**Materials Characterization Paper**
*In Support of the*
**Advanced Notice of Proposed Rulemaking –**
**Identification of Nonhazardous Materials That Are Solid Waste**

**Construction and Demolition Materials – Land Clearing Debris**

*December 16, 2008*

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## *1. Definition of Land Clearing Debris*

Land clearing debris is defined as growing stock and other timber sources cut or otherwise destroyed in the process of converting forest land to non-forest uses.[1] Growing stock that is removed in silvicultural operations such as pre-commercial thinning is also included in this definition. Land clearing debris is typically in the form of tree tops and branches, trees cut or knocked down and left on site, and stumps. In non-forested areas, such as grasslands and desert, land clearing debris may include soil, rocks, and shrubs, although fuel is primarily derived from previously forested areas.

## *2. Annual Quantities of Land Clearing Debris Generated and Used*

(1) **Sectors that generate Land Clearing Debris:**

- NAICS 561730 Landscaping Services - This industry comprises (1) establishments primarily engaged in providing landscape care and maintenance services and/or installing trees, shrubs, plants, lawns, or gardens and (2) establishments primarily engaged in providing these services along with the design of landscape plans and/or the construction (i.e., installation) of walkways, retaining walls, decks, fences, ponds, and similar structures (U.S. Census Bureau 2007).
- NAICS 11310 - This industry comprises establishments primarily engaged in one or more of the following: (1) cutting timber; (2) cutting and transporting timber; and (3) producing wood chips in the field (U.S. Census Bureau 2007)..
- NAICS 236 – This subsector comprises establishments primarily responsible for the construction of buildings. The work performed may include new work, additions, alterations, or maintenance and repairs. The on-site assembly of precut, panelized, and prefabricated buildings and construction of temporary buildings are included in this subsector. (U.S. Census Bureau 2007).

(2) **Quantities and Prices of Land Clearing Debris Generated:**

- In 2002, 30 million short tons of land clearing debris were generated in the U.S. According to a 2002 USDA Forest Service Study, 10 percent was considered to be unusable because of size, location, or other reasons. Based on this assumption,

[1] This is distinct from forest derived biomass, which is extracted from logging operations on areas that will remain forest land.

27 million short tons of land clearing debris were available for recovery in 2002 (McKeever 2002, p. 3-4).

- Paper mills sign one, two or three year contracts with supply companies for land clearing debris used as fuel. The price per ton depends significantly on the distance over which the material must be transported. One source identified for the development of this document suggests that ground wood that meets mill specifications commands a market price ranging from $15 to $20 per ton (Goldstein 2006, p. 29).
- A developing market for biomass is exportation to Europe, where biomass demand has increased due to cap-and-trade policies and other efforts to reduce fossil fuel use and emissions (Yepsen 2008, p. 51).

(3) **Trends in generation of Land Clearing Debris:**

- Information was not readily available to gauge the trend in the generation of land clearing debris.

### *3. Uses of Land Clearing Debris*

(1) **Fuel uses of Land Clearing Debris:**

- Land clearing debris is commonly used as a fuel in industrial boilers. In general, this material can be combusted for energy recovery if the processing capacity and markets for the fuel exist. Oven-dry wood produces approximately 9,000 Btu/lb when burned, and can also be converted to liquid or gaseous fuel. Mixed wood debris with some green wood has a Btu value typically near 7,300 Btu/lb, and debris with higher percentages of green wood can have lower Btu values, though land clearing debris is typically dried as part of its processing. In addition, it is possible to produce different forms of solid fuel from wood debris, such as charcoal (SWANA 2002, p. 2, 24, 30, Goldstein 2006, p. 29).

(2) **Non-combustion uses of Land Clearing Debris:**

- Non-combustion beneficial use applications for land clearing debris include shredding for mulch and other land applications. Land clearing debris can also be composted.

(3) **Quantities of Land Clearing Debris Landfilled:**

- Information was not readily available to gauge the amount of land clearing debris that is disposed in landfills.

(4) **Quantities of Land Clearing Debris Stockpiled/Stored:**

- The data sources consulted in the development of this document did not suggest that large quantities of land clearing debris are stored or stockpiled.

## *4. Management and Combustion processes for Land Clearing Debris*

(1) **Types of units using Land Clearing Debris:**

- For combustion/fuel applications, land clearing debris is primarily used by wood-fired industrial boilers and burners. Mulch is sold to landscaping companies, suppliers, or retailers for use by residential and commercial customers.

(2) **Sourcing of Land Clearing Debris:**

- Some companies that process land clearing debris use wood derived from their own land. Other processors typically receive land clearing debris from land clearing companies and municipalities that collect yard trimmings. Processing companies then provide wood chips to mills with whom they have contracted (Goldstein 2006, p. 29).

(3) **Processing of Land Clearing Debris:**

- At processing facilities, land clearing debris goes through a multi-step process to produce marketable wood fuel. After the debris arrives at the processing facility, it is inspected for contaminants, and an excavator is used to remove any contaminants identified. A bulldozer with a rake then shakes the material to remove any soil that is attached to the debris. Following this step, the woody products are staged in stockpiles to dry prior to grinding. Processors then grind the debris so that it can easily be fed into an industrial boiler. The ground wood generally needs to be 2-inch minus in size and scope for most mills. Some processing facilities achieve the 2-inch minus size in one grind, whereas other processes will do double grinding (Goldstein 2006, p. 29).

  After land clearing debris is processed, the mills that purchase wood fuel derived from this material will often conduct a test burn to evaluate the moisture content of the fuel. Mills prefer wood fuel with a low moisture content because it has a higher Btu value per pound (Goldstein 2006, p. 29).

(4) **State status of Land Clearing Debris use as fuel:**

- According to state responses to a 2006 survey by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO), two states—New York and North Carolina—have approved the use of recovered wood materials as a fuel source on at least one occasion, but it is unclear whether these approvals apply to wood debris from land clearing or the beneficial use of finished wood product. In both states, the beneficial use of recovered wood materials as a fuel does not appear to have pre-approved status (ASTSWMO 2007, p.B-42).

## *5. Land Clearing Debris Composition and Impacts*

(1) **Composition of Land Clearing Debris:**

- By definition, land-clearing debris is made up of cleared vegetation, and may include rocks and soil.

(2) **Impacts of Land Clearing Debris use:**

- ***Cost Impacts:*** The net cost impacts associated with the beneficial use of land clearing debris as a fuel depends on the avoided input or fuel costs for facilities that use these materials and the cost of beneficial use itself. Information on the processing costs for land clearing debris is not readily available, but the fuel savings associated with using this material as a substitute for conventional fuels could be as follows, depending on the fuel replaced:[2]

  Natural Gas (Industrial): $7.35 / MMBtu (EIA 2008a, Table 20)
  No. 2 Distillate (Industrial): $16.80 / MMBtu (EIA 2008b, Table 36)
  Residual Fuel Oil Average: $9.19 / MMBtu (EIA 2008b, Table 38)
  Coal – Average Delivered Price in 2006: $2.23 / MMBtu (EIA 2007, Table ES1)

- ***Emissions Impacts of Combustion:*** Exhibit 1 compares the emission factors for wood with the corresponding values for conventional fuels that land clearing debris may displace. The estimates in the exhibit suggest that the combustion of wood results in higher PM emissions than natural gas or distillate oil, but lower PM emissions than coal or residual oil systems. The data in Exhibit 1 also suggest that wood results in lower $SO_2$ emissions than most conventional fuels. The estimated $NO_x$ emissions associated with wood combustion are similar to those associated with distillate and lower than the $NO_x$ emissions for other conventional fuels.[3]

- ***Lifecycle Emissions Impacts:*** Use of land clearing debris as a replacement for traditional primary fuels may eliminate the environmental impacts associated with extraction and processing of traditional fuels. In addition to the emissions impacts of combustion described above, Exhibit 1 lists the quantities of the total cradle-to-gate emissions for these fuels based on typical processes in the United States in the late 1990s, with wood scrap combustion presented as a proxy for land clearing debris. Note that there may be impacts associated with the processing of land clearing debris into useable fuel that are not accounted for in the values presented in Exhibit 1. In addition, there may be alternative uses (e.g., composting) that are environmentally preferable to combustion.

[2] To express these values as dollars per MMBtu, the following thermal conversion factors were used: 1,031 Btu per 1,000 cubic foot of natural gas, 138,690 Btu per gallon of Number 2 distillate, 149,690 Btu per gallon of residual fuel oil, and 22,473,000 Btu per short ton of coal (EIA 2005, Tables A1, A4, and A5).

[3] We note that the emission factors for wood presented in Exhibit 1 represent averages for wood-burning boilers. To the extent that these data reflect the combustion of finished wood product (e.g., C&D wood debris), they may not be representative emissions from the combustion of land clearing debris.

***Exhibit 1: Comparative Impacts of Wood Combustion versus Alternative Primary Fuels***

| Pollutant | Wood | Coal | | Distillate Fuel Oil | | Residual Fuel Oil | | Natural Gas | |
|---|---|---|---|---|---|---|---|---|---|
| | Combustion | Combustion | Combustion plus Upstream | Combustion | Combustion plus Upstream | Combustion | Combustion plus Upstream | Combustion | Combustion plus Upstream |
| | ---------- *lb./MMBtu* ---------- | | | | | | | | |
| *Criteria Pollutants* | | | | | | | | | |
| PM2.5 | - | - | - | - | - | - | - | - | - |
| PM10 | 0.019 | 0.054 | 0.054 | 0.011 | 0.011 | 0.093 | 0.093 | 0.009 | 0.009 |
| PM, unspecified | - | - | 0.246 | - | 0.012 | - | 0.012 | - | 0.004 |
| NOx | 0.167 | 0.482 | 0.504 | 0.173 | 0.234 | 0.367 | 0.428 | 0.301 | 0.417 |
| VOCs | - | 0.006 | 0.014 | 0.001 | 0.363 | 0.002 | 0.367 | 0.009 | 0.524 |
| SOx | 0.008 | 1.446 | 1.469 | 0.209 | 0.394 | 1.593 | 1.781 | 0.073 | 1.985 |
| CO | 1.511 | 0.068 | 0.085 | 0.036 | 0.082 | 0.033 | 0.079 | 0.058 | 0.282 |
| Pb | $1.33x10^{-4}$ | $8.93x10^{-6}$ | $9.19x10^{-6}$ | $4.60x10^{-6}$ | $5.61x10^{-6}$ | $5.80x10^{-5}$ | $5.90x10^{-5}$ | - | $2.72x10^{-7}$ |
| Hg | - | $2.05x10^{-6}$ | $2.14x10^{-6}$ | $1.58x10^{-6}$ | $1.77x10^{-6}$ | $8.67x10^{-6}$ | $8.85x10^{-6}$ | - | $7.18x10^{-8}$ |

**Source:**
Franklin Associates 1998.
**Note:**
"-" signifies data not available; may equal zero.

The emission information presented in this table is derived from Life Cycle Inventory (LCI) data, as compiled by Franklin Associates. LCI data identifies and quantifies resource inputs, energy requirements, and releases to the air, water, and land for each step in the manufacture of a product or process, from the extraction of the raw materials to ultimate disposal. The LCI can be used to identify those system components or life cycle steps that are the main contributors to environmental burdens such as energy use, solid waste, and atmospheric and waterborne emissions. Uncertainty in an LCI is due to the cumulative effects of input uncertainties and data variability.

There are several life cycle inventory databases available in the U.S. and Europe. For this paper, we applied the most readily available LCI database that was most consistent with the materials and uses examined. These LCI data rely on system boundaries as defined by Franklin Associates, as described in the documentation for this database, available at: http://www.pre.nl/download/manuals/DatabaseManualFranklinUS98.pdf.

## References

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