pools/Wetlands
    4. Historic Sites
    5. Potential Prehistoric Sites
    6. Visual Resources

a. **Vegetation Data** – Once the THO boundary was located on the map, a GIS application (Point Grid Generator) was used to systematically place 6 evenly spaced sample points within the THO. This process was intended to duplicate the 1990 study in both the number of points sampled, and how the points were located within the THO. These six plot locations were located in the field using handheld GPS units. Points that fell within one chain of a truck road, landing or un-harvested area were moved into the THO in one chain increments until they were greater than one chain from the “untreated” area. The relocation of the plot was in the cardinal direction that most directly brought the plot into the THO. The vegetation plots were also used to locate the two CWM samples and the soil sample points.

General observations were made within two chains (132’) of plot center in all directions. Tree data were taken on a variable radius plot utilizing a BAF 10 prism.

1. Plot Number – plots numbered 1-6 on each THO

2. Pre-harvest SAF Type – Society of American Foresters cover type estimated from residual stand and stumps of dominant and co-dominant trees.

SAF Forest Cover Type Codes:			
0	Open	26	sugar maple-basswood
5	balsam fir	27	sugar maple
11	aspen, white birch	28	black cherry-maple
15	red pine	30	red spruce-yellow birch
16	aspen	31	red spruce-sugar maple-beech
17	pin cherry	32	red spruce
18	paper birch	33	spruce-fir
20	white pine, red oak, white ash	35	Northern white cedar
21	Eastern white pine	37	white cedar
22	white pine, hemlock	39	ash, elm, red maple
23	Eastern hemlock	54	red oak, basswood, white ash
24	hemlock-yellow birch	55	Northern red oak
25	sugar maple, beech, yellow birch	108	red maple

3. Pre-harvest Size Class – Estimate based on stumps and residual stand.
   1. Seedling/sapling (0-5 inches dbh)
   2. Softwood poletimber (>5 to 9 inches dbh)
   3. Hardwood poletimber (>5 to 11 inches dbh)
   4. Softwood sawtimber (>9 inches dbh)
   5. Hardwood sawtimber (>11 inches dbh)

4. Residual SAF Type – SAF cover type based on composition of dominant and co-dominant residual trees (see SAF Forest Type codes above).

5. Site quality – estimated using site indicator herbaceous plants, soils and sawlog heights of dominant and co-dominant trees in the vicinity of the point. Sawlog height was the predominant factor. Example:

	Site I	Site II	Site III	Site IV
		(Number of 16’ logs)		
Beech–Y. birch–S. maple	3+	2-2 ½	1-1 ½	< 1

W. pine – p. birch	3 ½ +	2 ½ - 3	2	< 2

6. Residual stand size class – using classes in #3 above, determination based on residual trees only.

7. Soil Drainage Class–
    1. *Poorly drained* soils had saturation periods of more than six months per year, concave topography commercially operable under frozen conditions – and with sedges, sensitive fern, interrupted fern, cinnamon fern, cattails, and jewelweed as indicator species.
    2. *Moderately well-drained* soils had convex topography, depth to pan or bedrock of 1 ½ to 3 feet, and annual saturation of 3-6 months.
    3. *Well-drained* soils had sandy, gravelly texture, terrace or moraine topographic configuration, and annual saturation periods of 0-3 months.

8. Slash disposal – General disposition of the slash generated by the harvest on the 2 chain radius plot.
    1. *Removed from site* generally indicated a whole-tree harvest or sites where residues were piled and burned.
    2. *Evenly distributed, tops intact* are characterized by tops left where they fell and not lopped.
    3. *Evenly distributed greater than 3 feet* indicates tops which were left where felled and lopped to a height greater than 3 feet if at all.
    4. *Evenly distributed less than 3 feet* indicates tops which were left where felled and lopped to a height less than 3 feet.
    5. *Unevenly distributed less than 3 feet* indicates tops moved but not evenly scattered, such as slash returned to the woods from a landing.
    6. *Piled/windrowed* indicates tops and/or residues felled or placed in piles or windrows during harvesting.

9. Surface characteristics –
    1. *Ledge, rock outcrops* had more than 25% of surface area in ledge or rock outcrops.
    2. *Moderately stony* had 15 to 50% of the surface area in stones or rocks.
    3. *Wet* had concave topography, was located at the toes of slopes, had seeps and/or wet site indicator plants such as sedges, cinnamon fern, sensitive fern, interrupted fern, jewelweed, and cattail.

10. Plot slope – percent slope at plot center in 10% classes

11. Aspect –

12. Dominant silvicultural method – primary silvicultural method used within the 2 chain radius plot.
    1. Overstory Removal/Clearcutting - (Less than 25% crown closure)
    2. Strip Cutting (strips removed alternating with strips retained or regen)
    3. Group Selection (patches 1/20-2 acres)
    4. Shelterwood, Seed Tree, Prep. Cut (25-74% crown closure)
    5. Individual Tree Selection/Thinning (≥ 75% crown closure)
    6. Other: Specify

13. Expected dominant vegetation (3-5 years after cutting) – predicted dominant vegetation type which will be established within a 2 chain radius of plot center 3-5 years following cutting.
    1. None
    2. Ferns and herbaceous plants
    3. Rubus sp.
    4. Shrubs
    5. Tree Coppice
    6. Trees
    7. Non-native, Invasive Species

    9. Unknown (if beech, enter 10 under item 14)

14. Expected dominant reproduction species composition of trees (3-5 years after cutting):
    1. No Commercial Trees
    2. Hemlock
    3. White Pine
    4. Spruce-fir
    5. Other Softwood
    6. Aspen-White Birch-Red Maple
    7. Sugar Maple-Beech-Yellow Birch-Ash-Basswood
    8. Other Commercial Hardwood
    9. Mixed Hardwood-Softwood
    10. UGS (Beech, Striped Maple, *Ostrya virginiana* and/or *Viburnum alnifolium*)
    11. Invasive exotic shrubs or trees

15. Expected dominant reproduction condition (3-5 years after cutting):
    1. ≤ 3 feet tall, 0-33% crown closure
    2. ≤ 3 feet tall, 34-66% crown closure
    3. ≤ 3 feet tall, > 66% crown closure
    4. > 3 feet tall, 0-33% crown closure
    5. > 3 feet tall, 34-66% crown closure
    6. > 3 feet tall, >66% crown closure

16. Deer and/or moose browsing impacts (for additional details see *Browsing Site Conditions for Managed Northern Hardwoods,* Appendix E for a complete description):
    1. None to Light
    2. Moderate
    3. Heavy
    4. Severe

Tall Woody Species (3' to 15' saplings)	**Low Intensity (None to Light)**	**Moderate Intensity (Moderate)**	**Intensive Browsing Evidence of Regeneration Impacts (Heavy)**	**High Intensity Historically Intense Browsing (Severe)**
	1	2	3	4
Condition of Forest	Diverse mix of tree saplings, shrubs, forbs, ferns, and grasses of varying heights. Little sign of browsing.	Preferred forage species show some signs of browsing, but not affecting height growth. No browse lines.	Unpalatable species show increase in density while others decline in number and occur in poor form. Mostly beech and striped maple and other unpalatable species in understory in stems >1 ft. in height.	In later stages, New York and hayscented ferns, sedges occupy opening as an almost complete mat with only occasional tree sapling showing. Browse line evidence throughout forest. Mid-story, if present, dominated by 1 or 2 unpalatable woody species (black birch, beech, red spruce, buckthorn, etc.)

b. **Tree Data:** A BAF-10 variable radius plot sample was completed at each of the six plot centers within the harvested area of the Timber Harvest Operation.

1. Tree Species Codes:

1	Cedar, N.W.	21	Non-commercial	41	Aspen, Big Tooth
2	Fir, Balsam	22	Wildlife	42	Aspen, Trembling
3	Hemlock	23	Dogwood (NC*)	43	Alder, Speckled (NC)
4	Pine, Red	24	Ironwood (NC)	44	Hophornbeam (NC)
5	Pine, White	25	Birch, Grey (NC)	45	Maple, Silver
6	Spruce, Norway	26	Elm, Slippery	46	Maple, Striped (NC)
7	Spruce, spp.	27	Elm, American	47	Oak, Black
8	Softwood	28	Hickory, spp.	48	Oak, White
9	Blank	29	Cherry, Black	49	Oak, Chestnut
10	Ash, White	30	Oak, Swamp White	50	Birch, Black
11	Aspen, spp.	31	Willow, spp. (NC)	51	Apple (NC)
12	Basswood	32	Serviceberry (NC)	52-74	Blanks
13	Beech	33	Ash, Mountain (NC)	75	Pine, Scotch
14	Birch, Paper	34	Black Locust	76	Pine, Jack
15	Birch, Yellow	35	Cherry, Pin (NC)	77	Pine, Pitch
16	Butternut	36	Oak, Chinkapin	78	Cedar, Eastern Red
17	Maple, Red	37	Box Elder (NC)	79	Tamarack
18	Maple, Sugar	38	Ash, Green	80	Spruce-White
19	Oak, Red	39	Ash, Black		
20	Hardwood	40	Cottonwood		*NC = non-commercial

2. DBH – The diameter breast height is estimated with a Biltmore stick. 10% of the diameters checked with a diameter tape. DBH was recorded in 1” diameter classes.

3. Tree Quality – See Appendix F for a complete description of US Forest Service tree grading standards used to determine tree quality class.
   1. AGS – an acceptable growing stock tree (AGS) is a commercial species less than rotation age with relatively good vigor, containing no pathogens that may result in the death or serious deterioration before rotation age and which contains or has the potential of producing merchantable sawtimber of USFS grade 3 quality or better.
   0. UGS – an unacceptable growing stock tree (UGS) is a tree (mature or immature) which will not grow or prospectively meet AGS standards primarily because of roughness, poor form, or non-commercial species.

4. Status – 1) Alive 2) Dead

5. Canopy Position – 1) Dominant/Co-Dominant 2) Suppressed

6. Wildlife –
    1. Soft Snag
    2. Hard snag – Cavity
    3. Bear Use
    4. Visible Nest
    9. None

7. Tree Damage Class –
    1. Open Wound < 30% of Circumference
    2. Open Wound ≥ 30% of Circumference
    3. Top Broken, 16-49% Crown Missing
    4. Top Broken, ≥ 50% Crown Missing
    5. Root Exposed, Torn or Broken
    6. Bent Over, Partially or Wholly Destroyed

8. Crown Dieback – (see definitions Appendix G)
    1. 0-15%
    2. 16-49%
    3. ≥ 50%

9. Live Crown Ratio – (see definitions Appendix G): 1) ≥ 35%, 2) < 35%

c. **Soil Impacts:** A soil data point was placed at the end of each CWM-carbon transect line for a total of 18 soil points per THO. The three CWM-carbon transect lines, 24' long, were located at azimuths of 30, 150, and 270 degrees from plot center at each vegetative data plot. No adjustment was made if the point fell on a skid trail or truck road. If the point fell on a large rock or ledge, the data point was moved to a location just beyond it along the same azimuth. Data were collected using techniques based on a subset of measurements developed by the USDA-Forest Service (Page-Dumroese et al. 2009).

Procedure

"Data point" is defined as a 6" circular area at 24' from plot center along the defined azimuth. Dig into the soil if needed to determine depth of compaction. Refer to Forest Soil Disturbance Monitoring Protocols; Volume 1, Rapid Assessment (Page-Dumroese et al. 2009) for detailed descriptions.

1. Skid Trail? 1) Yes, 2) No

2. Bare Soil Present? 1) Yes, 2) No

3. Erosion Present? 1) Yes, 2) No
    1. If yes, indicate most severe erosion type present.
        i. Sheet erosion; minute rills occasionally present
        ii. Rill erosion; rills up to 6" deep
        iii. Gully erosion

2. Depth of erosion in inches

4. Rutting Present? 1) Yes, 2) No
    1. If yes, identify maximum depth.
        i. 0-6”
        ii. 6-12”
        iii. Over 12”

5. Soil Compaction Present? 1) Yes, 2) No
    1. If yes, indicate extent.
        i. 0-4”
        ii. 4-12”
        iii. Over 12”

6. Soil Disturbance Class: Record Class 0, 1, 2 or 3

Disturbance Class	Abbreviated Description
0	***Natural, undisturbed soil conditions*** – No evidence of past equipment No erosion or compaction Forest floor (duff; organic layers) intact
1	***Minimal soil disturbance*** – Wheel tracks or depressions may be evident, but faint or shallow Forest floor mostly present and intact Bare mineral soil is uncommon on the ground surface Soil compaction is shallow (0-4”), but is only slightly greater than under natural conditions
2	***Soil disturbance is common*** – Wheel tracks/ruts are evident in the mineral soil Forest floor partially missing, and bare soil may be exposed Soil compaction is present in the mineral soil to a depth of 4-12” Soil structure is typically platy A typical situation is a light to moderately-used skid trail
3	***Soil is highly disturbed*** – Wheel tracks are very evident, being greater than 4“ deep Forest floor partially or fully gone There is evidence of surface soil removal, gouging and piling Soil compaction is more than 12” deep Soil structure is platy or massive to a depth of over 12”

d. **<u>Coarse Woody Material (CWM) for Carbon:</u>** Three coarse woody material transect lines, 24’ long, were located at azimuths of 30, 150, and 270 degrees from plot center at each of the six vegetative data plots, for a total of 18 transects per THO. CWM-Carbon is defined as downed, dead tree and shrub boles, large limbs, and other woody pieces that are severed from their original source of growth and on the ground. CWM also includes dead trees (self-supported by roots, severed from roots, or uprooted) that are leaning >45 degrees from vertical. For multi-stemmed woodland trees such as juniper, only tally stems that are dead, detached and on the ground, or dead and leaning >45 degrees from vertical.

<u>Minimum length of any tally piece is 3.0 feet. When CWM pieces are close to 3.0 feet total length, measure the length to the nearest 0.1 foot to determine if it is ≥ 3.0 feet.</u> CWM total length is the length of the piece that lies between that piece’s diameter at the small end (down to 3” diameter point) and its diameter at the large end.

When a transect crosses a forked, down tree bole or a large branch connected to a down tree, tally each qualifying piece separately. Each piece must meet minimum diameter and length requirements.

See USDA Forest Service, Forest Inventory & Analysis National Core Field Guide: Phase 3 Field Guide – Down Woody Materials, Version 5.1; October 2011, for complete data collection procedures.

CWM does not include:

- Woody pieces <3 inches diameter at point of intersection with the transect
- Dead trees leaning 0-45 degrees from vertical
- Dead shrubs self-supported by their roots
- Trees showing any sign of life
- Stumps that are rooted in the ground (i.e., not uprooted)
- Dead foliage, bark or other non-woody pieces that are not an integral part of a bole or limb (bark attached to a portion of a piece is an integral part)
- Roots or main bole below the root collar

Procedure

A. Establish three transects 24' long from the vegetation plot center at azimuths of 30, 150, and 270 degrees, respectively.

B. Record each piece of CWM that intersects the line separately by point number.

1. Line number
2. Species (utilize species codes above)
3. Diameter at transect crossing point
4. Diameter at large end
5. Diameter at small end (down to 3 inch diameter)
6. Total length (down to 3 inch diameter)
7. Decay class 1 – 5 (definitions provided in table below).
8. Complete? 1) Yes, 2) No (used to document completion of the line even if no CWM was present)

Decay Class	Structural Integrity	Texture of Rotten Portions	Color of Wood	Invading Roots	Branches and Twigs
1.	Sound, freshly fallen, intact logs	Intact, no rot; conks of stem decay absent	Original color	Absent	If branches are present, fine twigs are still attached and have tight bark
2.	Sound	Mostly intact; sapwood partly soft (starting to decay), but can't be pulled apart by hand	Original color	Absent	If branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3.	Heartwood is sound, piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	Reddish-brown or original color	Sapwood only	Branch stubs will not pull out
4.	Heartwood is rotten, piece does not support its own weight, but maintains its shape	Soft, small blocky pieces; a metal pin can be pushed into heartwood	Reddish or light brown	Through-out	Branch stubs pull out
5.	None, piece no longer maintains its shape, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

e. **Coarse Woody Material (CWM) for Wildlife Habitat:** A CWM-Wildlife Habitat plot was taken at each vegetation plot, for a total of 6 per THO. These were fixed radius plots with a radius of 26.2 feet. CWM-Wildlife Habitat is defined as dead and downed pieces, or portions of pieces, of wood that are at least 3 feet in length with a large-end diameter of at least 12 inches. Material must be detached from the bole of a standing live or dead tree. If the piece is still partially rooted, the lean angle must be >45 degrees from vertical. (Standing dead trees with a lean angle <45 degrees from vertical are considered snags). Branched and forked pieces are tallied if the main bole meets conditions above. For each piece, the main bole is determined as the fork with the largest diameter. If CWM is fractured, either lengthwise or in broken sections, each portion is treated as a separate piece as long as it meets the above qualifications.

Procedure

A. Establish a fixed area plot with a 26.2 foot radius.

B. Measure all coarse woody debris with a large end diameter greater than 12 inches that falls within or partially within the plot.

C. Make note of whether the piece is hollow (yes or no). Cavities must be larger than a woodpecker hole to be considered hollow. Do not count stumps. If a piece has shattered, count each individual piece separately.

D. Record:
   1. Diameter
   2. Hollow? 1) Yes, 2) No

9. Complete? 1) Yes, 2) No (used to document completion of the line even if no CWM was present)

f. **Truck Road Data:** Truck Road Data were collected on the truck road that had the most potential for impact. Data collection started on the landing end of the road, two chains (132 feet) from the landing, and then every 8 chains for ½ mile, or to where the truck road entered a public road, whichever was less.

Procedure

A. First data collection point is 2 chains from landing and 8 chains thereafter. If less than 2 chains, consider road as part of landing.

B. At each data collection point record:

1. Road Type: 1) Permanent, 2) Temporary

2. Number of Functional Drainage Structures in preceding road segment: (Functional Drainage Structure is any natural or man-made drainage that effectively drained road surface water on skid trails and temporary truck roads. On permanent truck roads, functional drainage structures included broad based dips and pole or metal culverts.)

3. Number of Recommended Drainage Structures in preceding road segment – These were determined by conversion of Table 1 in the "Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont" (AMPs) from feet to chains and are based on the tables used in the 1990 assessment. Numbers shown in the 1990 assessment were rounded up or down to give a whole number of structures per segment.

Recommended number of waterbars for skid trails and temporary truck roads after logging.

Road Grade	Per 1.5 chains	Per 2 chains	Per 3 chains	Per 8 chains
0-1%	0	0	1	1
1-2%	0	1	1	2
2-5%	1	1	2	4
5-10%	1	2	3	7
10-15%	2	2	3	9
15-20%	2	3	4	12
20-25%	3	3	5	13
25-30%	3	4	6	15
30-40%	3	4	7	18

Recommended number of functional drainage structures for permanent truck roads:

Road Grade	Per 2 chains	Per 8 chains
0-1%	0	1
1-2%	0	2
2-5%	1	3
5-10%	1	4
10-15%	1	4
15-20%	1	4

4. Actual Protective Strip Width:
    1. < 50’
    2. 50’
    3. 70’
    4. 90’
    5. 110’
    6. 130’
    7. >130’ or no stream visible
    9. Stream crossing

5. Recommended Protective Strip Width (see Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont, Table 4):
    1. No stream visible
    2. 50’
    3. 70’
    4. 90’
    5. 110’
    6. 130’
    7. > 130’
    8. Stream crossing

6. Silt fencing or hay bale check dams used in segment: 1) Yes, 2) No

7. Surface Erosion Type (most severe type observed in last segment):
    1. Sheet or minute rill present
    2. Rills up to 6” deep
    3. Gullies, 6-12” deep
    4. Significant gullies, 12-24” deep
    5. Advanced gullies, > 24” deep
    9. No apparent or slight erosion

10. Soil Drainage:

1. Poorly drained
2. Moderately well drained
3. Well drained

11. Average grade of last segment:
    1. 1%
    2. 2%
    3. 5%
    4. 10%
    5. 15%
    6. 20%
    7. 25%
    8. 30%
    9. 40%

12. Steep segments (grade exceeding 10% for more than 300'): 1) Yes, 2) No

g. **Skid Trail Data:** Skid Trail Data were collected on a main skid trail. Data collection started on the landing end of the skid trial, one and a half chains (99 feet) from the landing, and then every 3 chains for 1/3 of a mile or to where the skid trail ended, whichever was less. If several choices existed, the trail with the most potential for impact was chosen for examination.

Procedure

A. Examine from landing to end of harvest area or 1/3 mile, whichever is less. First data point 1.5 chains from landing and every 3 chains thereafter.

B. Record:
   1. Number of Functional Drainage Structures in preceding road segment:
   2. Number of Recommended Drainage Structures (see tables above):
   3. Actual Protective Strip Width:
      1. < 50'
      2. 50'
      3. 70'
      4. 90'
      5. 110'
      6. 130'
      7. >130' or no stream visible
      9. Stream crossing
   4. Recommended Protective Strip Width (see Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont, Table 4):
      1. No stream visible
      2. 50'

3. 70’
4. 90’
5. 110’
6. 130’
7. > 130’
8. Stream crossing

5. Silt fencing or hay bale check dams used in segment: 1) Yes, 2) No

6. Surface Erosion Type (most severe type observed in last segment):
    1. Sheet or minute rill present
    2. Rills up to 6” deep
    3. Gullies, 6-12” deep
    4. Significant gullies, 12-24” deep
    5. Advanced gullies, > 24” deep
    9. No apparent or slight erosion

7. Soil Drainage:
    1. Poorly drained
    2. Moderately well drained
    3. Well drained

8. Average grade of last segment:
    1. 1%
    2. 2%
    3. 5%
    4. 10%
    5. 15%
    6. 20%
    7. 25%
    8. 30%
    9. 40%

9. Steep segments (grade exceeding 20% for more than 300’): 1) Yes, 2) No

h. **<u>Landings</u>:** all landings associated with a THO were evaluated separately. If the study team was unable to distinguish the location of the landing, or if it was being utilized for something else (such as a house site or had been restored to agricultural use) it was not evaluated.

Procedure

A. Record:
1. Landing number:

2. Landing size (acres and tenths of acres):

3. Average slope of landing:

1. 0-5%
2. 6-15%
3. > 15%

4. Recommended Protective Strip Width (see Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont, Table 4):
    1. No stream visible
    2. 50’
    3. 70’
    4. 90’
    5. 110’
    6. 130’
    7. > 130’

5. Landing located in protective strip (determined from Table 4 in the AMPs)? 1) Yes, 2) No

6. Landing located in wetland? 1) Yes, 2) No

7. If landing was in a wetland, was it used under frozen conditions? 1) Yes, 2) No

8. Evidence of petroleum spills? 1) Yes, 2) No

9. Landing graded with diversion ditches installed to prevent sediment from entering surface waters (determined by landing area slope, evidence of surface erosion and potential for sedimentation)? 1) Yes, 2) No

10. Soil Drainage:
    1. Poorly drained
    2. Moderately well drained
    3. Well drained

11. Surface Erosion Type (most severe type observed):
    1. Sheet or minute rills present
    2. Rills up to 6” deep
    3. Gullies, 6-12” deep
    4. Significant gullies, 12-24” deep
    5. Advanced gullies, > 24” deep
    9. No apparent or slight erosion

12. Landing seeded and mulched? 1) Yes, 2) No, 9) Unknown

i. **<u>Stream Crossings:</u>** A systematic method of locating stream crossings was not used. Stream crossings were evaluated when encountered while assessing truck roads, skid trails, streams, and navigating between vegetation plots. Crossings on roads associated with the THO were evaluated even if not within the THO (e.g., truck roads or skid trails outside the harvested area, but clearly part of the operation).

For the purposes of determining if a stream crossing existed, a “stream” had to have defined banks and a gravel bottom. For the purposes of the assessment, a permanent stream had to have water present during the driest part of the summer. Streams not meeting this criterion were considered intermittent.

Procedure

A. Stream crossing data were collected every time a skid trail or truck road crossing was encountered on a THO while conducting site evaluations.

B. Record:
   1. Road Type:
      1. Permanent truck road
      2. Temporary truck road
      3. Skid road
   2. Stream Type:
      1. Permanent
      2. Intermittent
   3. Crossing Type:
      1. Metal culvert
      2. Wooden culvert
      3. Ford
      4. Bridge
      5. Log ford
      6. Brush
      7. Other
      8. Removed
   4. Bank-Full Width of Stream (see Best Management Practices for Forestry: Protecting Maine’s Water Quality. Maine Forest Service. 2004 pp. 45-46): record feet and tenths of feet.
   5. Bank-Full Depth of Stream: record average bank-full depth of stream in feet and tenths of feet.
   6. Bank-Full Area of Stream: Bank-full width times average bank-full depth.
   7. Structure Size Opening[141] (only used when wooden or metal culverts are in place): record culvert opening size in square feet to nearest tenth.

[141] All bridges and culverts left in place after logging were evaluated to determine if the structure size opening was adequate to accommodate expected stream flow for a 1-3 year, 10-year, and 25-year flood event following the process outlined in the Maine Forest Service publication “Best Management Practices for Forestry: Protecting Maine’s Water Quality” (Maine Dept. of Conservation, 2004). The purpose of this observation was not to determine AMP compliance, but to provide an indication of the hydraulic capacity of the stream crossing structures under current conditions.

8. Average Structure Size Width (used for bridges and box culverts): measure width of opening, typically between bridge abutments, and record in feet to nearest tenth.

9. Average Structure Size Height (used for bridges and box culverts): measure height from stream bed to bottom of structure and record in feet to nearest tenth.

10. Acute Angle of road to stream at crossing:
    1. 80-90 degrees
    2. 60-79 degrees
    3. < 60 degrees

10. Approaches to stream seeded and mulched (see AMP 12)? 1) Yes, 2) No, 9) Unknown

11. Streambed and approaches stable? 1) Yes, 2) No

12. Turn-ups or broad-based dips installed before crossing (see AMP 11)? Identified if found within 25 feet of crossing (1990 identified these if found within 132 feet of the stream crossing, at the bottom of slopes approaching a stream crossing and a minimum of 25 feet from the stream crossing). 1) Yes, 2) No

13. Evidence of sedimentation within 1 chain downstream of crossing:
    1. Natural
    2. Thinly coated streambed
    3. Plumes or thick deposits

14. Extent of slash or woody debris in stream channel within 1 chain upstream or downstream of crossing:
    1. Natural (logging debris and slash absent)
    2. Moderate (logging debris or slash present but not blocking or altering stream flow)
    3. Blocking or altering streamflow

15. Evidence of petroleum spills? 1) Yes, 2) No

16. Fish Present (FISH PRES) Would this point in stream support fish?:
    1) Yes, 2) No

17. Fish Passage (FISH): Identify crossing structures which could potentially inhibit aquatic organism movement[142]
    1. Open bottom structure (open to natural streambed), or structure removed

[142] The categories used to document conditions favorable to fish passage were chosen to correspond to those established for the US Forest Service BMP Monitoring Protocol (Welsch et al. 2007).

2. Closed bottom structure, natural streambed substrate material is present and continuous on the inside bottom of the structure
3. Closed bottom structure, natural streambed substrate material is not present or is not continuous on the inside bottom of the structure
4. Closed bottom structure with perched outlet or pole or slash ford

j. **<u>Streams and Surface Waters</u>**: One stream or water body shoreline (excluding wetlands which were assessed using a different protocol) was evaluated if it fell entirely or in part within the harvested area of the THO. If multiple streams or waterbodies were present, the one which appeared to have the potential to have been the most heavily impacted was chosen for evaluation.

Procedure

A. For stream, place point 1 at an elevation just above or below the THO and examine the stream at 4 chain intervals to the end or ½ mile, whichever is less.

   For waterbody shoreline, place point 1 at one end of the intersection of the THO boundary and the waterbody shoreline, and examine the shoreline at 4 chain intervals to the end of the THO or ½ mile, whichever is less.

B. Record:

   1. Segment number:

   2. Water Body Type:

      1. Intermittent stream
      2. Permanent stream/river
      3. Lake
      4. Pond
      5. Other
      9. None

   3. Actual Protective Strip Width (PSW):
      1. <50’
      2. 50’
      3. 70’
      4. 90’
      5. 110’
      6. 130’
      7. >130’
      9. Stream crossing

   4. Recommended Protective Strip Width (RSW):
      1. <50’

2. 50’
3. 70’
4. 90’
5. 110’
6. 130’
7. >130’
9. Stream crossing

Protective Strip Width Guide Slope of Land Between Roads or Landings and Stream Banks or Lake Shores	Width of Strip Between Roads or Landings and Stream (Feet along surface of ground)
0-10%	50’
11-20%	70’
21-30%	90’
31-40%*	110’

*Add 20’ for each additional 10% side slope

5. Protective Strip Canopy Condition (DENS): Take crown cover reading with densiometer at bank-full width every four chains. Record decimal percent open.

6. Dominant Condition (COND)[143]:
   1. Natural condition: clean adjacent rocks, stable, little sediment natural stream location, no plumes, no alluvial fans
   2. Moderate: thinly coated streambed, logging debris or slash present but not blocking or altering stream flow
   3. Natural condition disrupted: adjacent rocks coated with sediment, active bank cutting, heavy sedimentation, stream relocated, many plumes and alluvial fans, logging debris or slash blocking or altering stream flow

7. Likely Cause of Erosion/Condition (CE)…Logging caused or natural:
   1. Logging
   2. Natural

8. Protective Strip Entries by log transport machinery within 25’ of water body (BSE): Excluding stream crossings, where logging equipment, including bulldozers or rubber-tired skidders operated within 25 feet of the stream channel. Record number of entries, excluding stream crossings

9. Stream Crossings in segment (XING): Record number of skid trail or road crossings

10. Slash in Streams (SLASH)[144]:

[143] The presence or absence of both logging slash and sediment were taken into consideration in determining dominant condition of the stream or water body.

1. Less than 100 cubic feet;
2. 100-200 cubic feet;
3. More than 200 cubic feet

11. Skidding in Streams (SKID): Operation of skidding equipment in the stream channel other than skid trail crossings. 1) Yes, 2) No

k. **Vernal Pools and Wetlands**:

Definition of Wetland: Areas that are inundated by surface or ground water with a frequency sufficient to support significant vegetation or aquatic life that depend on saturated or seasonally saturated soil conditions for growth and reproduction. Such areas include but are not limited to marshes, swamps, sloughs, potholes, fens, river and lake overflows, mud flats, bogs, and ponds, but excluding such areas that grow food or crops in connection with farming activities.

Definition of Vernal Pool: a small wetland in a shallow natural depression that typically fills with water during the spring and/or fall and may dry during the summer. Vernal pools have no permanent inlet stream and no viable populations of fish. Vernal pools are typically sparsely vegetated with herbaceous plants and are shaded by trees from the surrounding upland forest. Many vernal pools provide critical breeding habitat for amphibians.

Procedure:

A. Significant wetlands and mapped vernal pools were identified through the use of GIS mapping using the significant wetlands data layer. Sampling was completed using the same procedure used for streams and waterbodies. The first point is located just above or below the THO for wetlands or vernal pools occurring along the edge of the sale area boundary. For wetlands or vernal pools located entirely within the THO, locate the first point where convenient, then space sample points at 4 chain intervals in the center of the 50' wetland buffer.

B. Record:
   1. Equipment (rutting) evidence in wetland? (RW) 1) Yes, 2) No
   2. Equipment (rutting) evidence in 50 foot buffer? (RBUFF): 1) Yes, 2) No
   3. Harvesting of trees in wetland? (HVST): 1) Yes, 2) No
   4. Densiometer Reading: Take crown cover reading in center of 50' buffer, every four chains around wetland or ½ mile, whichever is less. Record decimal percent open.

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[144] The amount of logging slash observed in each stream segment was recorded in one of the three following categories: 0-100 cubic feet; 100-200 cubic feet; and more than 200 cubic feet. The categories used to document the amount of slash in a stream segment were chosen to correspond to those established for the US Forest Service BMP Monitoring Protocol. They are not tied to any biological impact index, but were merely chosen as a means to visualize the volume of slash. To provide some context, a standard cord of wood measuring 4' by 4' by 8' equals 128 cubic feet.

5. Skid Trail through Wetland (SKIDWET): 1) Yes, 2) No
    a. Was Fill Added (SKID FILL): 1) Yes, 2) No

6. Truck Road Through Wetland (TRKWET): 1) Yes, 2) No
    a. Was Fill Added (TRK FILL): 1) Yes, 2) No

I. **Historic Sites:**

During the interview and in the request for maps, the person contacted with knowledge of the THO was asked to identify and locate on a map any historic site that he/she was aware of within the THO boundary. These historic sites were located and evaluated as well as any others that were encountered during the site visit.

Procedure

A. Each of the sites identified was evaluated by component, with each component given a separate site number if applicable.

B. Record:

1. Site Number (Number):

2. Site Component (COMP):
    1. House foundation or cellar depression
    2. Outbuilding foundation or depression
    3. Dams and mill foundations
    4. Remnant plantings (lilac, apple trees, etc.)
    5. Rock alignment or depression; origin unknown
    6. Stone walls
    7. Shack; collapsed or otherwise
    8. Other: sugar arches, cemeteries, charcoal kilns, features of unknown function. Describe:

3. Cause of Damage/Disturbance (visual ID):
    1. Truck road
    2. Skid trail
    3. Log landing
    4. Major/substantial erosion
    5. Substantial rutting
    6. Felling
    7. Equipment - one time skid

4. Potential damage to subsurface resources surrounding feature indicated by ground disturbance in 3 zones:
    1. Within 20’
    2. Within 100’
    3. Greater than 100’

5. Damage to Visible Feature:

1. Breached
2. Filled
3. Rearranged
4. No Impact

m. Potential Prehistoric Sites Data

The pre-contact archaeological predictive model GIS layer was overlaid on the timber harvest operation maps in order to identify timber harvests that contained archaeologically high-risk sites (≥ 6 factors). Observers then visited the area mapped as high risk and noted on-site characteristics such as a noticeable terrace, obvious pits and mounds, whether harvesting activity took place in the area, whether the site had been previously disturbed (i.e., plowed or graded), or whether there was a prominent rock exposure, and then provided a general description of the site. For such identified locales, it is assumed that a pre-contact site might be present.

In addition, the assessment team collected data on sites that were located during the field visits. Field-identified sites were required to exhibit all of the following characteristics:

- Within 100 of streams or obvious relic drainage AND
- A terrace with a slope of less than or equal to 5% AND
- Flat with a south to west aspect

Procedure

A. Each potential prehistoric site identified by the predictive model that appeared to overlap THO boundaries was visited in the field and potential impacts were assessed.

B. Record:

1. Site located by:
    1. On the ground only
    2. Identified by predictive model only
    3. Located by both methods

2. Terrace Type (TERRACE): 1) Outwash Plain, 2) Alluvial

3. Pit/Mound (PITMOUND): 1) None, 2) Occasional, 3) Extensive

4. Terrace Impact Activity (ACTIVITY):
    1. Road/Trail
    2. Landing
    3. Rutting
    4. Combination
    9. None

5. Disturbance (DISTURBANCE):

1. Obvious activity, obvious erosion, point specific disturbance
2. Limited surface disturbance with occasional depressions
3. No disturbance observed

6. Previous site disturbance (Previously tilled): 1) Yes, 2) No, 9) Unknown

n. **Visual Resources Data**

For the purposes of this assessment, a harvesting operation was evaluated for visual impacts only if it was visible from a public or quasi-public outdoor area. The outdoor area must receive considerable public use (more than a few people) and have recreational or scenic values. These areas were defined as paved public roadways, public recreation areas, designated trails (hiking, bicycle, equestrian, and cross-country skiing), streams (with watersheds greater than 10 square miles), lakes and ponds (greater than 25 acres in size), designated natural areas, and designated scenic areas.

Procedure

A. If the timber harvesting operation was visible from one of the areas noted above, including selection cuts that were only visible to the trained eye, a potential aesthetic impact was assumed and detailed data were collected. In some cases the cut was seen from two or more locations, or in several locations along a view corridor such as a road or trail. In these cases, views were evaluated at several points along the view corridor, and the overall evaluation of impacts was based upon only those points of greatest impact. For each evaluation point, both the length of the view corridor and the area of the harvest that was visible were recorded. For each viewing location, photographs were taken of the associated harvesting operation.

B. Record:

1. Type of Public Resource (record name of each resource noted)
    1. Paved Public Highway
        a. Local
        b. State
        c. Interstate
    2. Recreation Areas
        a. Local
        b. State
        c. Federal
    3. Trail
        a. Hiking
        b. Bike path
        c. Bike route
        d. X-C Ski
        e. Natural area

f. Other

4. Navigable Waterway
   a. River/Stream
   b. Lake/Pond[145]

5. Scenic Area[146]
   a. Designated scenic road
   b. Scenic viewpoint or resource

For each of the public resources noted, record the following (select up to 5 most prominent viewpoints):

1. Name of viewpoint/public resource

2. Distance from viewer (note all that apply and distance)
   1. On Site (e.g., publically accessible resource)
   2. Adjacent (< 100' from viewpoint and visible)
   3. Foreground (100' - 0.5 miles)
   4. Middleground (0.5 miles - 4 miles)
   5. Background (> 4 miles)
3. Corridor length/size of viewing area

4. Area of THO visible (acres)

5. Photo number(s)

6. Characteristics for viewpoint
   1. Harvesting
      a. Size of openings:
         1. Thinning, but very small or no visible openings (except natural openings such as wetlands)
         2. Small openings (1-3 acres)
         3. Large openings (> 3 acres) that are noticeable or dominate views
      b. Edge transition:
         1. No distinct edges
         2. Transitions feathered with shrubs or small trees
         3. Abrupt edges with a wall of trees and dead branches visible
      c. Edge configuration:
         1. No edge
         2. Irregular edge

[145] With public access or > 5 acres

[146] Check local town plans to determine if either viewing location or harvest location is noted as a scenic resource

    3. Straight edge along cut line
  d. Horizon or Ridge Line:
    1. Horizon line cut
    2. Horizon line noticeably thinned
    3. Horizon line cut with few trees remaining
  e. Stumps:
    1. Low; difficult to see
    2. Stumps > 1’ common, somewhat noticeable
    3. Numerous stumps over 1’ visible, very noticeable
  f. Slash and Debris[147]:
    1. Slash and debris non-existent or consistent with natural decay
    2. Slash 18”– 3’, over 200 feet from viewer and will disappear in 2 years
    3. Slash > 3’ high common, large piles, hanging or large downed trunks and limbs common
  g. Exposed Earth[148]:
    1. No exposed earth
    2. Occasional glimpses but appears vegetation will quickly establish
    3. Exposed earth very visible

2. Residual Stand
  a. Visible from Viewing Point: 1) Yes, 2) No
  b. Spacing between Trees:
    1. Thinning, small openings in canopy
    2. Groups or solitary individuals remaining with large openings
    3. Clearcut with only occasional trees remaining
  c. Size of Trees:
    1. Mix of age classes with saw timber to pole size predominating
    2. Primarily pole size and saplings
    3. Primarily saplings with few larger trees
  d. Health of Residual Stand:
    1. Few or no mechanical wounds present, forest appears healthy
    2. Mechanical wounds present, diseased/dying trees evident
    3. Wounds, dead or dying trees common (bomb explosion)

[147] Note if slash used for stream crossing is visible from viewpoint.

[148] Not including roads and landings, which are addressed in another table

3. Roads and Landings
    a. Visible: 1) Yes, 2) No; make note of road and/or landing
    b. Ground Appearance:
        1. Vegetation established up to edges of road and along much of road surface, no evident erosion
        2. Occasional areas of exposed earth that will grow in near future
        3. Large areas of exposed earth with evidence of erosion
    c. Road Size:
        1. Narrow, 10-12 feet
        2. Average, 12-18 feet
        3. Wider than 18 feet, offset tracks abundant
    d. Alignment:
        1. Road curves out of sight shortly, designed with contours
        2. Generally well designed but visually dominant
        3. Long, straight stretches and designed against contours
    e. Wood Chip Debris:
        1. Minimal or no wood chips evident
        2. Small area of road or landing covered with wood chipping debris
        3. Large areas of wood chips and debris remain, preventing herbaceous or other plant growth
    f. Public Access: 1) Public access permitted, 2)No public access

4. Wetlands & Streams
    a. Visible: 1) yes, 2) no
    b. Slash Left in or Adjacent to Wetland:
        1. No slash
        2. Small amounts adjacent to wetland or stream
        3. Slash in and adjacent
    c. Buffer:
        1. Buffer intact between THO and wetland or stream
        2. Small intrusions into buffer area
        3. No buffer

5. Views[149]
    a. Distant Views:
        1. THO improves or reveals distant view
        2. No change in distant view
        3. THO opens negative view
    b. Foreground View:

[149] For example, an opening might provide views to distant mountains or foreground views of a stream or wetland.

1. THO improves foreground views
2. No change
3. THO degrades foreground view

6. Overall Visual Rating
   a. Improves view
   b. Little visual change
   c. Moderate visual impact
   d. Severe visual impact

7. USFS Visual Rating
   a. Enhancement: Operation results in improvements to the visual quality of the landscape by adding diversity (e.g., adding plantings or opening up positive views).
   b. Preservation: Operation represents no discernible change to the forest landscape from viewing areas.
   c. Retention: Operation is barely discernible to an observer and would have very short-term impacts.
   d. Partial Retention: Harvesting activities that are visually subordinate to the surrounding landscape (i.e., appear as a very small part of the total view) and appear to fit reasonably well into the landscape (i.e., shape, size, and edge of cuts are not highly noticeable). Duration of impacts will be short (one to two years) beyond observation.
   e. Modification: Operation may be visually dominant (i.e., quite noticeable), but the cut does not strongly contrast with the surrounding landscape (e.g., moderate size openings that do not break the horizon line with natural edge transition).
   f. Maximum Modification: Operation is visually dominant, large openings but avoids negative features such as abrupt edge with bare tree trunks, distinct horizon line cut, or poor quality trees dominating open areas.
   g. Unacceptable Modification: Operation results in a view that is highly obtrusive and unsightly with strong contrasts with the surrounding landscape.

SAMPLE DATA TABLES USED TO RECORD VISUAL ASSESEMENT DATA:

Visual Impacts

Viewpoints Inventoried/Type of Public Resource	Distance from Viewer 1 2 3 4 5	Corridor Length/Size of Viewing Area	Area of THO Visible (acres)	Photograph Number(s)
1.				
2.				
3.				
4.				
5.				

Harvesting

Viewpoints Inventoried/Type of Public Resource	Size of Openings 1 2 3	Edge Transition 1 2 3	Edge Configuration 1 2 3	Horizon or Ridge Line 1 2 3	Stumps 1 2 3	Slash and Debris[1] 1 2 3	Exposed Earth[2] 1 2 3
1.							
2.							
3.							
4.							
5.							

[1] Note if slash used for stream crossing is visible from viewpoint. [2] Not including roads and landings which are addressed in another table.

Roads and Landings

Viewpoints Inventoried/Type of Public Resource	Visible (note road and/or landing) 1 2	Ground Appearance 1 2 3	Road Size 1 2 3	Alignment 1 2 3	Wood Chip Debris 1 2 3	Public Access 1 2
1.						
2.						
3.						
4.						
5.						

Wetlands and Streams

Viewpoints Inventoried/Type of Public Resource	Visible 1 2	Slash Left in or Adjacent to Wetland 1 2 3	Buffer 1 2 3
1.			
2.			
3.			
4.			
5.			

Views[1]

Viewpoints Inventoried/Type of Public Resource	Distant Views 1 2 3	Foreground View 1 2 3
1.		
2.		
3.		
4.		
5.		

[1]For example, an opening might provide views to distant mountains or foreground views of a stream or wetland.

Overall Visual Rating

Viewpoints Inventoried/Type of Public Resource	Overall Visual Rating 1 2 3 4
1.	
2.	
3.	
4.	
5.	

USFS Visual Ratings

Viewpoints Inventoried/Type of Public Resource	USFS Visual Rating 1 2 3 4 5 6 7
1.	
2.	
3.	
4.	
5.	

Appendix E: Browsing Site Conditions for Managed Northern Hardwoods

excerpted from *Deer Doing Damage to Land Managed for the Production of Marketable Forest Products:* Vermont Fish & Wildlife Department Working Group; Report to the Legislature, February 2012

Attachment A - BROWSING SITE CONDITIONS FOR MANAGED NORTHERN HARDWOODS

Site conditions by presence and life form of species under different browsing intensities

Tall Woody Species (3' to 15' saplings)	Low Intensity (*None to Light)	Moderate Intensity (Moderate)	Intensive Browsing Evidence of Regeneration Impacts (Heavy)	High Intensity Historically Intense Browsing (Severe)
	1	2	3	4
Condition of Forest	Diverse mix of tree saplings, shrubs, forbes, ferns, and grasses of varying heights. Little sign of browsing.	Preferred forage species show some signs of browsing, but not affecting height growth. No browse lines.	Unpalatable species show increase in density while others decline in number and occur in poor form. Mostly beech and striped maple and other unpalatable species in understory in stems >1 ft. in height.	In later stages, New York and hayscented ferns, sedges occupy opening as an almost complete mat with only occasional tree sapling showing. Browse line evident throughout forest. Mid-story if present dominated by 1 or 2 unpalatable woody species (black, birch, beech, red spruce, buckthorn, etc.).
White Ash Red Oak	Occasional sign of browsing.	Frequently browsed, reduced heights relative to other species.	Reduced density, all misshapen or hedged, few have any leaves remaining.	Absent or present as dead and dying whips.
Sugar Maple Yellow Birch	Occasional sign of browsing.	Light * to moderate browsing showing minor changes in form.	Heights impaired relative to unpalatable species.	"Hedged" in form.
Hemlock Balsam Fir	Unbrowsed except near DWAs.	Well formed, present at different heights. Browsing may be heavy near DWAs.	Obvious browsing of lower branches, some bark stripping.	Reduction in density noted, heavily browsed plants with poor form.
Striped Maple Black Cherry	Unbrowsed.	Browsing of some laterals and terminals.	Browsing impacting form on most stems.	Poor form and height suppression.
Beech Black Birch Ironwood	Unbrowsed.	No indication of browsing or light browsing only.	Light to moderate browsing especially on stump sprouts.	Moderate to heavy browsing on most plants. Reduction in density noted. Poor form and height suppression.
White Pine	Present, no sign of browsing.	No indication of browsing.	Browsing on some branches and terminals.	Reduction in density, most in poor form and height suppression.
Hobblebush Pin Cherry White Birch	Unbrowsed, common in understory.	Some branches browsed lightly – no reduction in density.	Most plants show browsing, reduction in density.	Plants sparse with poor form & height suppression.

*Relationship to DeCalesta/Forex		
Browse Assessment	DeCalesta	Forex
Low Intensity	Light	1 (Light)
Moderate Intensity	Moderate	2 (Moderate)
Intensive Browsing	Heavy	3 (Heavy)
High Intensity	Severe	3 (Heavy)

This rating system was designed cooperatively by The Woodland Owners Association, VT Dept. of Forest, Parks and Recreation and VT Fish & Wildlife Dept.

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Attachment A - BROWSING SITE CONDITIONS FOR MANAGED NORTHERN HARDWOODS

Site conditions by presence and life form of species under different browsing intensities

Short Woody Species (.5' to <3' Seedlings)	Low Intensity (*None to Light)	Moderate Intensity (Moderate)	Intensive Browsing Evidence of Regeneration Impacts (Heavy)	High Intensity Historically Intense Browsing (Severe)
	1	2	3	4
White Ash Red Oak	Light browsing to moderate.	Heavily browsed.	Seedlings and saplings >.5' mostly absent in understory. Some whips mostly lacking leaves.	Occurs only as (<.5') seedlings and as mature trees.
Sugar Maple Yellow Birch	Light browsing.	Light browsing, still well formed in short & tall woody forms.	Moderate browsing, some misshapen plants. Reduced density obvious.	Occur only as (<.5') seedlings and as mature trees.
Hemlock Balsam Fir	None to light browsing.	Light to moderate browsing.	Moderate to heavy browsing. Mostly misshapen plants.	Occur only as (<.5') seedlings and as mature trees.
Striped Maple	Not browsed.	None or light browsing.	Heavy browsing.	Severe browsing. Limited and poor form.
Beech Black Birch Ironwood	Not browsed.	Not browsed or areas with light browsing.	Light to moderate browsing on branches and terminal shoot.	Heavy to severe browsing or limited and poor form. Many misshapen plants.
White Pine	Not browsed.	Not browsed.	Frequent terminal shoot browsing.	Most browsed, lacking terminal shoot. Reduced density and poor in form.
Hobblebush	Unbrowsed to light, varying heights and density.	Light to moderate browsing, stems occur to waist height.	Suppressed heights and reduced density noted.	Limited in number. All poorly formed.
Rubus	None to light browsing. Present, varying heights.	Light to moderate browsing on current year's growth.	Moderate to heavy browsing. Reduction in density noted.	Severe browsing. Few present. All heavily browsed.

Herbaceous Layer	Low Intensity (*None to Light)	Moderate Intensity (Moderate)	Intensive Browsing Evidence of Regeneration Impacts (Heavy)	High Intensity Historically Intense Browsing (Severe)
	1	2	3	4
Orchids** Lilies	Present, flowering different heights.	Nearly absent, occasional species.	Rare.	Absent.
Asters** Twisted Stalk Wild Nettles Jewelweed Trillium Meadow rue	High density, mix of species of varying heights. Most flowering or possessing buds.	Moderately browsed. Some flowering stems. Low in height..	Low density, many browsed stems lacking flowering parts. Few flowering individuals.	Absent or rare.
New York & Hay-scented Ferns***	Infrequent in small patches.	Frequent in understory.	Forming dense patches.	High density to complete carpets that suppress other species.

** *In higher BA areas with little cutting in past.*
*** *In more recently cut or disturbed areas or areas with a history of overbrowsing*

Appendix F: AGS/UGS Definitions

Adapted from FSH 2409 21.d, GMNF supplement #16, 1979 and FIA Northern Core Field Guide 5.0, 2010

HARDWOOD TREE GRADES			
GRADING FACTORS	GRADE 1	GRADE 2	GRADE 3
Length of grading zone (ft)	Butt 16	Butt 16	Butt 16
Length of grading section[a] (ft)	Best 12	Best 12	Best 12
Minimum DBH (in)	16[b]	13	11
Minimum DIB at the top of the grading section (in)	13[b] 16 20	11[c] 12	8
Clear cuttings on 3rd best face[d]			
minimum length (ft)	7 5 3	3 3	2
number on face (max)	2	2 3	unlimited
yield in face length (min)*	5/6	4/6	3/6
Cull deduction, including crook and sweep but excluding shake, maximum w/in grading section (%)	9	9[e]	50

[a] Whenever a 14- or 16-ft section of the butt log is better than the best 12-ft section, the grade of the longer section will become the grade of the tree. This longer section, when used, is the basis for determing the grading factors, such as diameter and cull deduction.

[b] In basswood and ash, DIB at the top of the grading section may be 12-in and DBH may be 15-in.

[c] Grade 2 trees can be 10-in DIB at the top of the grading section if otherwise meeting suface requirements for small grade 1's.

[d] A clear cutting is a portion of a face free of defects, extending the width of the face. A face is one-fourth of the surface of the grading section as divided lengthwise.

[e] 15% crook and sweep, or 40% total cull deduction are permitted in grade 2 if size and surface of grading section qualify as grade 1. If rot shortens the required clear cuttings to the extent of dropping the butt log to grade 2, do not drop the tree's grade to 3 unless the cull deduction for rot is greater than 40%.

*Minimum Yield in Face Length			
Face Length	Grade 1 Min. Yield	Grade 2 Min. Yield	Grade 3 Min. Yield
12-ft	10-ft	8-ft	6-ft
14-ft	11.7-ft	9.3-ft	7-ft
16-ft	13.3-ft	10.7-ft	8-ft

Source: U.S.D.A. Forest Service Research Paper NE-333, 1976.

1. *An acceptable growing stock tree (AGS) is a commercial species less than rotation age with relatively good vigor, containing no pathogens that may result in the death or serious deterioration before rotation age and which contains, or has the potential of producing, merchantable sawtimber of USFS grade 3 quality or better (below).*

For white pine, AGS is as above, White Pine Sawtimber Tree Grade 2 or better (below).

EASTERN WHITE PINE TREE GRADES				
GRADING FACTORS	GRADE 1	GRADE 2	GRADE 3	GRADE 4
Minimum DBH (in)	9	9	9	9
Length of grading zone (ft)	Butt 16	Butt 16	Butt 16	Butt 16
Length of grading section (ft)	Best 12	Best 12	Best 12	Best 12
Maximum weevil injury in butt 16 ft (number)	None	None	2 Injuries	No limit
Minimum face requirements on grading section	Two full length or four 8-ft 50% length good faces[1]. (In addition, knots on balance of faces shall not exceed size limitations for Grade 2 sections.)	NO GOOD FACES REQUIRED. Maximum diam-eter of knots on 3 best faces: **SOUND RED KNOTS** not to exceed 1/6 of scaling diameter or 3-in maximum[2]. **DEAD OR BLACK KNOTS**, in-cluding over-grown knots, not to exceed 1/12 scaling diameter and 1-1/2-in maximum.	NO GOOD FACES REQUIRED. Maximum diam-eter of knots on 3 best faces: **SOUND RED KNOTS** not to exceed 1/3 of scaling diameter of 5-in maximum[2]. **DEAD OR BLACK KNOTS**, in-cluding over-grown knots, not to exceed 1/6 scaling dia-meter and 2-1/2-in maximum.	Includes all trees not qualifying for Grade 3 or better and judged to have at least 1/3 of their gross volume in sound wood suitable for manufacture into standard lumber.
Maximum sweep or crook in *grading section* (%)	20	30	40	No limit
Maximum total scaling deduction in *grading section* (%)	50	50	50	No limit

After the tentative grade of the section is established from face examination, the section will be ***reduced one grade*** whenever the following defects are evident[3]:

CONKS, PUNK KNOTS AND PINE BORER DAMAGE ON THE SURFACE OF THE SECTION

Degrade one grade if present on one face.
Degrade two grades if present on two faces.
Degrade three grades if present on three to four faces.

If the final grade of the grading section is 1, 2 or 3, examine the tree for weevil injuries in the merchantable stem ***above*** 16-ft. If the total apparent weevil damage exceeds 3, degrade the tree grade one below the section grade[3]. Otherwise the tree grade is the same as the final section grade.

[1] Trees under 16-in DBH require four 8-ft full length good faces.
[2] Scaling diameter is estimated at the top of the grading section.
[3] No tree will be designated below Grade 4 unless net tree scale is less than one-third of gross tree scale.

Note: The hi-lighted text indicates NRS modification from the original EWP Tree Grade Table (U.S.D.A. Forest Service Research Paper NE-214, 1971).

For other softwoods, AGS is as above, FIA 'Other Softwoods' Grade 1 (below).

OTHER SOFTWOODS Minimum Merchantability Specifications for Grade 1 Grade the best 12 ft within the 1st 16 ft.[1]					
Grade	**DIB at the top of the grading section**	**Length (2-ft multiples w/o trim)**	**Total Deduction**	**Sweep Permitted**	**Other Requirements***
1	6" - 12"	12' - 16'	50%	25%	Sound knots not over 2" in diameter are permitted.
	13" +	12' - 16'	50%	25%	Sound knots not over 3" in diameter are permitted.

[1] When ever a 14-ft or 16-ft section of the butt log is better than the best 12-ft section, the grade of the longer section will become the grade of the tree. This longer section, when used, is the basis for determining the grading factors, such as DIB and sweep.

* One branch or sound knot that exceeds the diameter limitations is permitted to meet Grade 1 specifications. This is a Northern allowance. Sound knots are measured at the point where the limb would normally be trimmed from the main stem.

Note: The hi-lighted text indicates NRS modification from the original specifications from the Northeast Field Guide, Version 3.0. The above specifications are based on a log grade. Tree grades have never been developed for these other softwood species that include spruce, fir, hemlock, larch (tamarack), cypress and cedar.

2. *An unacceptable growing stock tree (UGS) is a tree (mature or immature) which will not grow or prospectively meet AGS standards primarily because of roughness, poor form, or non-commercial species.*

Appendix G: Crown Health Measurements

LIVE CROWN RATIO is a percentage determined by dividing the live crown length by the actual tree length. LIVE CROWN RATIO for leaning and down trees must be rated in relation to the actual length of the tree bole (as opposed to height above the ground.) A clinometer can also be used to verify the LIVE CROWN RATIO by determining the values of both lengths and determining the ratio of the two values. Once calibrated, you can estimate LIVE CROWN RATIO. Trees with less than one third live crown ratio are considered less healthy, so in this assessment, LCR is recorded in 2 categories: ≥35%, or < 35%.

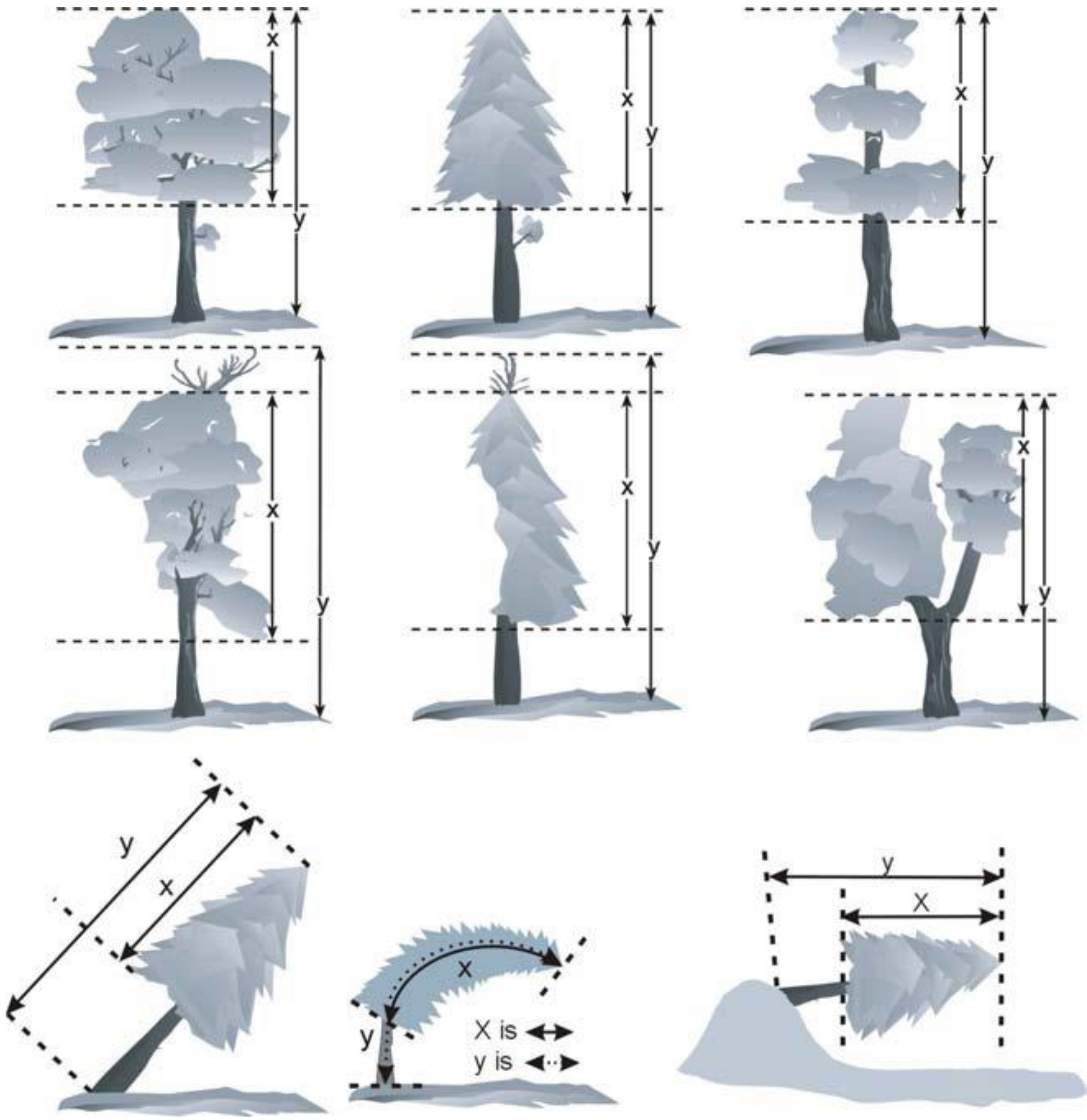
Trees

Live crown length is the distance from the live crown top (dieback in the upper portion of the crown is not part of the live crown) to the "**obvious live crown**" base. Many times there are additional live branches below the "obvious live crown." These branches are only included if they have a basal diameter greater than 1.0 inch and are within 5.0 feet of the base of the obvious live crown. The live crown base becomes that point on the main bole perpendicular to the lowest live foliage on the last branch that is included in the live crown. The live crown base is determined by the live foliage and not by the point where a branch intersects with the main bole. Occasionally, small trees or certain species may not have 1.0-inch diameter branches. If this occurs, use the 5.0-foot rule, and apply it to branches that you feel contribute significantly to tree growth.

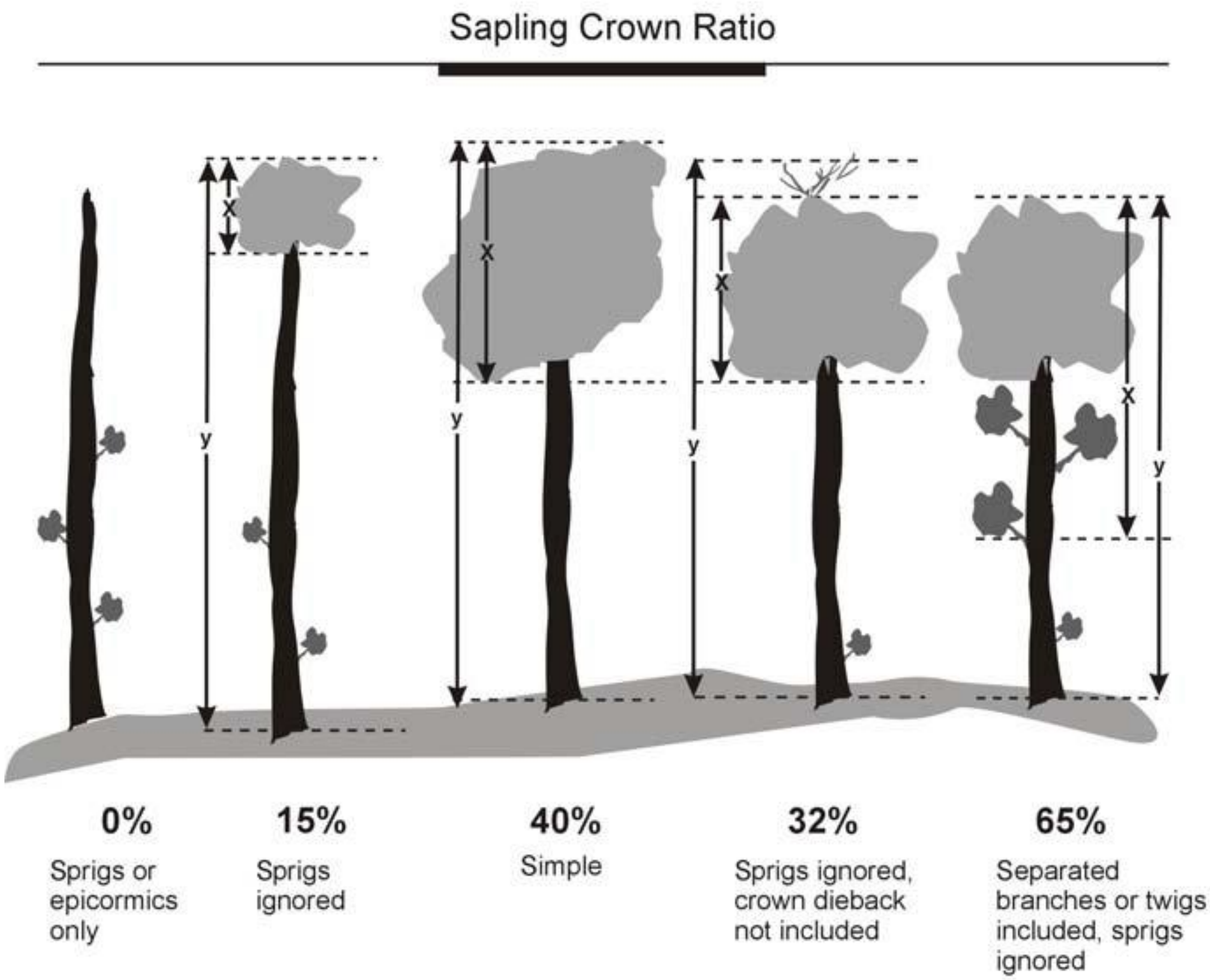
Saplings

Determine sapling LIVE CROWN RATIO by dividing the live crown length by actual tree length, then enter the appropriate code into the PDR. Live crown length is the distance between the top live foliage (dieback and dead branches are not included) and the lowest live foliage on the lowest live twig for saplings. Be sure to eliminate vine foliage as best you can when determining the live crown. The live crown base for saplings is different from trees 5.0 inches DBH/DRC and larger. The 5-foot/1-inch rule does not apply in this case. Do not include sprigs or leaves on the main stem below the lowest live twig.

LIVE CROWN RATIO examples:



Sapling LIVE CROWN RATIO determination examples.



CROWN DIEBACK estimates reflect the severity of recent stresses on a tree. Estimate CROWN DIEBACK as a percentage of the live crown area, including the dieback area. The crown base should be the same as that used for the LIVE CROWN RATIO estimate (suppressed lower branches are not considered in either LCR nor dieback). Assume the perimeter of the crown is a two-dimensional outline from branch-tip to branch-tip, excluding snag branches and large holes or gaps in the crown. Project a two-dimensional crown outline, block in the dieback and estimate the dieback area. When the cause for dieback is clearly due to breakage, it is not considered dieback. Three categories of dieback are used in this study, 0-15% crown dieback, 16-50%, and >50% (corresponding to healthy, uncertain recovery, most likely to further decline).

CROWN DEFINITIONS

Crown Top
The crown top is the highest point of a standing tree. Young trees usually have more conical-shaped crowns and the main terminal is the top. Older trees and many hardwoods have globose and flat-topped crowns, where a lateral branch is the highest point. For some measurements the highest live foliage is considered the live crown top. Other measurements include a dead top. Some crown measurements assess how much of the expected crown is present and include broken or missing tops.

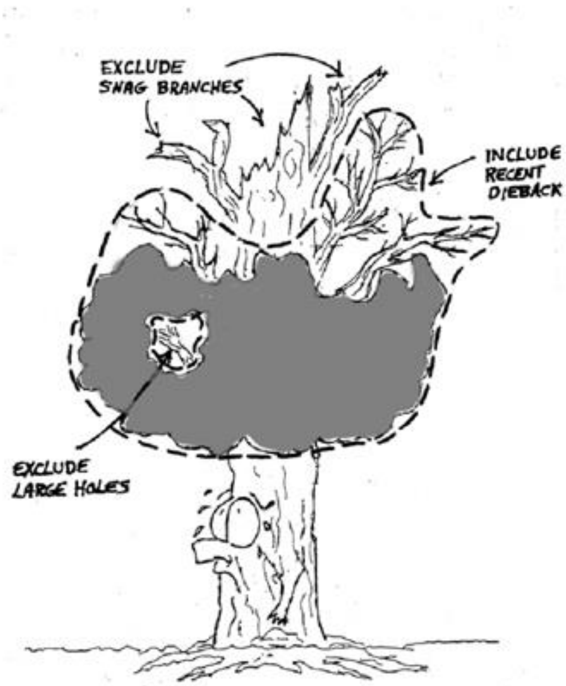
Dieback
This is recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Dieback is only considered when it occurs in the upper and outer portions of the tree. When whole branches are dead in the upper crown, without obvious signs of damage such as breaks or animal injury, assume that the branches died from the terminal portion of the branch. Dead branches in the lower portion of the live crown are assumed to have died from competition and shading. Dead branches in the lower live crown are not considered as part of crown dieback, unless there is continuous dieback from the upper and outer crown down to those branches**.**

Epicormic
Shoot growth, from latent or suppressed buds, that arises from old branches, from the trunk or near large branch wounds or breaks. Epicormics remain epicormics until they regain the size of previous branches for trees with no branches 1.0 inch or larger in diameter at the base above the swelling. For trees that had 1.0 inch or larger branches when the epicormics formed, epicormics become branches once they reach 1.0 inch in diameter.

Live Branch
A live branch is any woody lateral growth supporting foliage, and is 1.0 inch or larger in diameter at the base above the swelling where it joins a main stem or larger branch. Small trees or certain tree species greater than 5.0 inches DBH/DRC may have only live twigs which have not yet reached 1.0 inch or larger at the point of attachment. If the death of larger branches is not the cause of these twigs, the twigs are considered branches for these smaller branched trees until the tree matures to a point where twigs have attained 1.0 inch or larger in diameter at the base above the swelling where it joins a main stem or larger branch.

Live Crown Base
The live crown base is an imaginary horizontal line drawn across the trunk from the bottom of the lowest live foliage of the **"obvious live crown"** for trees and from the lowest live foliage of the lowest twig for saplings. The "obvious live crown" is described as the point on the tree where most live branches/twigs above that point are continuous and typical for a tree species (and/or tree size) on a particular site. Include most crown branches/twigs, but exclude epicormic twigs/sprigs and straggler branches that usually do not contribute much to the tree's growth. The base of the live branch/twig bearing the lowest foliage may be above or below this line.

For trees 5.0 inches DBH or greater, if any live branch is within 5 feet below this "obvious live crown" line, a new horizontal line is established. Create the new line at the base of live foliage on that branch. Continue this evaluation process until no live branches are found within 5 feet of the foliage of the lowest qualifying branch (Figure 12-1).


EXCLUDE
SNAG BRANCHES
INCLUDE
RECENT
DIEBACK
EXCLUDE
LARGE HOLES

Occasionally, all original major crown branches/twigs are dead or broken and many new twigs/sprigs develop. These situations are likely to occur in areas of heavy thinning, commercial clearcuts and severe weather damage:

- Trees that had an "obvious live crown" with live branches now have no crown to measure until the new live twigs become live branches. When these new live branches appear, draw the new live crown base to the live foliage of the lowest live branch that now meets the 5-foot rule.
- Saplings and small trees that had only live twigs should establish the crown base at the base of the live foliage on the new lowest live twig. If no live twigs are present, there is no crown to measure.

Snag Branch
A dead upper crown branch without twigs or sprigs attached to it. A lower branch on woodland trees such as juniper is not considered a snag branch unless the branch reaches into the upper crown, or reached into the upper crown when the branch was alive. A branch that died due to shading in any crown is not a snag branch.

Sprig
Any woody or non-woody lateral growth, without secondary branching, less than 1.0 inch in diameter at the base above the swelling at the point of attachment to a branch or crown stem.

Twig
Any woody lateral growth, with secondary branching, less than 1.0 inch in diameter at the base above the swelling at the point of attachment to a branch or crown stem.