Technical references related to forest biomass harvesting

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1. Berger, A. L., Palik, B., D’Amato, A. W., Fraver, S., Bradford, J. B., Nislow, K., King, D., & Brooks, R. T. (2013). Ecological impacts of energy-wood harvests: Lessons from whole-tree harvesting and natural disturbance. Journal of Forestry. 111(2): 139-153., 111(2), 139–153. https://doi.org/10.5849/jof.12-020
    a. **Key points:** There is a gradient of increasing structural departure ranging from conventional harvesting to whole tree harvesting to energy wood harvesting, compared to natural disturbance. The authors suggest that whole tree harvesting studies provide the best insight into the impacts of energy wood harvesting on forest structure and function. However, energy wood harvesting that include the removal of stumps, large and fine deadwood, and small diameter living stems would venture into a large unexplored region of harvesting impact research.
2. Bergman, R., Puettmann, M., Taylor, A., & Skog, K. E. (2014). The Carbon Impacts of Wood Products. Forest Prod. J. Volume 64, Number 7/8, 2014; Pp. 220–231., 64(7/8), 220–231. https://doi.org/10.13073/FPJ-D-14-00047
    a. **Key points:** Woody biofuel use and the store of carbon in wood products has reduced carbon emissions impacts, and therefore results in lower net carbon emissions compared to non-wood product alternatives.
3. Bergman, R., Sahoo, K., Englund, K., & Mousavi-Avval, S. H. (2022a). Lifecycle Assessment and Techno-Economic Analysis of Biochar Pellet Production from Forest Residues and Field Application. Energies Journal, 15(4), 1–18. https://doi.org/10.3390/en15041559
    a. **Key points:** The authors concluded that biochar production from forest residues with portable systems is environmentally beneficial and economically viable.
4. Lee Bloomquist, “Knock on wood, it’s been going great – Hibbing Public Utilities re-fires wood boiler”. Business North News. February 21, 2022. http://www.businessnorth.com/businessnorth_exclusives/knock-on-wood-it-s-been-going-great/article_9b1f6652-9342-11ec-93f1-afdd3db91c6a.html
    a. **Key points:** Hibbing Public Utilities, a steam and electrical generating facility, re-started its biomass boiler in December 2021, and the boiler was already paying off within the first month of operation. The article states that wood is a baseload resources that can be depended on “24/7”, unlike solar and wind. The facility bought $251,000 in wood chips during the first month, which is now being circulated throughout the iron range in the form of heat and electricity.
5. Brown, R. N., Ek, A. R., & Kilgore, M. A. (2007). An assessment of dead wood standards and practices in Minnesota. [Report]. University of Minnesota. http://conservancy.umn.edu/handle/11299/37716
    a. **Key points:** This review describes the amount of dead wood in MN forests, its importance to forest health, policies related to its management, and the level of compliance to these guidelines. MN timberland has more than 270 million

standing dead trees, with an average of 7.87 cords of coarse woody debris (CWD) per acre. The majority of CWD is small diameter, and the quality of CWD is very diverse. Current guidelines recommend leaving snags whenever possible, spreading slash, and leaving 2-5 bark-on downed logs greater than 12-inch diameter per acre scattered across the site. The study found that recommendations for CWD were met 79% of the time on general harvest sites, and 69% in RMZs.

6. Buchholz, T., Gunn, J. S., & Saah, D. S. (2017). Greenhouse gas emissions of local wood pellet heat from northeastern US forests. Energy, 141, 483–491. https://doi.org/10.1016/j.energy.2017.09.062
    a. **Key points:** The use of sawmill residues for pellets resulted in the strongest greenhouse gas benefits compared to fossil fuels, with benefits from up to 75% pulpwood and 25% sawmill residue. The authors suggest that shifting the existing harvest of pulpwood volume to pellets is a beneficial climate solution.
7. Buchholz, T., Gunn, J., Springsteen, B., Marland, G., Moritz, M., & Saah, D. (2021). Probability-based accounting for carbon in forests to consider wildfire and other stochastic events: Synchronizing science, policy, and carbon offsets. Mitigation and Adaptation Strategies for Global Change, 27(1), 4. https://doi.org/10.1007/s11027-021-09983-0
    a. **Key points:** Probability-based greenhouse gas accounting can integrate events such as wildfire, drought, or insect damage in carbon accounting for offset registries. This approach can incentivize forest restoration treatments that would promote long-term carbon stabilization (such as by reducing wildfire risk) and can be implemented cost-effectively.
8. Domke, G. M., Becker, D. R., D'Amato, A. W., Ek, A. R., & Woodall, C. W. (2012). Carbon emissions associated with the procurement and utilization of forest harvest residues for energy, northern Minnesota, USA. Biomass and Bioenergy. 36: 141-150., 36, 141–150. https://doi.org/10.1016/j.biombioe.2011.10.035
    a. **Key points:** The results suggest that there is an initial carbon debt with the utilization of harvest residues for energy, but this debt is repaid over time through emissions from decomposition.
9. Domke, G. M., Walters, B. F., Nowak, D. J., Smith, J., Nichols, M. C., Ogle, S. M., Coulston, J. W., & Wirth, T. C. (2021). Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990–2019. https://doi.org/10.2737/FS-RU-307
    a. **Key points:** Forest land, harvested wood products, and urban trees offset more than 11% of total greenhouse gas emissions annually, and 14% of carbon dioxide emissions. Live vegetation in forests and urban trees compose 80% of the carbon sink strength. Conversions from forested land to non-forested land results in net emissions. 55% of all carbon in forest ecosystems is stored in the soil, and this stock experiences minimal changes annually. Carbon storage in harvested wood products continues to increase annually.
10. Reed, D., Bergman, R., Kim, J.-W., Tayler, A., Harper, D., Jones, D., Knowles, C., & Puettmann, M. E. (2012). Cradle-to-Gate Life-Cycle Inventory and Impact Assessment of Wood Fuel Pellet Manufacturing from Hardwood Flooring Residues in the Southeastern United States. Forest Prod. J. Volume 62, Number 4, 2012; Pp. 280–288. 2012, 62(4), 280–288.

   a. **Key points:** Life-cycle inventory and impact assessment showed that wood pellets provide a net renewable energy source. The fossil emission reductions when combusting pellets compared with natural gas varies from 123% reduction when the flooring burdens are allocated to the pellets based on their relative value to 56% when mass allocation is assumed.

11. Sahoo, K., Alanya-Rosenbaum, S., Bergman, R., Abbas, D., & Bilek, E. M. (Ted). (2021). Environmental and Economic Assessment of Portable Systems: Production of Wood-Briquettes and Torrefied-Briquettes to Generate Heat and Electricity. Fuels, 2(3), 345–366. https://doi.org/10.3390/fuels2030020
    a. **Key points:** The use of forest residues to make densified products and burn them to produce heat was environmentally better and economical compared to fossil fuel-based alternatives (e.g., propane). The authors concluded that utilizing forest residues to make wood briquettes and torrefied wood briquettes with portable systems and using them to make heat as well as electricity are economical and provide much lower carbon footprints.