Developing Woody Biomass Retention Guidelines in Maine

Jeffrey G. Benjamin[1], Donald J. Mansius[2], Kate Albert Read[3]

Abstract

Woody biomass retention guidelines have been developed for Maine's forest industry as part of a two-year effort led by the University of Maine, Maine Forest Service, and the Trust to Conserve Northeast Forestlands. The initiative involved a multi-stakeholder consultation process and a review of scientific studies relevant to impacts from biomass harvesting. The objectives of this paper are to: 1) describe the guideline development process, 2) summarize the final guidelines, and 3) identify future work related to implementation.

The guidelines are intended for use by loggers, foresters, and landowners to protect soil, water quality and biodiversity on timber harvesting sites in Maine. They can be adapted and included in site-specific recommendations developed by a licensed forester and they are intended to inform the landowner's decision-making while reviewing the forester's prescription. Most importantly, implementation of these practices on the ground depends on the professional judgment, knowledge, and skill of the logger conducting the harvest operation. Every acre of forest cannot be managed the same way and the guidelines should not be interpreted in that manner. The guidelines address elements of forest structure related to soil, water quality, and biodiversity. These elements include snags, wood of all sizes left on the forest floor, live cavity trees and mast-producing trees. The guidelines are applicable to any harvest operation, but they may be of greatest importance on harvests where woody biomass is a significant component of the product mix.

[1] Corresponding Author: Assistant Professor of Forest Operations, University of Maine, 5755 Nutting Hall, Orono ME 04469, email: jeffrey.g.benjamin@maine.edu
[2] Director of Forest Policy and Management, Maine Forest Service
[3] Formerly with the Trust to Conserve Northeast Forestlands

Introduction

Federal energy policies to reduce dependence on foreign oil have created opportunities to produce energy from wood. These initiatives prompted some states, such as Minnesota and Wisconsin, to develop woody biomass harvesting guidelines to proactively address environmental concerns with increased harvest levels. Harvest of woody biomass in Maine is not a new concept. In fact, bioenergy facilities that produce electricity by burning wood are common throughout the state and many have been in operation since the 1980s. Some are stand alone facilities and others are integrated within pulp and paper mills. During that time, guidelines specific to woody biomass harvesting were missing from existing best management practices and regulations.

There has also been an increase in wood-for-energy initiatives throughout Maine over the last few years. In fact, biomass chip harvests have increased dramatically since 2000 (Figure 1) and that trend is expected to continue given plans for new and expanded capacity in the region for wood pellets, bioenergy, and bioproducts. We do not know the impact these new initiatives will have on wood supply, but it is certainly possible that competition for raw material between wood-using facilities will increase. Increased competition may impact harvest levels through shorter rotations, or increased use of small diameter and poor quality stems. This may create opportunities for timber stand improvement by combining such harvests with conventional forest management and silvicultural treatments. Regardless of the outcome, there is concern that these and other related activities will put more pressure on our forests (Benjamin *et al.* 2009, Marciano *et al.* 2009).

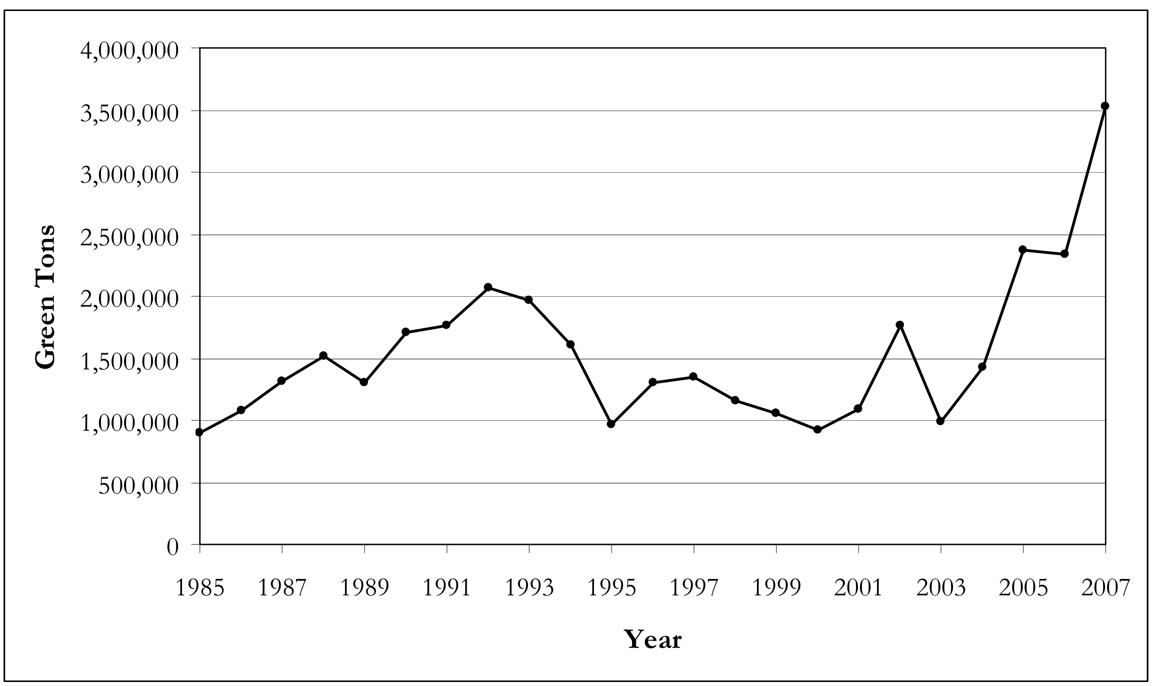

Figure 1. Historic biomass chip harvest levels in Maine (Maine Forest Service 2008).

In 2007, an initiative led by the University of Maine, in collaboration with the Maine Forest Service, and the Trust to Conserve Northeast Forestlands, was undertaken to proactively address some environmental concerns related to biomass harvests within Maine's forest industry. The goal was to develop a set of voluntary guidelines to assist loggers, landowners, and foresters in protecting soils, water quality, and forest biodiversity with respect to retention of woody biomass during forest operations. The objectives of this paper are to: 1) describe the guideline development process, 2) summarize the final guidelines, and 3) identify future work related to implementation.

Development Process

The initiative involved a multi-stakeholder consultation process representing views of foresters, landowners, wood using facilities, loggers, and conservation groups. A technical committee was established to review scientific studies relevant to environmental impacts associated with biomass harvesting. This review formed the basis of a technical report from which specific guidelines for woody biomass retention were developed. External reviews were conducted by respected professionals working in the fields of soil science, water quality and biodiversity. This was an iterative process between all parties and many versions of the document were circulated and reviewed during the course of the work. The final guidelines represent the collective effort of many individuals with often diverse perspectives of Maine's forest industry. As a result, not everyone is in agreement with all aspects of the recommendations, but the work was undoubtedly improved with the consultative approach. Final deliverables included a technical report to provide context for the project and to summarize findings from the literature review, and a brochure-style summary of the site-specific guidelines[4].

Summary of Guidelines

Scope

The first challenge for the technical committee and stakeholders was to establish the scope of work. Throughout the process decisions were made regarding definitions, target audience, scale (site-level or landscape), focus (harvest or retention), and format (prescriptive or general). Woody biomass was defined from a forest operations perspective to be comprised of logging residues, previously un-merchantable stems, and other such woody material harvested directly from the forest typically for the purposes of energy production. Harvest of woody biomass is often integrated with traditional forest operations, so it can be difficult to isolate effects of woody biomass removals at a site level. As such, it is important to consider retention of woody biomass during all harvest activities and to emphasize post-harvest site condition rather than the amount of any given product removed during harvest.

[4] Refer to the publications link at: www.forest.umaine.edu/faculty-staff/directory/jeffrey-benjamin/

In their final form, the guidelines focus on the amount and type of woody biomass that should be retained in the forest after a harvest operation to protect soil productivity, water quality, and site-level biodiversity.

Every acre of forest cannot be managed the same way and the guidelines should not be interpreted in that manner. The guidelines address elements of forest structure including snags, wood of all sizes left on the forest floor, live cavity trees and mast-producing trees. Although the guidelines are applicable to any harvest operation, they may be of greatest importance on harvests where woody biomass is a significant component of the product mix. Fundamentally, logging contractors do not treat woody biomass differently than other forest products – it is simply another product sorted at the landing – so the same general principles of forest operations apply.

Recommendations for retention of woody biomass should be used in conjunction with rules and regulations, environmental standards, and best management practices already established for traditional operations. These practices and policies can be adapted and included in site-specific recommendations developed by a licensed forester, so the guidelines developed in this project are intended to inform the landowner's decision-making as they review the forester's prescription. Most importantly, implementation of these practices on the ground depends on the professional judgment, knowledge, and skill of the logger conducting the harvest operation. These guidelines are intended to be used by loggers, foresters, and landowners in this context.

Soils

A review of scientific literature related to forest soils was conducted with particular emphasis on soil productivity studies from the northeastern region of the United States. Several long-term studies – including Hubbard Brook Experimental Forest in New Hampshire and the Weymouth Point Study Area in Maine – formed the basis of the review (Likens *et al.* 1970, Smith *et al* 1986, Hornbeck *et al.* 1990). The review summarized nutrient and biomass distribution in trees, and highlighted short-term and long-term effects of whole-tree harvesting on nutrient depletion. The following section highlights the key findings related to soil productivity and a complete list of soil related guidelines is provided in Appendix A.

Forest soils are complex biological, chemical, and physical systems. Soil productivity is directly related to nutrient availability which depends on factors such as minerals in the parent material, rates of mineral weathering, leaching losses and erosion, past land use, atmospheric deposition, vegetation composition, rotation length, rate of tree growth and harvest intensity. Nutrient amounts removed in biomass from whole-tree operations are much greater than nutrient amounts removed from conventional stem-only harvesting. This is because, as shown in Figure 2, nutrient concentrations are much higher in branches and particularly in needles and leaves, and therefore a much larger portion of the total biomass nutrients is removed when branches and foliage are included in the harvest removal (Young and Carpenter 1976). The more fine woody material that is left on site during harvest operations, the less risk there is to long-term soil productivity.

Not all soils are created equal. Higher quality forest sites tend to have a higher natural nutrient supply and they cycle nutrients more rapidly. The greater the nutrient supply, and the faster the rate of nutrient transformation into available forms, the lower the risk that harvesting will reduce soil productivity as long as there are no other limiting factors of greater importance on the site. This means that for a given level of biomass retention, the risk to soil productivity is lower on higher quality sites.

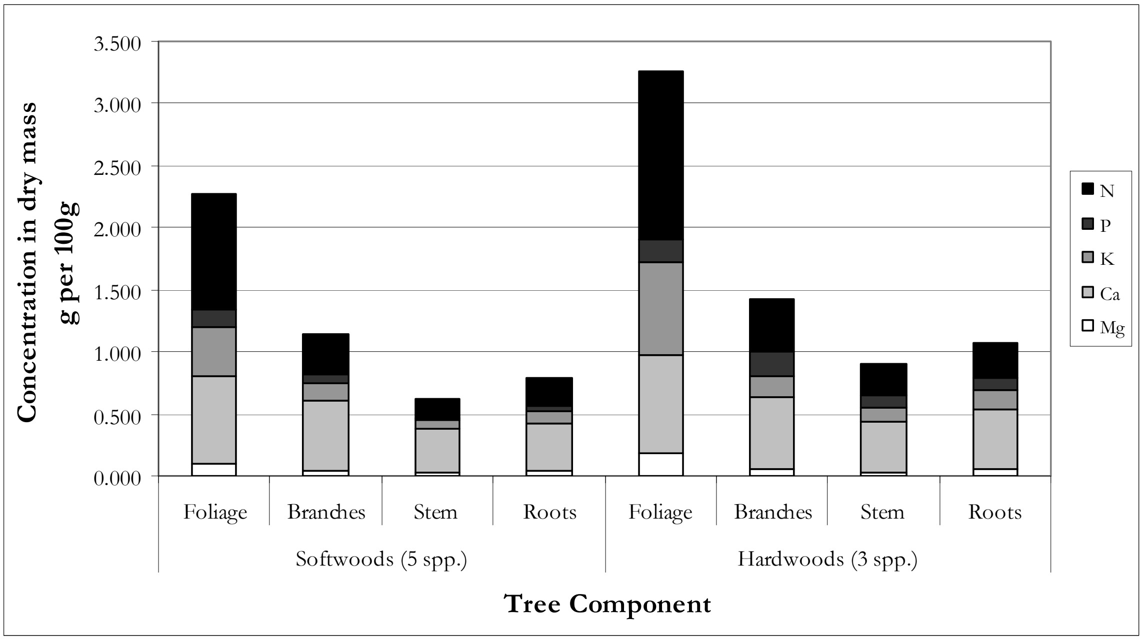

Figure 2. Average concentration of macro-nutrients in foliage, branches, stems, and roots of young hardwood and softwood species in Maine (*Young and Carpenter 1976*).

Forest soils produce excess nutrients through mineral weathering and organic matter decomposition as part of the natural function of the soil, and these excess nutrients beyond vegetation requirements are typically leached from the site. Increased nutrient removals through harvesting that are less than or equal to these excess nutrients should not alter forest site productivity. If harvesting results in nutrient removals that exceed these excesses, then forest soil nutrient availability will decline. By avoiding the intensification of biomass removals on soils with characteristics that suggest limited nutrient amounts (e.g., shallow soils) or slow rates of nutrient supply (e.g., sandy soils), we also avoid the risk of reducing site productivity through harvesting. Although it is possible to restore nutrient supply in a forest soil in some circumstances by increasing rotation length or altering species composition, short-term improvements in nutrient availability can only be achieved through the application of fertilizers, biosolids, or other soil manipulations.

In conducting research for this section, it was found that most of the studies on whole-tree harvesting utilize the method of whole-tree clearcutting. Yet, less than 5% of harvests in Maine were categorized as clearcuts or land use changes between 2002 and 2007 (Maine Forest Service 2009). Clearcutting represents a more severe disturbance and maximizes soil nutrient loss through increased soil leaching and erosion. Therefore, the results of soil productivity studies focusing on whole-tree clearcut harvesting may suggest a more severe impact than the current silviculture systems currently employed in Maine (e.g. thinning and partial harvests). On the other hand, while clearcutting may represent a larger overall disturbance to a site, partial harvesting, in general, allows more wood to be extracted in a given period of time because partial cuts do not require buffers or separation zones (Hagan and Boone 1997). It is likely, however, that whole-tree clearcutting provides the most conservative basis with which to judge the environmental impacts of increased biomass harvesting since all merchantable vegetation is removed from the site. Therefore, while the results of these studies are severe, they are still relevant in illustrating the relationship between amounts of biomass extraction and nutrient retention.

Water Quality

The Maine Forest Service's Best Management Practices for Forestry is a program that focuses on education, outreach, and voluntary measures to protect water quality during timber harvesting activities (Maine Forest Service 2004). The program now includes monitoring protocols to determine the use and effectiveness of BMPs on timber harvesting operations within the state. As shown in Table 1, recent years have shown significant improvement in BMP use and effectiveness. In 2000, BMPs were not used on 25% of harvests, but by 2008 compliance increased by close to 20% in total.

Table 1. Comparison of BMP use from 2000 to 2008 (*Maine Forest Service 2009*).

Reporting Period	Sampling Units	Appropriate BMP Use (%)	Non-application of BMPs (%)
2000-2001	181	41	25
2001-2003	288	52	8
2005	102	79* (92**)	4* (6**)
2006-2007	252	77*	4* (2**)
2008	122	72* (92**)	4* (2**)

* Crossings ** Approaches

Due to the success of the water quality program in Maine, this section of the guidelines only serves as a reminder about several important aspects of water quality as it relates to the amount of woody biomass retained on harvesting sites, but it is not intended as a replacement of existing Water Quality BMPs. In one of the few studies directly related to the impact of woody biomass harvesting on water quality, Shepard (2006) concludes that since woody biomass is often harvested in conjunction with other round wood forest products, existing BMPs for any harvest can be followed to protect water quality. A complete list of water related guidelines is provided in Appendix A.

The University of Maine has been involved with water quality research for many years. In 1996, the Water Research Institute prepared a report for the Maine Department of Environmental Protection to review the effects of forest practices on water quality in Maine (Kahl 1996). That same year, the Cooperative Forestry Research Unit also completed a literature review of forestry related non-point source pollution in Maine (Stafford *el al.* 1996). Both Kahl (1996) and Stafford *et al.* (1996) closely examined the impact of forest practices in relation to water quality and also the use of best management practices to mitigate undesirable consequences. They focused primarily on regional studies that were applicable to Maine including the Hubbard Brook Experimental Forest in New Hampshire and the Weymouth Point Study Area in Maine. Both reports provide detailed descriptions of the relationships between harvest practices and many issues important to water quality including site disturbance, hydrology, nutrient cycling, stream temperature, and stream flow. Kahl (1996) in particular points out that the level of site disturbance from harvest activities is related to both harvest intensity and compliance with best management practices, but in general harvesting has the potential to reduce long-term site productivity as well as to decrease water quality. He summarizes that harvesting impacts nutrient cycling and water quality in three ways due to removal of nutrients in the harvested material, decreased uptake of nutrients and water, and changes to biogeochemical processes. The latter is linked to increased runoff of nutrients and sediment caused by soil compaction, rutting, increased stream temperature, and altered hydrology. None of these issues are unique to woody biomass harvests, rather they apply to timber harvesting in general, so as long as water quality BMPs are followed there should be no additional impact with woody biomass removals.

Forest Biodiversity

Timber harvesting can be a tool used to manage wildlife habitat values and, if carefully planned, it is compatible with most aspects of biodiversity. As with other forest resources, the potential risk to biodiversity increases with the amount and type of woody biomass removed from a site and with the frequency of such removals (Whitman and Hagan 2007, Vaillancourt *et al.* 2008). Therefore, high rates of woody biomass removal can negatively affect forest biodiversity. The following section highlights the key findings related to forest biodiversity and a complete list of soil related guidelines is provided in Appendix A.

For this section, an emphasis was placed on studies that identified the impact of woody biomass harvesting on biodiversity. Many studies are concerned that biomass harvesting will lead to agriculture-like conversions of forestlands or levels of harvesting that will extensively alter current habitat conditions. Much research has been conducted over the last 20 years in regard to forest biodiversity specific to the northeast United States, but it also covers highly diverse regions such as tropical rainforests and old growth forests (Hansen *et al.* 1991, Putz *et al.* 2001) and recent studies of forest structure from other geographic regions like the Pacific Northwest (Dunk and Hawley 2009), Canada (Vaillancourt 2008), and Nordic countries (Roberge *et al.* 2008). As important as those issues are, only a small number of papers were found that attempted to postulate the impacts to biodiversity from woody biomass harvesting specifically.

It is also important to place forest management concerns related to biodiversity into context with the existing forest industry in Maine. Between 2002 and 2007, over 50% of all harvests were conducted as partial harvests, and less than 5% were categorized as clearcuts or land use changes (Maine Forest Service 2009). Maine's forest industry also relies heavily on natural regeneration. An average of 40% of all harvests between 2002 and 2007 were classified as shelterwood harvests (Maine Forest Service 2009), and between 1996 and 2007 less than 2% of harvested acres were planted (Maine Forest Service 2009). Clearly Maine has not succumbed to vast agriculture-like conversions of forestland into monoculture energy plantations even with an energy wood market since the 1980s.

The amount and type of woody biomass removed from a harvest site is highly dependent on the harvest method and equipment used. Whole-tree harvesting is the dominant harvest method in Maine with over 85% of harvested areas using ground-based skidding systems in the last four years (Benjamin 2009). Although this type of harvest delivers tops and limbs of merchantable trees to roadside for processing into energy wood, the amount of timber removed from a site varies with silvicultural prescription and landowner objectives. The equipment in use today is not designed to efficiently handle and process small diameter stems, snags, or other such downed woody material which has been described earlier to hold special habitat value. Specialized woody biomass accumulation technologies are commercially available and include slash bundlers, residue compaction units, and mobile chippers, but to date their use has not proven to be cost effective in Maine.

Notwithstanding the observations made in the previous two paragraphs, timber harvesting in Maine, and removal of woody biomass in particular, does have implications on forest biodiversity. The goal of this section is to highlight the important aspects of woody biomass as it relates to forest biodiversity and to remind practitioners to plan harvests with those features in mind. Fortunately, much work has already been completed for the forests of Maine in this regard. Woody biomass harvesting practices will have to comply with established recommendations for biodiversity as defined for non-biomass harvests.

A comprehensive manual outlining recommended guidelines for maintaining biodiversity in the forests of Maine was originally published by Flatebo *et al.* (1999) and many of the general recommendations in Appendix A were summarized from the updated version by Elliot (2008). One of the primary goals for biodiversity in Maine's managed forest is to ensure that adequate habitat is present to maintain viable populations of native plant and animal species. Recommendations are written for site-specific characteristics covering five stand characteristics and 10 special habitats and ecosystems (including riparian and stream ecosystems, vernal pools, beaver-influenced ecosystems, woodland seeps and springs, nesting areas for colonial wading birds, deer wintering areas, nesting sites for woodland raptors, old-growth and primary forests, rare plant or animal sites, and rare natural communities). Stand-level recommendations are related to vertical structure and crown closure; native species and composition; downed woody material, snags, and cavity trees; mast; and forest soils, forest floor and site productivity.

The guidelines by Elliot (2008) also address landscape-level considerations which focus on patterns, processes and linkages across landscapes and regions. They address the distribution of native forest communities, age structure of the landscape, habitat patch size, habitat connectivity, disease agents, insects, pests, and weeds. The guidelines also address two land-use issues: public access and roads, and conversion to non-forest use. The manual provides a clear definition of each element targeted for conservation, provides a rationale for its importance to biodiversity, and presents recommended practices. Both versions of Maine's biodiversity guidelines (Flatebo *et al.* 1999, Elliot 2008) generally focus on what is being retained in the forest after a harvest, so they are as applicable to woody biomass harvesting as they are to traditional round wood operations.

All timber harvesting can affect wildlife habitat, but the key concern is whether impacts are significant at the landscape level and biological indicators are important tools for measuring forest biodiversity in this regard. Hagan and Whitman (2006) point out however, that although science can direct selection of biological indicators, it is still weak in selecting specific target levels. Elliot (2008) also describes significant challenges to setting specific targets at the site-level. For this region, stand-level targets for forest structure have been established based on expert opinion. For example, Elliot (2008) recommends retaining *"a minimum of four secure cavity trees or snags per acre, with one exceeding 24 inches dbh and three exceeding 18 inches dbh"*. Specific size classes for downed logs are also suggested to be *"greater than 12 inches dbh and greater than 6 feet in length"*. These, and other regional targets, are qualified by statements indicating it is not always possible or appropriate to manage the habitat requirements for all species in all areas at the same time and that some management practices can conflict with each other. Stand-level application of those guidelines is left to the forest practitioner. Since there is not widespread acceptance of those guidelines within Maine's forest industry, specific targets for maintenance of site-level biodiversity were not included in Maine's biomass guidelines.

Implementation

A deliberate effort was made to avoid prescriptive language as the guidelines were developed, so the challenge now becomes how to implement the guidelines. Even though detailed retention targets of a certain number of stems per acre would have been easier to implement and audit, scientific evidence is lacking in that regard. Forest practitioners (including loggers and landowners) must find different ways to implement the concepts addressed in the guidelines during harvest operations. The key to this approach is planning. They must develop a pre-harvest plan that considers critical elements related to retention of woody biomass. Plans may include avoiding biomass removals on some portions of the harvest block, retention of critical habitat areas identified by cavity trees, creation of downed wood during harvest activities, and use of brush in trails for erosion prone locations. These issues must be handled on a site by site basis.

Several organizations in Maine are incorporating the guidelines into existing training and education programs for loggers, family forest owners, and foresters. Some of these groups include: the State Implementation Committee for SFI, the Maine Forest Service, the Certified Logging Professional Program, Master Logger Certification Program, and the Small Woodland Owners Association of Maine.

Conclusions

The recently developed woody biomass retention guidelines for Maine summarize key issues related to soil productivity, water quality and forest biodiversity in the context of an existing biomass industry. Maine is fortunate to have long-term soil studies, successful BMPs for water quality, and extensive research on forest biodiversity. Even with all of that information, it is still left to the forest practitioner to make site-level decisions and these guidelines serve as reminders for what is important in that regard with respect to woody biomass.

Acknowledgements

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Appendix A

List of Woody Biomass Retention Guidelines for Maine

General Recommendations

Develop a site-specific harvest plan that addresses the forest values identified in this brochure. Publications and programs, such as the Water Quality BMPs, Master Logger Harvest Integrity System, and the Certified Logging Professional Program, can provide general pre-harvest planning guidance. Contact your local MFS District Forester for on-the-ground assistance. Call 1-800-367-0223, or visit www.maineforestservice.gov, for more information.

• Follow all applicable regulations and Water Quality BMPs.

• Strive to optimize utilization and value of all products removed from each site. For example, it is worth considering whether tops, limbs or other woody material has greater value on a trail to prevent erosion or on the landing as biomass chips.

Soil Productivity

Except where scarification of the soil is important for regeneration, leave the litter layer, stumps, and roots as intact as possible. Wood decaying on the ground, especially tops and limbs, contributes nutrients that help build up the growth potential of the soil.

• Leave as many tops and branches as possible on: low-fertility sites, shallow-to-bedrock soils, coarse sandy soils, poorly drained soils, steep slopes, and other erosion-prone sites.

Water Quality

The Water Quality BMP manual describes many fundamental approaches to protect water quality on harvest operations. These include anticipating site conditions, controlling water flow, and stabilizing exposed soil.

• In particular the Water Quality BMP manual highlights that:
  – disturbance of the forest floor should be minimized;
  – woody biomass may be used to control water flow, to prevent soil disturbance, and/or to stabilize exposed mineral soil, especially on trails and the approaches to stream crossings; and
  – woody biomass used for erosion control and soil stabilization may be left in place, if it is above the normal high water mark of streams or other water bodies.

Forest Structure

Wood of all sizes provides a range of habitats for other organisms that are essential to a fully productive forest.

• **Leave as much dead wood on site as possible.**

– Leave as many snags standing as safety and access will permit.

– Leave any felled snags in place.

– Limit disturbance to existing down logs.

– If large woody material is lacking on the ground, consider leaving some newly-cut logs scattered throughout the harvest area.

– Large woody material can be created over time by retaining all snags possible and leaving some large trees to die.

• **Leave some live wildlife trees.**

– Retain live cavity trees on site. Cavity trees are live trees with holes, open seams or hollow sections that wildlife can use.

– Leave live trees with rot when cavity trees are not available.

• **Leave some mast producing trees.**

– Species such as oak, beech, apple, black cherry, pin cherry, hickory, and raspberry produce valuable food for many wildlife species.

• **Vary the amount of snags, down logs, and wildlife trees across the harvest area.**

– Stream buffers, retention patches and other protection zones provide an opportunity to leave more large trees than may be possible in other harvest areas.

– Leaving lightly cut or un-cut patches in heavy harvest areas yields more biodiversity benefits than widely dispersed single trees.

– The larger the retained patch, the greater the benefit to sensitive understory species.

• **Leave as much fine woody material as possible.**

– Where possible and practical (depending on harvest method and system) retain and scatter tops and branches (fine woody material) across the harvest area.

– If trees are delimbed at roadside, haul a portion of the tops and limbs back into the woods. Leave the material along skid trails if carrying it off the trail would cause greater damage.