

# Forest Biomass Retention and Harvesting Guidelines for the Southeast

by the Forest Guild Southeast Biomass Working Group



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February 2012

Forest Guild Southeast Biomass Working Group included the following members:

**Josh Dickinson**, Forest Trust, Florida  
**Amadou Diop**, National Wildlife Federation, Alabama  
**Alex Finkral**, Forest Land Goup, North Carolina  
**John Fenderson**, National Network of Forest Practitioners, Tennessee  
**Dave Halley**, True North Forest Management Services, North Carolina  
**Greg Meade**, The Nature Conservancy, Virginia  
**Stephen Montgomery**, The Nature Conservancy, Ohio  
**Nathaniel Osborne**, North Carolina State University, North Carolina  
**Alyx Perry**, Southern Forests Network, North Carolina  
**Carl Schmidt**, U. S. Fish and Wildlife Service, Piedmont NWR, Georgia  
**Bob Mitchell**, The Jones Center for Ecological Research, Georgia  
**Ken Smith**, University of the South, Tennessee  
**Clint Trammel**, Georgia  
**Bruce White**, GFR Forestry Consultants, PLLC, North Carolina  
**Nate Wilson**, University of the South, Tennessee

Staff:

**Bob Perschel**, Forest Guild, Massachusetts  
**Alexander Evans**, Forest Guild, New Mexico  
**Mike DeBonis**, Forest Guild, New Mexico

This report was made possible by generous support from the National Wildlife Federation, Doris Duke Charitable Foundation, Lyndhurst Foundation, and Merck Family Fund.

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Available online at:

[www.forestguild.org/publications/research/2012/FG\\_Biomass\\_Guidelines\\_SE.pdf](http://www.forestguild.org/publications/research/2012/FG_Biomass_Guidelines_SE.pdf)

*The Forest Guild practices and promotes ecologically, economically, and socially responsible forestry as a means of sustaining the integrity of forest ecosystems and the human communities dependent upon them.*

forest**GUILD** PO Box 519 Santa Fe, NM 87504 505-983-8992 [www.forestguild.org](http://www.forestguild.org)

# **Forest Biomass Retention and Harvesting Guidelines for the Southeast**

*Guidelines for ensuring forests can support wildlife, maintain biodiversity, provide clean water, sequester carbon, protect forest soil productivity, and continue to produce income after a biomass harvest or repeated harvests*

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# 1. Introduction and Background

Developing domestic, renewable sources of energy is a national priority. In the Southeast, forest biomass is a potential source of renewable energy and fuel that also supports local economies. Biomass harvests can also be used to promote the growth of higher-value trees and forest products, reduce forest-fire risk, and support the removal of invasive species and restoration. The *Southern Forest Futures Project* identified demand for forest biomass for energy as one of the major potential drivers of forest change in the Southeast. Forecasts for forest bioenergy suggests a 54 to 113 percent expansion of harvesting levels by 2050.<sup>1</sup> It is also important to acknowledge the other main drivers of change in Southern forests: urbanization, a changing climate, and invasive species.<sup>1</sup> Any stress that more intensive and widespread biomass removal puts on Southern forests will exacerbate the ecological stress caused by an expanding population, a warming climate, and the spread of exotic plants and animals.

## *The Forest Guild Guidelines*

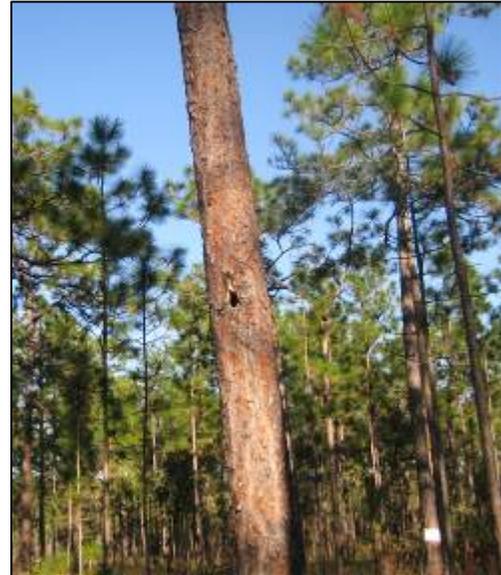
The goal of the Forest Guild guidelines is to identify how expanding markets for forest bioenergy can enhance forests while meeting the social and economic needs of society. These guidelines are designed to fill the gaps where existing Best Management Practices (BMPs) or new state-based biomass guidelines may be insufficient to protect forest resources under new biomass harvesting practices and technologies. While the guidelines were developed to address the current issue of increased biomass harvesting, they are, for the most part, applicable to any Southeastern forest harvest. We have developed these guidelines to assist several audiences: field foresters, loggers, state policy makers, biomass facilities wishing to assure sustainability, third-party certifiers, and members of the public interested in protecting forests. This report focuses on post-harvest forest conditions and not on the type of harvest. The goal is to ensure the forest can support wildlife, maintain biodiversity, provide clean water, sequester carbon, protect forest soil productivity, and continue to produce income after a biomass harvest or repeated harvests.

## **Forest Guild Principles**

- 1. The well-being of human society is dependent on responsible forest management that places the highest priority on the maintenance and enhancement of the entire forest ecosystem.*
- 2. The natural forest provides a model for sustainable resource management; therefore, responsible forest management imitates nature's dynamic processes and minimizes impacts when harvesting trees and other products.*
- 3. The forest has value in its own right, independent of human intentions and needs.*
- 4. Human knowledge of forest ecosystems is limited. Responsible management that sustains the forest requires a humble approach and continuous learning.*
- 5. The practice of forestry must be grounded in field observation and experience as well as in the biological sciences. This practical knowledge should be developed and shared with both traditional and non-traditional educational institutions and programs.*
- 6. A forester's or natural resource professional's first duty is to the forest and its future. When the management directives of clients or supervisors conflict with the Mission and Principles of the Guild, and cannot be modified through dialogue and education, a forester or natural resource professional should disassociate.*

### *Creating the Guidelines*

Our working group consisted of 20 Forest Guild members representing 15 organizations. The process was led by Forest Guild staff and was supported by two Forest Guild reports: *Ecology of Dead Wood in the Southeast*<sup>2</sup> and the *Revised Assessment of Biomass Harvesting Guidelines*.<sup>3</sup> Wherever possible, we based our recommendations on peer-reviewed science. However, in many cases research is inadequate to connect practices, stand-level outcomes, and ecological goals. Where the science remains inconclusive, we relied on field observation and professional experience. Since these guidelines are driven by science, they should be reviewed and updated as new information becomes available.



Zander Evans

In developing these guidelines, the team emphasized the **importance of professional judgment in practicing forestry and implementing these guidelines**. It may be that a recommendation is inappropriate for a particular stand because of past management history or unique site conditions. These guidelines are presented **not as static targets to be maintained at all times in all places, but rather as guideposts on a path to sustainability**. These guidelines represent only one of a long list of criteria that should be considered for sustainable forest management and in and of themselves do not mean that a given harvest or forest management is sustainable.

The guidelines focus on the specifics of four major forest types of the Southeastern U.S.: Southern Appalachian hardwoods, upland hardwoods and mixed pine–hardwoods, bottomland hardwoods, and piedmont and coastal plain pinelands. These forest types can be found from New Jersey to Florida and west into Texas.<sup>2</sup>

### ***Definitions***

#### *Biomass*

In a scientific context, the term “biomass” includes all living or dead organic matter. In common parlance, biomass usually refers to woody material that has historically had a low value and has not been considered merchantable in traditional markets. Biomass harvesting can also involve the removal of dead trees, downed logs, brush, and stumps, in addition to tops and limbs. Changing markets and regional variations determine which trees are considered sawtimber or pulpwood material and which are relegated to the biomass category. This report does not discuss biomass from agricultural lands and short-rotation woody biomass plantations.

In this report, the term **biomass** refers to vegetation removed from the forest, usually logging slash, small-diameter trees, tops, limbs, or trees not considered merchantable in traditional markets.

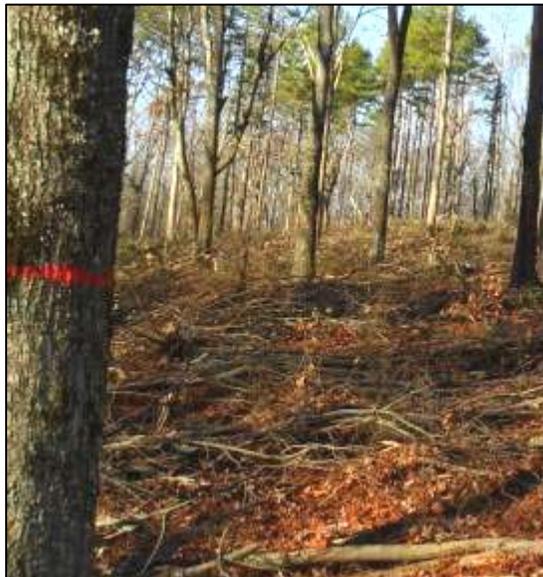
In this report, the term **biomass** refers to *vegetation removed from the forest, usually logging slash, small-diameter trees, tops, limbs, or trees not considered merchantable in traditional markets*. Similarly, we use the phrase **biomass harvesting** to refer to the *removal of logging slash, small-diameter trees, tops, or limbs*.

### *Downed Woody Material*

Woody material is sometimes categorized into coarse woody material (CWM) and fine woody material (FWM). CWM has been defined as downed dead wood more than 6 inches in diameter at the large end and FWM as less than 6 inches in diameter at the large end.<sup>4</sup> The USDA Forest Service defines CWM as downed dead wood with a small-end diameter of at least 3 inches and a length of at least 3 feet, and FWM as that with a diameter of less than 3 inches.<sup>5</sup> FWM has a higher concentration of nutrients than CWM. Large downed woody material, such as logs greater than 12 inches in diameter, is particularly important for wildlife. In this report, we use the term **downed woody material (DWM)** to encompass all three of these size classes, but where the piece size is particularly important, we discuss a specific size of material.

### *Biomass Harvesting in a Landscape Context*

It is important to recognize the range of landowner objectives in the Southeast and how they might affect the utility of biomass harvesting guidelines. In forests dedicated to intensive management for forest products, ecological values such as wildlife habitat are superseded by the goal of maximizing production. While existing BMPs are still applicable and critical to production forests, landowner objectives may be at odds with the increased retention



recommended in these guidelines. However, in forests where landowner objectives encompass multiple uses, such as timber production, wildlife habitat, and recreational opportunities, recommendations that guide the sustainable removal of biomass are crucial. Similarly, these guidelines will be useful to managers using biomass harvesting as a tool in forests where the primary objective is wildlife habitat or preservation of ecosystem function. For example, biomass harvests could facilitate sand pine conversion to frequently burned longleaf pine grasslands.

We acknowledge that in many areas current harvest technology and existing markets may not remove more biomass than traditional harvests. However, these guidelines are precautionary and designed to

avoid problems that are likely to arise as biomass removal becomes both more intensive and widespread. New harvesting technology, management practices, and markets may facilitate intensive biomass utilization that removes more material from the forest, and practices may expand the part of the landscape that is intensively managed so that landscape-level goals for habitat or biodiversity require utilization of biomass harvesting and retention guidelines.

## 2. Guidelines for Biomass Retention and Harvesting for All Forest Types

The following recommendations are applicable across a range of forest types in the Southeast. However, different forest types naturally develop different densities of snags, DWM, and large downed logs, and the amount of this material that accumulates naturally in any forest type will vary with age. The recommendations in this section set minimum retention targets based on the best available information for wildlife habitat and maintenance of ecological processes such as soil nutrient cycling. Section 3 presents research that may help landowners and foresters interested in additional tree, snag, and DWM retention tailored to specific forest types.

### *Site Considerations to Protect Rare Forests and Species*

- Biomass harvests in critically imperiled or imperiled forest types (i.e., globally recognized or listed as S1 or S2 in a state natural heritage program; see section 4 for a list of programs) should be avoided unless necessary to perpetuate the type. Management of these and other rare forest types should be based on guidance from the natural heritage program or other local ecological experts.
- Biomass harvesting may be appropriate in sensitive sites to control invasive species, enhance critical habitat, or reduce wildfire risk. However, restoration activity should be guided by ecological goals and not designed solely to supply biomass. It is unlikely that restored sites will contribute to the long-term wood supply because biomass removals for restoration may not be repeated at regular intervals. In fire-adapted ecosystems, including many Southeastern forests, less biomass may be available for harvest where fire is an active ecological process. Where fire has been excluded, biomass removal may be crucial to re-introducing fire safely.
- Old-growth forest stands with little or no evidence of harvesting are rare and should be protected from harvesting, unless necessary to maintain their structure or ecological function.

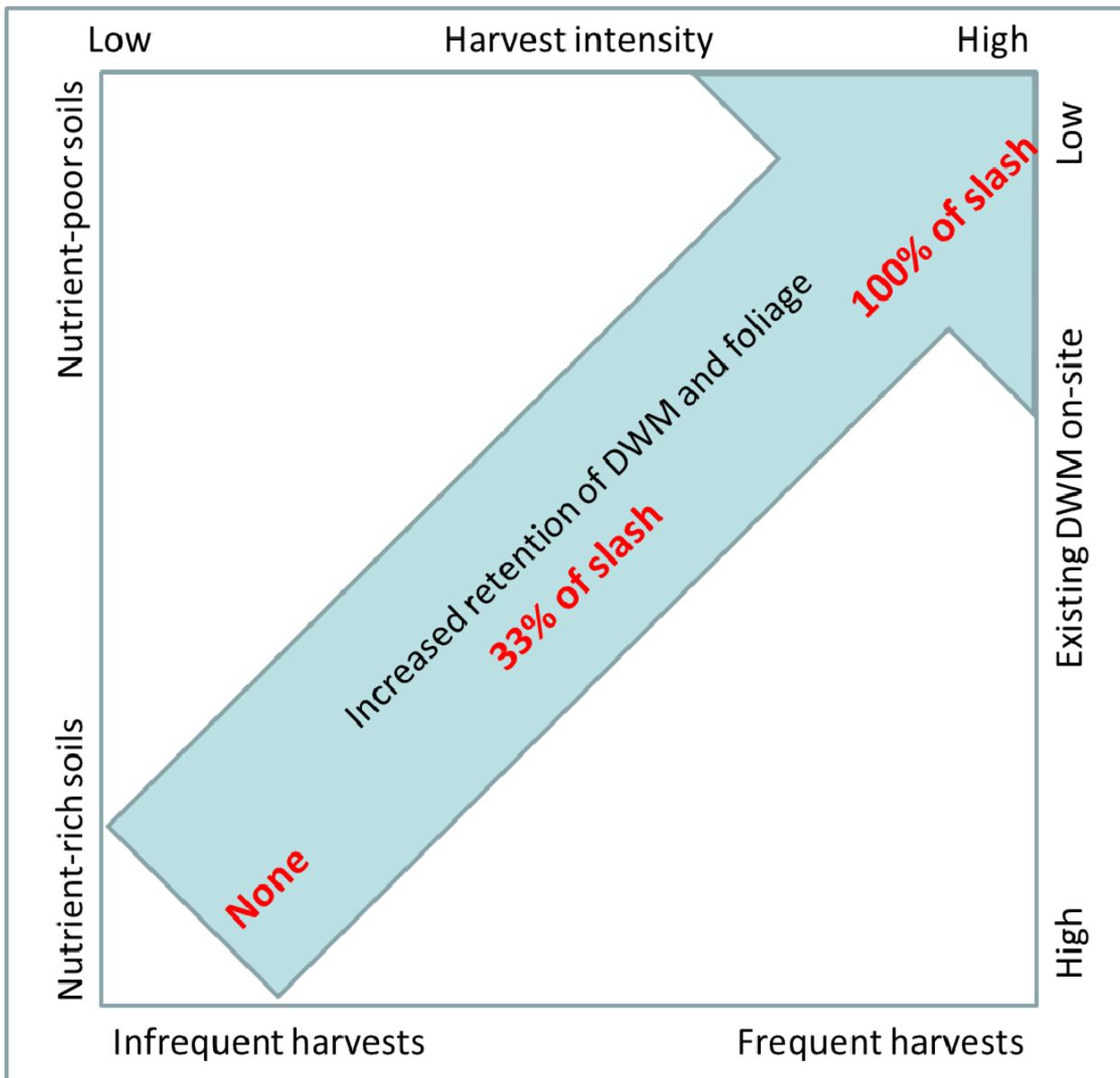


Nathaniel Osborne

### ***Retention of Foliage and Downed Woody Material***

A review of scientific literature suggests that removing tree branches and foliage can have negative impacts on long-term soil productivity in the Southeast (see *Ecology of Dead Wood in the Southeast* for a more detailed discussion of the relevant scientific literature).

Intensive removal of biomass may cause nutrient depletion on sensitive sites such as those with shallow, coarse-textured soils. While some areas with nutrient depletion are known, such as the well-drained, clayey-to-loamy soils on the Citronelle and associated geological formations of the Gulf Coast, it is crucial for long-term sustainability that landowners understand the nutrient status of their forests. On sites where large quantities of DWM already exist, less retention is necessary (see Table 1 for minimum tonnage of DWM). As the graphic below indicates, where harvest intensity is low and harvests are infrequent less DWM needs to be left on-site.



*Guidelines for DWM Retention*

- On an average site with existing DWM, about 1/3 of harvest slash should be left on-site.
- Retain DWM of all sizes on-site, including FWM, CWM, and large downed logs.
- Ideally, slash should be distributed more or less evenly across the site. This is usually easiest if dead wood is left where trees are felled. If whole trees are skidded to a landing it is better to bring slash back into the stand than to leave it in large piles at the landing. For example, Forest Stewardship Council guidelines say “Slash is concentrated only as much as necessary to achieve the goals of site preparation and the reduction of fuels to moderate or low levels of fire hazard.”<sup>6</sup>
- Where accelerated erosion is likely, use methods which leave logging debris and other natural forest litter scattered over the site.
- If possible, harvest hardwood or mixed pine–hardwood forests in the winter to reduce nutrient removal.<sup>7</sup>



Stephen Montgomery

***Retention of Forest Structures for Wildlife and Biodiversity***

- Leave and protect roots, stumps, and large downed woody material.
- Leave and protect live cavity trees, den trees, other live decaying trees, and snags (i.e., dead standing trees), particular larger ones. Individual snags that must be felled for safety requirements should not be removed from the forest.

**Table 1. Goals for Forest Structures (see Section 3 for more details)**

<b>Forest Type</b>	<b>Snags</b>	<b>DWM</b>
Southern Appalachian Hardwoods	At least 17 snags per acre greater than 4” DBH	At least 3 tons per acre (t/ac)
Upland Hardwoods and Mixed Pine–Hardwoods	At least 11 snags per acre greater than 4” DBH	At least 3 t/ac
Bottomland Hardwoods	At least 6 snags per acre greater than 10” DBH	At least 3 t/ac
Piedmont and Coastal Plain Pinelands	At least 5 snags per acre greater than 4” DBH	At least 1 t/ac

Table 1 is based on the scientific literature review in *Ecology of Dead Wood in the Southeast*<sup>2</sup> as well as other biomass harvesting and retention guidelines.<sup>3</sup> These guidelines are not meant to be attained on every acre at all times. Rather, they are average targets to be applied across a stand, harvest block, or potentially an ownership. For help visualizing DWM quantities, please see the Natural Fuels Photo Series [depts.washington.edu/nwfire/dps/](https://depts.washington.edu/nwfire/dps/).

- If these forest structures do not currently exist, select and identify live trees to become these structures in the future. Retaining live decaying trees helps ensure sufficient snags in the future. Similarly, both decaying trees and snags can eventually become large downed logs.
- Since there are differences in decay rates and wildlife utilization, retain a variety of tree species as snags, DWM, and large downed logs. Larger snags have greater ecological importance and should be protected or recruited.
- If forest disturbances such as hurricanes, tornadoes, ice storms, fire, and insect infestations create large areas of dead trees, leaving all snags or decaying trees may be impractical. If an area is salvage logged, leave biological legacies as outlined in Table 1.

### ***Water Quality and Riparian Zones***

In general, water quality and riparian concerns do not change with the addition of biomass removals to a harvest plan. Refer to state water quality Best Management Practices (BMPs) and habitat management guidelines for additional measures to protect streams, vernal pools, and other water bodies (see Section 5 for a list of these BMPs).

- DWM retention described above is also important for water quality, because DWM reduces overland flow and holds water.
- Leave and protect existing woody material in streams, ponds, and lakes. DWM in riparian systems provides sites for vegetation colonization, forest island growth and coalescence, forest floodplain development, and wildlife habitat.
- Leave and protect live decaying trees (e.g., cavity/den trees), snags, and large downed logs in riparian or stream management zones.
- Extra care should be taken working in or around forested wetlands because of their importance for wildlife and ecosystem function. Wetlands are often low-fertility sites and may support rare natural communities, so removal of DWM may be inappropriate.



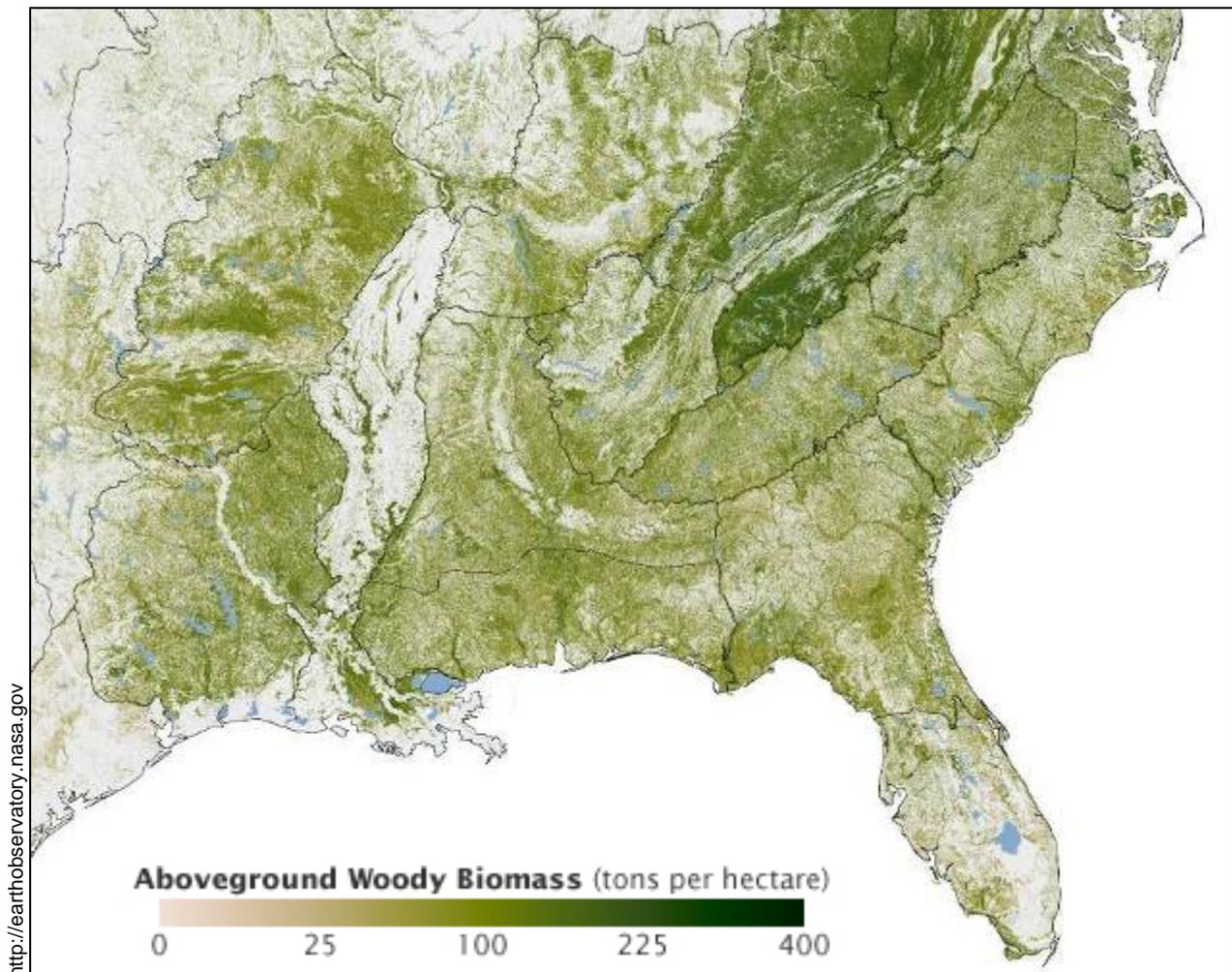
Tallulah River, Chattahoochee National Forests

### ***Harvesting and Operations***

The Forest Guild guidelines are designed to augment and enhance existing BMPs. It is crucial that harvests follow BMPs that protect water quality, particularly on skid trails and roads.

- Encourage decisions that keep forest as forests and advocate against conversion of forests to non-forest use.
- Involve a professional forester (or a licensed forester in states where available) in the development of a long-term management plan and supervision of harvests.

- Engage a certified logger from the Master Logger Certification Program or similar program when harvesting.
- Follow all BMPs for the state or region.
- Plan and construct roads and skid trails based on professional advice and BMPs.
- Integrate biomass harvesting with other forest operations. Re-entering a stand where timber was recently harvested to remove biomass can increase site impacts such as soil compaction and may harm post-harvest regeneration.
- Use low-impact logging techniques such as directional felling or use of slash to protect soil from rutting and compaction from harvest machines.
- Use appropriate equipment matched to site and operations.



### 3. Relevant Research for Southeastern Forest Types

#### *Southern Appalachian Hardwoods*

Research shows that the quantity of CWM in Southern Appalachian hardwoods varies from 3 to 41 t/ac. Given the range of recorded quantities of CWM, it seems reasonable to recommend the bottom of the range (3 t/ac) as a minimum retention guideline until further research is available. Since the range of snags in Southern Appalachian hardwood forests ranges from 17 to 53 per acre (>4" DBH), recommending retention or recruitment of at least 17 snags per acre sets a minimum threshold. Because of their greater ecological importance, snags larger than 20 inches in diameter should receive particular attention and protection.

#### *Upland Hardwoods and Mixed Pine–Hardwoods*

Fewer scientific studies are available for upland hardwoods or mixed pine–hardwoods, but the range, 3 to 29 t/ac, is similar to the range for Southern Appalachian hardwoods, so using the same minimum of 3 t/ac of CWM is appropriate until new research can provide more details. Based on the range of snags reported in the scientific literature for these forests (11 to 41 per acre >4" DBH), maintaining or recruiting at least 11 snags per acre may be a minimum goal. Larger snags have greater ecological importance and should be protected or recruited.

#### *Bottomland Hardwoods*

We endorse the recommendation of the Lower Mississippi Valley Joint Venture Resource Conservation Working Group for retention of forest structure in the lower Mississippi Valley.<sup>8</sup>

**Table 2. Lower Mississippi Valley Joint Venture Recommendations**

<b>Forest Variables</b>	<b>Desired Stand Structure</b>	<b>Conditions That May Warrant Management</b>
Coarse Woody Debris (>10" DBH)	>200 ft <sup>3</sup> /ac*	<100 ft <sup>3</sup> /ac
Small Cavities (hole >10in dbh)	>4 visible holes/ac <b>or</b> >4 snags/ac ≥4" DBH <b>or</b> ≥2 trees/ac >20" DBH	<2 visible holes/ac <b>or</b> <2 snags/ac ≥4" DBH <b>or</b> <1 trees/ac ≥20" DBH
Den Trees/ Large Cavities	One visible hole / 10 ac <b>or</b> ≥2 trees/ac ≥25" DBH (≥7.8 ft <sup>2</sup> BA/ac ≥25" DBH)	No visible holes on 10 ac <b>or</b> <1 trees/ac ≥25" DBH (≥3.9 ft <sup>2</sup> BA/ac ≥25" DBH)
Standing Dead and/or Stressed Trees	>6 trees/ac ≥10" DBH <b>or</b> ≥2 trees/ac ≥20" DBH (>3.9ft <sup>2</sup> BA/ac >10" DBH)	<4 trees ≥10" DBH/ac <b>or</b> <1 trees/ac ≥20" DBH (<2 ft <sup>2</sup> BA/ac ≥10" DBH)

\*200 ft<sup>3</sup>/ac is approximately 3 t/ac of DWM.<sup>2</sup>

While these recommendations were designed for the lower Mississippi Valley, they may be an appropriate goal for other bottomland hardwood forests in the Southeast.

### ***Piedmont and Coastal Plain Pinelands***

Southeastern pine plantations tend to have less CWM than other forest types covered in these guidelines, but one study of natural pine stands in Georgia and South Carolina found nearly 4 tons of CWM per acre. Maintaining at least 1 ton of CWM per acre in pine stands may protect some habitat values, but may not obviate the need for fertilization in plantations. Plantations often have few snags, though in one loblolly pine plantation researchers found an average of 8.2 snags. Researchers have recommended at least 3 snags per acre to maintain cavity-nesting bird populations. Based on the team's professional judgment, a goal of 5 snags of at least 4 inches in diameter per acre is a reasonable goal for piedmont and coastal plain pinelands.



David Moorhead, Forestry Images

## 4. Carbon Considerations

The carbon implications of using forest biomass for energy are important, since one of the motivations for using forest biomass for energy is to reduce greenhouse gas emissions. However, carbon accounting is a complex and contentious endeavor. A full discussion of the carbon implications of forest biomass use in energy systems is beyond the scope of these guidelines, but recent studies, such as *Biomass Supply and Carbon Accounting for Southeastern Forests*,<sup>9</sup> which use a comparative accounting approach provide detailed views of carbon emissions from forest biomass. A few key points from these studies include the following:

- The carbon accounting framework and modeling assumptions can determine whether a particular analysis indicates forest biomass increases, decreases, or has no effect on atmospheric carbon during specific time periods.
- The carbon impact of forest biomass is spatially and temporally complex and involves tradeoffs. For example, expanded use of forest biomass for electricity may increase atmospheric carbon in the near-term (~50 years), but decrease atmospheric carbon after that period.
- Use of biomass for heating, cooling, or combined heat and power applications is more efficient, and hence lowers total carbon emissions to the atmosphere, as compared to standalone electricity production.

No matter what the carbon accounting method or energy technology used, protecting forests from conversion to other land uses is the most important forest management measure to store carbon and mitigate climate change.

The use of logging slash for energy production has a lower carbon impact than the use of live trees for energy because logging slash will decay and emit carbon and other greenhouse gases, while live trees will continue to sequester carbon. Similarly, since trees naturally die, decay, and emit carbon, harvests that focus on suppressed trees likely to die in the near future produce fewer carbon emissions overall than harvests of trees that are healthier, sequester carbon faster, and have long life expectancies. When biomass harvests remove suppressed trees with shorter life expectancies, the remaining healthier trees, “crop trees,” can grow faster and larger and produce higher-value products. These more valuable products have the potential to store carbon off-site longer than products with a shorter life cycle, such as paper or shipping pallets. These products also will meet human needs while emitting less carbon than alternatives such as steel or concrete. However, the harvest of future crop trees for energy is the worst-case scenario: such a harvest reduces on-site carbon, probably limits the economic productivity of the stand, and reduces the opportunity to produce higher-value products that provide long-term carbon storage and displace more carbon-intensive products.



Zander Evans

It is important to recognize that in some cases a practice that contributes to a significant reduction in atmospheric carbon may be, or may appear to be, in conflict with considerations regarding biodiversity or long-term site productivity, as outlined in previous sections of this document. For example, while utilizing logging slash for energy may prove important in a scenario designed to reduce atmospheric carbon, on the other hand, the retention of some logging slash post-harvest may also be important for the maintenance of forest productivity. In such cases, as in many areas of forestry, divergent goals must be balanced for the specific operating unit or ownership. As discussed in previous sections, the guidelines in this report are primarily intended to support decision making about the maintenance of ecological function and value in a forest management context.

## 5. Resources and References

### *State Best Management Practices and Natural Heritage Programs*

#### **Alabama**

- Alabama's Best Management Practices for Forestry [www.forestry.state.al.us/BMPs.aspx](http://www.forestry.state.al.us/BMPs.aspx)
- Alabama Natural Heritage Program [www.alnhp.org](http://www.alnhp.org)

#### **Arkansas**

- Arkansas Best Management Practices [www.arnatural.org/forestry/bmps.htm](http://www.arnatural.org/forestry/bmps.htm)
- Arkansas Natural Heritage Commission [www.naturalheritage.com/](http://www.naturalheritage.com/)

#### **Florida**

- Florida Silviculture Best Management Practices  
“Snags, den and cavity trees, as well as mast producing trees, left in the Special Management Zone, are necessary to meet habitat requirements for certain types of wildlife.” [www.fl-dof.com/forest\\_management/bmp/index.html](http://www.fl-dof.com/forest_management/bmp/index.html)
- Florida Natural Areas Inventory [www.fnai.org](http://www.fnai.org)

#### **Georgia**

- Georgia Best Management Practices “Where accelerated erosion is likely, use methods that leave logging debris and other litter scattered evenly over the site.” [www.gfc.state.ga.us/forestmanagement/bmp.cfm](http://www.gfc.state.ga.us/forestmanagement/bmp.cfm)
- Georgia Natural Heritage Program [www.georgiawildlife.com/node/1363](http://www.georgiawildlife.com/node/1363)

#### **Kentucky**

- Kentucky's Recommendations for the Harvesting of Woody Biomass [forestry.ky.gov/Documents/Biomass Harvsting Recommendations Oct 2011.pdf](http://forestry.ky.gov/Documents/Biomass_Harvsting_Recommendations_Oct_2011.pdf)
- Kentucky Forest Practice Guidelines for Water Quality Management [www.ca.uky.edu/forestryextension/Publications/FOR\\_FORFS/FOR67.pdf](http://www.ca.uky.edu/forestryextension/Publications/FOR_FORFS/FOR67.pdf)
- Field Guide to Best Management Practices for Timber Harvesting in Kentucky [www.ca.uky.edu/forestryextension/Publications/FOR\\_FORFS/FOR69.pdf](http://www.ca.uky.edu/forestryextension/Publications/FOR_FORFS/FOR69.pdf)
- Kentucky Natural Heritage Database [naturepreserves.ky.gov/data/Pages/sppcommdata.aspx](http://naturepreserves.ky.gov/data/Pages/sppcommdata.aspx)

#### **Louisiana**

- Recommended Forestry Best Management Practices for Louisiana  
“Where accelerated erosion is likely, use methods which leave logging debris and other natural forest litter scattered over the site.” [www.ldaf.state.la.us/portal/Portals/0/FOR/for%20mgmt/BMP.pdf](http://www.ldaf.state.la.us/portal/Portals/0/FOR/for%20mgmt/BMP.pdf)
- Guidelines for Practicing Forest Environmental Enhancement in Louisiana [www.ldaf.state.la.us/portal/Portals/0/FOR/for%20mgmt/BMP.pdf](http://www.ldaf.state.la.us/portal/Portals/0/FOR/for%20mgmt/BMP.pdf)
- Louisiana Natural Heritage Program [www.wlf.louisiana.gov/wildlife/louisiana-natural-heritage-program](http://www.wlf.louisiana.gov/wildlife/louisiana-natural-heritage-program)

## **Maryland**

- A Guide to Forest Biomass Harvesting and Retention in Maryland [www.dnr.state.md.us/forests/pdfs/MDBiomassGuidelines.pdf](http://www.dnr.state.md.us/forests/pdfs/MDBiomassGuidelines.pdf)
- Maryland's Natural Heritage Program [www.dnr.state.md.us/wildlife/Plants\\_Wildlife/nhpintro.asp](http://www.dnr.state.md.us/wildlife/Plants_Wildlife/nhpintro.asp)

## **Missouri**

- Missouri Biomass Harvesting Best Management Practices [mdc4.mdc.mo.gov/applications/MDCLibrary/Library.aspx?ArtID=19813](http://mdc4.mdc.mo.gov/applications/MDCLibrary/Library.aspx?ArtID=19813)
- Missouri Natural Heritage Program [mdc.mo.gov/landwater-care/heritage-program](http://mdc.mo.gov/landwater-care/heritage-program)

## **North Carolina**

- Best Management Practices [ncforestservice.gov/water\\_quality/bmp\\_manual.htm](http://ncforestservice.gov/water_quality/bmp_manual.htm)
- North Carolina Natural Heritage Program [www.ncnhp.org/](http://www.ncnhp.org/)
- NCSU Extension: Developing Wildlife-Friendly Pine Plantations [www.ces.ncsu.edu/forestry/pdf/WON/won38.pdf](http://www.ces.ncsu.edu/forestry/pdf/WON/won38.pdf)
- North Carolina State University – Woody Biomass Extension [www.ces.ncsu.edu/forestry/programs/woody\\_biomass/](http://www.ces.ncsu.edu/forestry/programs/woody_biomass/)

## **Oklahoma**

- Best Management Practices Guidelines [www.forestry.ok.gov/waterqualitybmp](http://www.forestry.ok.gov/waterqualitybmp)
- Oklahoma Natural Heritage Inventory [www.oknaturalheritage.ou.edu/](http://www.oknaturalheritage.ou.edu/)

## **South Carolina**

- South Carolina Best Management Practices [www.state.sc.us/forest/refbmp.htm](http://www.state.sc.us/forest/refbmp.htm)  
“Where accelerated erosion is likely, use methods which leave logging debris and other litter scattered over the site.” “Leave snags and hollow den trees for cavity-dependent wildlife species, preferably in association with groups of mature trees.”
- South Carolina Heritage Trust Program [www.dnr.sc.gov/mlands/hpprogram.html](http://www.dnr.sc.gov/mlands/hpprogram.html)

## **Tennessee**

- Tennessee Forestry Best Management Practices [www.tn.gov/agriculture/forestry/bmps.shtml](http://www.tn.gov/agriculture/forestry/bmps.shtml)
- Tennessee Natural Heritage Inventory Program [www.tn.gov/environment/na/nhp.shtml](http://www.tn.gov/environment/na/nhp.shtml)

## **Texas**

- Forestry Best Management Practices [txforestservice.tamu.edu/main/article.aspx?id=14536](http://txforestservice.tamu.edu/main/article.aspx?id=14536)

## **Virginia**

- Virginia's Forestry Best Management Practices for Water Quality [www.dof.virginia.gov/wq/resources/ManualBMP/2011\\_Manual\\_BMP.pdf](http://www.dof.virginia.gov/wq/resources/ManualBMP/2011_Manual_BMP.pdf)
- Virginia Natural Heritage Program [dcr.virginia.gov/natural\\_heritage/](http://dcr.virginia.gov/natural_heritage/)

## West Virginia

- West Virginia Silvicultural Best Management Practices for Controlling Soil Erosion and Sedimentation from Logging Operations [www.wvforestry.com/BMP%20Book%202009.pdf](http://www.wvforestry.com/BMP%20Book%202009.pdf)
- West Virginia Natural Heritage Program [www.wvdnr.gov/wildlife/wdpintro.shtm](http://www.wvdnr.gov/wildlife/wdpintro.shtm)

## Forest Guild Reports

- *Ecology of Dead Wood in the Southeast*  
[www.forestguild.org/publications/research/2011/ecology\\_of\\_dead\\_wood\\_SE.pdf](http://www.forestguild.org/publications/research/2011/ecology_of_dead_wood_SE.pdf)
- *Revised Assessment of Biomass Harvesting Guidelines*  
[www.forestguild.org/publications/research/2009/biomass\\_guidelines.pdf](http://www.forestguild.org/publications/research/2009/biomass_guidelines.pdf)
- *Forest Biomass Retention and Harvesting Guidelines for the Northeast*  
[www.forestguild.org/publications/research/2010/FG\\_Biomass\\_Guidelines\\_NE.pdf](http://www.forestguild.org/publications/research/2010/FG_Biomass_Guidelines_NE.pdf)

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<http://www.srs.fs.usda.gov/futures/>
- 2 Evans, A. M. 2011. *Ecology of Dead Wood in the Southeast*. Forest Guild, Santa Fe, NM.  
[http://www.forestguild.org/publications/research/2011/ecology\\_of\\_dead\\_wood\\_SE.pdf](http://www.forestguild.org/publications/research/2011/ecology_of_dead_wood_SE.pdf)
- 3 Evans, A. M., R. T. Perschel, and B. A. Kittler. 2010. *Revised Assessment of Biomass Harvesting and Retention Guidelines*. The Forest Guild, Santa Fe, NM.  
[http://www.forestguild.org/publications/research/2009/biomass\\_guidelines.pdf](http://www.forestguild.org/publications/research/2009/biomass_guidelines.pdf)
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