

Maintaining Site Productivity during Biofuel Harvest Operations

BY DEBORAH PAGE-DUMROESE AND MARK KIMSEY

Demand for forest biomass for bioenergy production and other uses is expected to increase to four times the current level in the next one to five years. The search for alternative energy sources, including forest bioenergy, increases pressure on the productive capacity of our western forestlands. The questions are: Can forest soils in the western U.S. support more intensive timber harvesting for both traditional uses and emerging bioenergy markets? Are biomass harvesting for bioenergy and sustainable soil productivity compatible? The answers are “yes!”

Biofuel harvest operations are becoming more prevalent in the western U.S. because of the large amount of biomass accumulating in unharvested or overstocked stands. Markets for forest residues such as pulpwood or chips are increasing.

In the past, logging or thinning operations generated a considerable amount of residue that had previously been left on-site, burned in slash piles, or removed as hog fuel. Now we are considering removing forest residues that were once left on-site. Consequently, bioenergy harvesting may impact the soil's physical, chemical, and biological environment to a greater degree than traditional timber harvesting.

Soil impacts are usually dependent on the amount of organic matter and woody residues on the soil surface, soil texture (e.g., clay, silt, sand), rock



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content, and soil depth. For example, harvesting often compacts clay and silt soils more than sandy soils.

However, the soils that compact the easiest are often less susceptible to reductions in nutrients from biomass harvesting (e.g., finer textured soils typically have higher plant essential nutrients). This suggests that biomass removal mitigation strategies must reflect site conditions to maintain the health and fertility of the soil resource. Nutrients and carbon are removed when tops and leaves are removed, and therefore concerns over “mining” of the soil resource must be addressed. Thus the question: “Some woody residues must be left behind, but how much and what kind?”

Fine woody residues. Fine woody residues are usually defined as that portion of harvest residue that is less than three inches in diameter. Ecologically, it adds soil cover that can reduce soil erosion, moderate soil temperatures, and on some sites may increase soil nutrients. Published data indicate that in general, intensive residue removals do not universally reduce site productivity. However, removal of all fine woody residues following repeated harvests can cause substantial growth declines on coarse textured soils with low soil organic matter. On some Pacific Northwest forest sites, nitrogen (N) is limiting, but often there is an adequate supply of other nutrients so that even repeated intensive removals of fine woody residues will not induce nutrient deficiencies. However, in dry or cold forests where N cycling is slow due to climate, N losses in harvested materials may substantially reduce productivity by lowering decomposition and N mineralization rates. During typical biomass harvesting, a large amount of top breakage occurs, and this material should be sufficient to alleviate con-

cerns about nutrient loss, erosion, or compaction.

Coarse woody residues. Coarse woody residue is defined as wood greater than seven inches in diameter and is usually laying on the soil surface. Coarse wood can be added to a site during logging or when a snag falls. Ecologically, coarse woody residues function as habitat for a variety of organisms, including fungi, mosses, liverworts, insects, amphibians, reptiles, small mammals, and regenerating plants. On any given site, coarse wood is naturally regulated by local climatic regimes, which determine decomposition rates. As woody debris decays, it eventually forms soil wood (covered by mineral soil and forest floor material), where it helps to improve nutrient cycling and increases water-holding capacity. This slow incorporation of woody material into the mineral soil improves soil properties over the long term and influences tree growth over time. Coarse wood also affects ponding, sediment trapping, and aeration in streams. In addition, coarse wood can alter site water balance and water quality, both through storage and release of water, and by reducing runoff and erosion. During harvest operations, coarse wood is often used to protect wet soil areas from compaction and rutting, or used post-harvest to help limit runoff and erosion from skid trails and forest roads.

How much woody residues should I leave? It is relatively easy to determine how much coarse and fine woody residues are present on the soil surface before biomass harvesting by either visual estimates or measurements. One good rule of thumb is to retain the same amount of coarse and fine woody residue that is on-site pre-harvest. More specifically, research suggests that retaining 30 percent of fine woody residues on slopes less than 30 percent and 50 percent retention on steep slopes is a reasonable and conservative estimate of the amount of material needed to maintain biodiversity, prevent erosion and com-

paction, build soil organic matter, and maintain nutrients where possible. One note of caution, if a site has been heavily impacted or is subject to a short fire-return interval, then leaving additional material behind could help improve long-term soil quality.

Best Management Practices.

Opportunities for Best Management Practices (BMPs) for biomass harvesting are mostly common sense: limit logging when the soil is wet, match equipment to the site, use winter logging to minimize ground disturbances, leave the stumps in place, and don't create large slash piles for burning. Minimizing the size of slash piles to less than 15 percent of the total land area harvested will also help keep soil impacts confined. Long-term research indicates that the key to sustainable forestry is to keep the surface organic horizons (fresh and decaying organic matter) intact so you can maintain nutrient cycling and moisture retention and prevent erosion. Dry, coarse-textured soils are more susceptible to nutrient losses during bioenergy harvesting than moist, fine-textured soils. To minimize soil productivity losses during biomass harvesting for bioenergy, leave fine woody debris and needles (or leaves) on the soil surface.

On many sites before harvest operations begin, you can develop your own BMPs based on soil nutrient levels, depth of the mineral soil, amount of rocks, and local climatic regimes (rainy, cool, hot, dry, etc.). Ecologically, it is important to leave both coarse and fine woody residues after harvest operations and to leave the surface organic matter intact. Knowing if your soil is limited in N or other nutrients can help you determine how much fine or coarse woody residue will benefit your land. You can also determine if compaction might be an issue, if your soils readily develop ruts, or if you have a drainage problem. Geospatial information on the physical and chemical properties of your soil type(s) is available from the Natural Resource

Conservation Service (NRCS) Web Soil Survey (<http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>). You can use this information to help develop your own risk rating system that assesses your soil type, topography and climatic regime.

Biomass harvesting that follows site specific BMPs that reduce the risk of compaction, erosion, and nutrient losses can provide valuable forest products while maintaining soil pro-

ductivity for future forest growth. ■

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