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Biodiversity and Biomass Feedstock in the Southeastern US

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Introduction

When burned, fossil fuels release greenhouse gases that contribute to climate change. Bioenergy, primarily from plant-based sources, is one alternative that can help reduce dependence on fossil fuels and have positive climate effects (Malmberg 2021). Sustainably managed forests can be used to source biomass feedstock to provide fiber for bioenergy products, such as wood-based pellets or liquid fuels (Dale et al. 2017a). The term "biomass" has different uses in different contexts. Scientifically, biomass refers to the total mass of organic material that comes from plants and animals. In a forestry context, biomass refers to the dry weight of wood and other plant material. However, in the context of renewable energy from biological materials, biomass may refer to the feedstock of a bioenergy facility. In this briefing note, we will use the term "biomass" to refer to the quantity of cellulosic material from forests, either measured in forest inventories or converted to forest products. We use the term "biomass feedstock" to refer specifically to feedstocks for facilities that use biological materials from forests to produce bioenergy.

In the southeastern US, wood-based pellets for biomass feedstock are produced from a wide diversity of both hardwood and pine (*Pinus* spp.) species. Fiber for biomass is obtained from standard forest harvest operations, such as a final harvest in even-aged management (clearcut) or an intermediate harvest, such as thinning. From these harvest operations, biomass feedstock is primarily sourced from harvest residues (e.g., tops and limbs excluding stumps) and low-grade roundwood (small, diseased, or malformed trees). Larger dimension and higher quality trees are primarily used as sawtimber for solid wood products, such as dimension lumber and furniture, mostly due to the higher value of these wood products (NCASI 2022).

Some forest stakeholders have expressed concern about biodiversity responses to harvesting for biomass feedstock, use of hardwoods for biomass feedstock, and overall sustainability of forest stands where at least part of the harvested biomass is used for biomass feedstock. Biodiversity in managed forests is relatively well-studied, including biodiversity responses to specific components of forest management, such as site preparation and planting, thinning, and final harvest (for even-aged management). This briefing note examines how harvesting for biomass feedstock relates to forest harvesting and identifies current knowledge gaps concerning biodiversity response to this harvesting. It is important to note that the fate of harvested wood does not affect

Photo caption: Pine forest logging - Biodiversity responds to the structure created by forest harvest, not the products derived from the harvested wood.

biodiversity; instead, biodiversity responds to forest management activities and how these practices influence resultant forest structure.

1.0 Sustainable Forest Management

Sustainable forestry certification systems [e.g., Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), American Tree Farm System (ATFS)] compel certificate holders to conserve biodiversity throughout the forest cycle, including during harvest, regardless of the fate of harvested wood (e.g., biomass feedstock, lumber, pulp, etc.). Forest harvest in the southeastern US is also subject to state and regional forest biomass harvesting guidelines (Titus et al. 2021 and searchable Excel spreadsheets in supplemental materials[1]). These guidelines differ by state (US) and country (Titus et al. 2021), but all are largely adhered to via participation in sustainable forestry programs. Most of these guidelines fall within the context of state regulations or guidelines or certification programs (e.g., FSC, Programme for the Endorsement of Forest Certification; Titus et al. 2021). It is noteworthy that biomass guidelines almost universally include statements about protecting biodiversity, such as retaining forest structures for wildlife and biodiversity[2].

An expanding bioenergy market (e.g., wood-based pellets) has raised concerns by some forest stakeholders about deforestation (permanent loss of forest cover) and accompanying negative effects on biodiversity. However, a sustainable source of fiber is critical for long-term business plans of forest products companies, and deforestation is counter to this. Certification systems and regulations for use of wood for electricity generation and heat (e.g., the REDD-plus process; Christophersen and Stahl 2011) specify criteria for forest conservation and prohibit bioenergy manufacturers from depleting the forest resource. A detailed study of this question found that the introduction of wood pellet manufacturers in two woodsheds did not result in wood resource depletion (Dale et al. 2017a) and contributed to local markets for wood. Kline et al. (2021) further found that wood pellet production contributes to sustainability goals.

Based on an evaluation of FIA data, NCASI found no evidence of a decline in hardwood forest area in the southeastern US and found that even a doubling of wood pellet production would not increase harvest or conversion to non-forest land uses (NCASI 2022). It is also important to note that sourcing biomass feedstock diversifies opportunities for forest landowners and loggers (Garren et al. 2022; Dale et al. 2017b). In many areas of the southeastern US, there is a general lack of market for smaller diameter pine trees, for example, that are growing in dense stands. These dense stands provide only low-quality wildlife habitat and can increase the risk of forest health issues. The ability to reduce the tree density of these stands may be enhanced with thinning or harvesting for biomass feedstock (e.g., Kline et al. 2021; Dale et al. 2017a). The additional market for small trees and tops at final harvest also enhances landowner income and non-monetary benefits such as increased landowner satisfaction (Garren et al. 2022; Dale et al. 2017b).

2.0 Effects of Forest Management on Biodiversity

Clearcut harvesting is the dominant method of final harvest for southern pine, regardless of the harvested wood's fate. Clearcut harvests remove overstory, which can have short-term negative effects

[1] https://energsustainsoc.biomedcentral.com/articles/10.1186/s13705-021-00281-w#Sec27
[2] https://foreststewardsguild.org/wp-content/uploads/2019/05/FG_Biomass_Guidelines_SE.pdf

on species that require a forest overstory or specific microclimates, such as terrestrial salamanders (Tilghman et al. 2012). However, clearcut harvests roughly mimic natural, large-extent disturbances such as fire and windthrow (historically common in the southeastern US), and many organisms are adapted to the resultant young, open forest conditions. This includes at-risk species such as gopher tortoise (*Gopherus polyphemus,* Parish et al. 2020); early successional-associated birds (Grodsky et al. 2016; Lane et al. 2011; Hanberry et al. 2012; Hanberry et al. 2013), many of which are declining (King and Schlossberg 2013); reptiles (Jones et al. 2020); and species of economic and recreational importance, such as white-tailed deer (*Odocoileus virginianus*). When considered at a landscape scale, the mosaic of stand stages resulting from active forest management provides structural conditions to support diverse wildlife communities (e.g., Demarais et al. 2017).

Thinning, a common practice in forest management, removes a portion of the trees in a stand to increase residual tree growth, reduce tree density, and thus improve economic performance of a stand. Thinned trees can be chipped for pulp, chipped and sawed (based on tree size), or used as biomass feedstock. Thinning has positive and negative, but mostly neutral, short-term effects on multiple taxa, depending on the system, metric, and species or species group (Petrokofsky et al. 2020; Verschuyl et al. 2011). However, thinning increases open canopy conditions that allows development of the forest understory, which is favorable for many species that require an herbaceous understory, such as gopher tortoises (Greene et al. 2016), or forest midstory, such as many bird species (Verschuyl et al. 2011). It is important to note that canopy gaps are a natural part of unmanaged forests (McCarthy 2001). Thinning is thus within the normal range of forest disturbances. Thinning also provides forest managers with a tool to manipulate forest structure and create or maintain diverse forest stand conditions, especially if thinning is combined with other silvicultural treatments, such as selective herbicide and/or prescribed fire. For example, see Iglay et al. (2014).

Focusing on the short-term response to thinning can be misleading, as it may take more than a growing season for the stand to respond to the reduced tree density resulting from thinning and any subsequent treatments, such as prescribed fire or selective herbicide. These subsequent treatments, or mid-rotation management practices, are often used to extend open canopy conditions following a thinning (Iglay et al. 2014). As alluded to above, mid-rotation management practices can promote development of a pine-grassland structure, which largely increases plant and wildlife diversity (Iglay et al. 2014; Iglay et al. 2018). If additional woody material is removed for biomass feedstock during thinning, and prior to other management practices, further benefits for biodiversity may be realized if overstory and midstory tree density are reduced and sunlight exposure is increased for understory plant development. It is important to note that thinning is merely one management practice within forest stands in the context of entire landscapes managed for different purposes and harvested at different times, including unmanaged land or land in reserves. This complex mosaic of forest conditions is favorable to a diversity of wildlife communities that depend on different forest types and ages.

Photo caption: Thinned stand – Forest thinning, which can result from harvest of trees for biomass feedstock, is generally beneficial for a diversity of wildlife species.

2.1 Removal of Logging Residuals

Removal of logging residuals (tops, small limbs, stumps) is a possible source for biomass feedstock. Experimental studies of this practice have found some potential adverse effects, similar to effects of harvesting in general, such as on diversity and abundance of cavity-nesting birds, open-canopy nesting birds, and biomass of invertebrates (Riffell et al. 2011). However, Grodsky et al. (2016) found that winter birds in North Carolina responded more to the structural and vegetation conditions of a stand than the amount of downed wood removed from a forest stand. Additionally, Ranius et al. (2018) noted that other studies found neutral or both positive and negative effects on different taxa.

It is important to note that complete biomass removal is, in actual practice, rare. For example, in North Carolina, Fritts et al. (2014) showed that even when woody residuals were removed without following Biomass Harvesting Guidelines for an experimental treatment (which was intended to remove all woody residuals), approximately 20% of total downed woody debris (DWD, all branches and logs on the ground) was retained when compared to clearcut stands not harvested for biomass feedstock, illustrating that complete biomass removal is not practical. Following biomass harvesting guidelines, 35-52% of total DWD was retained in stands with residual removal compared to stands without residual removal (Fritts et al. 2014).

Photo caption: Biomass study – This is a plot in a study in North Carolina, supported by NCASI, Weyerhaeuser Company, and other partners, that investigated effects of biomass harvest on biodiversity.

More generally, several studies have focused on biodiversity response to coarse woody debris (CWD), large DWD, and sometimes snags (standing dead trees) and stumps (Enrong et al. 2006). These studies show variation among species, taxa, and regions (Donner et al. 2017). For example, southern toads (*Anaxyrus terrestris*) do not require CWD at night but were found to use CWD as refugia during daytime hours when there is a higher risk of desiccation (Fritts et al. 2015a). However, Fritts et al. (2015a) also noted that, when available, southern toads used other cover sources (e.g., vegetation), providing evidence for behavioral plasticity and perhaps less reliance on CWD. Some findings suggest that in regions where CWD decomposes quickly, including in much of the southern US, CWD may not be an essential resource (Boggs et al. 2020). In fact, over a nine-year experiment of CWD manipulations, rodent populations and community dynamics were not affected by varying CWD amounts in South Carolina (Larsen-Gray et al. 2021). Similarly, Fritts et al. (2015b) found that shrew abundance was affected by vegetation characteristics more than by DWD (as a combination of fine woody debris and CWD) in North Carolina and Georgia. Furthermore, a recent study highlighted the importance of considering beta (compositional) diversity rather than alpha (richness) diversity when studying community response to residual removal (Jones et al. 2022). Jones et al. (2022) found alpha diversity was lower in areas of residual removal. However, beta diversity (which accounts for species identification) was more stable among treatments because, while some species were lost from certain areas, others were gained (Jones et al. 2022).

3.0 Knowledge Gaps

As noted above, biodiversity response to forest management is well studied. Yet, there are limited studies specifically investigating biodiversity response to forest management with the goal of residual removal for biomass feedstock. This knowledge gap is highlighted by Petrokofsky et al. (2020), who reported that only 21% (n=44) of their systematic review studies (n=211) were specific to biodiversity responses of forest harvesting to extract material for biomass feedstock. Furthermore, Petrokofsky et al. (2020) called for more research on fungi, soil and humus biota, and understory vegetation responses to forest management (particularly when harvesting residuals is included). Similarly, Donner et al. (2017) reported that saproxylic organisms (e.g., invertebrates and fungi) are likely to be affected by removing woody residuals, as they are more directly dependent on dead or decaying wood, but there is limited research on these taxa. Additionally, future studies should consider analyzing diversity data as beta diversity rather than alpha diversity, as beta diversity provides more information about community composition than simply species richness (Jones et al. 2022).

4.0 Summary

Conducting research to fill knowledge gaps may be useful; however, as indicated above, the practices used to manage and harvest a forest stand are what influence biodiversity response, not the types of products derived from the trees and residues harvested from that stand. Overall, removal of logging residuals during harvest in the southeastern US is not a practice that should cause concern relative to loss or reduction of biodiversity, reduction in hardwood forests, or deforestation (NCASI 2022). As cited above, biodiversity responses to forest structure and harvest of wood for biomass feedstock, including residuals, should be evaluated within the framework of sustainable forest management along with other forest harvesting activities. Finally, it should be recognized that biodiversity in an area responds to disturbances within a stand and across the landscape irrespective of how the harvested materials are ultimately used as products.

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References

Boggs, A.D., Moorman, C.E., Hazel, D.W., Greenberg, C.H., and Pacifici, K. 2020. Relationships between white-footed mice and logging residue: Informing the sustainability of potential wood bioenergy harvests. *Forest Ecology and Management* 457(1):117706. https://doi.org/10.1016/j.foreco.2019.117706

Christophersen, T., and Stahl, J. 2011. REDD-plus and biodiversity. CBD Technical Series No. 59. Secretariat of the Convention on Biological Diversity. 65pp. https://www.cbd.int/doc/publications/cbd-ts-59-en.pdf

Dale, V.H., Parish, E., Kline, K.L., and Tobin, E. 2017a. How is wood-based pellet production affecting forest conditions in the southeastern United States? *Forest Ecology and Management* 396:143-149. https://doi.org/10.1016/j.foreco.2017.03.022

Dale, V.H., Kline, K.L., Parish, E.S., Cowie, A.L., Emory, R., Malmsheimer, R.W., Slade, R., Smith, C.T., Wigley, T.B., Bentsen, N.S., Berndes, G., Bernier, P., Brandão, M., Chum, H.L., Diaz-Chavez, R., Egnell, G., Gustavsson, L., Schweinle, J., Stupak, I., et al. 2017b. Status and prospects for renewable energy using wood pellets from the southeastern United States. *GCB Bioenergy* 9(8):1296–1305. https://doi.org/10.1111/gcbb.12445

Demarais, S., Verschuyl, J.P., Roloff, G.J., Miller, D.A., and Wigley, T.B. 2017. Tamm Review: Terrestrial vertebrate biodiversity and intensive forest management in the U.S. *Forest Ecology and Management* 385:308-330. https://doi.org/10.1016/j.foreco.2016.10.006

Donner, D.M., Wigley, T.B., and Miller, D.A. 2017. Forest biodiversity and woody biomass harvesting. In Efroymson, R.A., Langholtz, M.H., Johnson, K.E., and Stokes, B.J. (editors) *Advancing domestic resources for a thriving bioeconomy, Volume 2: Environmental sustainability effects of select scenarios from volume 1*. Chapter 11 (pages 398-447). ORNL/TM-2016/727. Oak Ridge, TN: US Department of Energy, Oak Ridge National Laboratory. https://doi.org/10.2172/1338837

Enrong, Y., Wang, X., and Huang, J. 2006. Concept and classification of coarse woody debris in forest ecosystems. *Frontiers of Biology in China* 1:76-84. https://doi.org/10.1007/s11515-005-0019-y

Fritts, S.R., Moorman, C.E., Hazel, D.W., and Jackson, B.D. 2014. Biomass Harvesting Guidelines affect downed woody debris retention. *Biomass and Bioenergy* 70:382-391. https://doi.org/10.1016/j.biombioe.2014.08.010

Fritts, S.R., Grodsky, S.M., Hazel, D.W., Homyack, J.A., Castleberry, S.B., and Moorman, C.E. 2015a. Quantifying multi-scale habitat use of woody biomass by southern toads. *Forest Ecology and Management* 346:81-88. https://doi.org/10.1016/j.foreco.2015.03.004

Fritts, S.R., Moorman, C.E., Grodsky, S.M., Hazel, D.W., Homyack, J.A., Farrell, C.B., and Castleberry, S.B. 2015b. Shrew response to variable woody debris retention: Implications for sustainable forest bioenergy. *Forest Ecology and Management* 336:35-43. https://doi.org/10.1016/j.foreco.2014.10.009

Garren, A.M., Bolding, M.C., Barrett, S.M., Aust, W.M., and Coates, T.A. 2022. Characteristics of forest biomass harvesting operations and markets in Virginia. *Biomass and Bioenergy* 163:106501. https://doi.org/10.1016/j.biombioe.2022.106501

Greene, R.E., Iglay, R.B., Evans, K.O., Miller, D.A., Wigley, T.B., and Riffell, S.K. 2016. A meta-analysis of biodiversity responses to management of southeastern pine forests—opportunities for open pine conservation. *Forest Ecology and Management, Special Section: Forest Management for Climate Change* 360:30-39. https://doi.org/10.1016/j.foreco.2015.10.007

Grodsky, S.M., Moorman, C.E., Fritts, S.R., Hazel, D.W., Homyack, J.A., Castleberry, S.B., and Wigley, T.B. 2016. Winter bird use of harvest residues in clearcuts and the implications of forest bioenergy harvest in the southeastern United States. *Forest Ecology and Management* 379:91-101. https://doi.org/10.1016/j.foreco.2016.07.045

Hanberry, B.B., Hanberry, P., Riffell, S.K., Demarais, S., and Jones, J.C. 2012. Bird assemblages of intensively established pine plantations in Coastal Plain Mississippi. *The Journal of Wildlife Management* 76(6):1205-1214. https://doi.org/10.1002/jwmg.361

Hanberry, B.B., Hanberry, P., Riffell, S.K., Demarais, S., and Jones, J.C. 2013. Wintering birds in intensively established pine plantations of Coastal Plain Mississippi. *Southern Journal of Applied Forestry* 37(2):91-96. https://doi.org/10.5849/sjaf.11-028

Iglay, R.B., Greene, R.E., Leopold, B.D., and Miller, D.A. 2018. Bird conservation potential of fire and herbicide treatments in thinned pine stands. *Forest Ecology and Management* 409:267-275. https://doi.org/10.1016/j.foreco.2017.11.021

Iglay, R.B., Leopold, B.D., and Miller, D.A. 2014. Vegetation responses to fire and herbicide in intensively managed, mid-rotation pine. *Forest Ecology and Management* 328:69-78. https://doi.org/10.1016/j.foreco.2014.05.029

Jones, G.M., Smith, L., Gottlieb, I.G.W., Ober, H.K., Brosi, B., and Fletcher Jr., R.J. 2020. Herpetofaunal responses to intensification of woody bioenergy production in a global biodiversity hotspot. *Forest Ecology and Management* 477:118493. https://doi.org/10.1016/j.foreco.2020.118493

Jones, G.M., Brosi, B., Evans, J.M., Gottlieb, I.G W., Loy, X., Núñez-Regueiro, M.M., Ober, H.K., Pienaar, E., Pillay, R., Pisarello, K., Smith, L.L., and Fletcher, R.J. 2022. Conserving alpha and beta diversity in wood-production landscapes. *Conservation Biology* 36(3): e13872. https://doi.org/10.1111/cobi.13872

King, D.I., and Schlossberg, S. 2014. Synthesis of the conservation value of the early-successional stage in forests of eastern North America. *Forest Ecology and Management* 324:186-195. https://doi.org/10.1016/j.foreco.2013.12.001

Kline, K.L., Dale, V.H., Rose, E., and Tonn, B. 2021. Effects of production of woody pellets in the southeastern United States on the sustainable development goals. *Sustainability* 13(s):821. https://doi.org/10.3390/su13020821

Lane, V.R., Miller, K.V., Castleberry, S.B., Cooper, R.J., Miller, D.A., Wigley, T.B., Marsh, G.M., and Mihalco, R.L. 2011. Bird community responses to a gradient of site preparation intensities in pine plantations in the Coastal Plain of North Carolina. *Forest Ecology and Management* 262(9): 1668-1678. https://doi.org/10.1016/j.foreco.2011.07.029

Larsen-Gray, A.L., Loeb, S.C., and Kalcounis-Rueppell, M.C. 2021. Rodent population and community responses to experimental, large scale, long-term coarse woody debris manipulations. *Forest Ecology and Management* 496:119427. https://doi.org/10.1016/j.foreco.2021.119427

McCarthy, J. 2001. Gap dynamics of forest trees: A review with particular attention to boreal forests. *Environmental Reviews* 9(1):1-59. https://doi.org/10.1139/a00-012

NCASI. 2022. *Trends in forest harvest, regeneration, and management in the southeastern United States as related to biomass feedstock*. Briefing Note. Cary, NC: National Council for Air and Stream Improvement, Inc.

______. 2021. *Greenhouse gas reductions for the US pulp and paper industry*. White Paper (WP-21-07). Cary, NC: National Council for Air and Stream Improvement, Inc.

Parish, E.S., Baskaran, L.M., and Dale, V.H. 2020. Framework for assessing land-management effects on at-risk species: Example of SE USA wood pellet production and gopher tortoise (*Gopherus polyphemus*). *WIREs Energy and Environment* 10(1):e385. https://doi.org/10.1002/wene.385

Petrokofsky, G., Hooper, O., Petrokofsky,L., Gant, A.E., Harvey, W.J., and Willis, K.J. 2020. What are the impacts of the wood pellet industry on biodiversity in southeastern USA? A systematic evidence synthesis. *Forest Ecology and Management* 483:118773. https://doi.org/10.1016/j.foreco.2020.118773

Ranius, T., Hämäläinen, A., Egnell, G., Olsson, B., Eklöf, K., Stendahl, J., Rudolphi, J., Sténs, A., and Felton, A. 2018. The effects of logging residue extraction for energy on ecosystem services and biodiversity: A synthesis. *Journal of Environmental Management* 209:409-425. https://doi.org/10.1016/j.jenvman.2017.12.048

Riffell, S., Verschuyl, J., Miller, D., and Wigley, T.B. 2011. Biofuel harvests, coarse woody debris, and biodiversity—A meta-analysis. *Forest Ecology and Management* 261(4):878-887. https://doi.org/10.1016/j.foreco.2010.12.021

Tilghman, J.M., Ramee, S.W., and Marsh, D.M. 2012. Meta-analysis of the effects of canopy removal on terrestrial salamander populations in North America. *Biological Conservation* 152:1-9. https://doi.org/10.1016/j.biocon.2012.03.030

Titus, B.D., Brown, K., Helmisaari, H.S., Vanguelova, E., Stupak, I., Evans, A., Clarke, N., Guidi, C., Bruckman, V.J., Varnagiryte-Kabasinskiene, I., Armolaitis, K., de Vries, W., Hirai, K., Kaarakka, L., Hogg, K., and Reece, P. 2021. Sustainable forest biomass: A review of current residue harvesting guidelines. *Energy, Sustainability and Society* 11(1):10. https://doi.org/10.1186/s13705-021-00281-w

Verschuyl, J., Riffell, S., Miller, D., and Wigley, T.B. 2011. Biodiversity response to intensive biomass production from forest thinning in North American forests—A meta-analysis. *Forest Ecology and Management* 261(2):221-232. https://doi.org/10.1016/j.foreco.2010.10.010