Wood-based pellets in Southeastern US

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Effects of pellet production on selected Sustainability Development Goals (SDGs) are evaluated using industry information, available energy consumption data, and published research findings. Challenges associated with identifying relevant SDG goals and targets for this particular bioenergy supply chain and potential deleterious impacts are discussed. We find that production of woody pellets in the SE US and shipments to displace coal for energy in Europe generate positive effects on affordable and clean energy (SDG 7), decent work and economic growth (SDG 8), industry innovation and infrastructure (SDG 9), responsible consumption and production (SDG 12), and life on land (SDG 15). Primary strengths of the pellet supply chain in the SE US are the provisioning of employment in depressed rural areas and the displacement of fossil fuels. Weaknesses are associated with potential impacts on air, water, and biodiversity that arise if the resource base and harvest activities are improperly managed. The SE US pellet supply chain provides an opportunity for transition to low-carbon industries and innovations while incentivizing better resource management.

Keywords: bioenergy ; forests ; pellets ; sustainability SDGs

1. Introduction

Wood-based pellets are produced in the southeastern United States (SE US) and shipped to Europe for the generation of heat and power. Since 2007, wood-based pellets have been produced in the southeastern United States (SE US) and shipped primarily to Europe for the generation of heat and power. As such, the supply chain has implications for forests in the SE region of the US, local forestry-sector employment, trans-Atlantic trade, and European efforts to reach renewable energy goals. Areas that source biomass for wood pellets in the SE US range across 13 states, from the Atlantic seaboard in the east (Virginia, North and South Carolina, Georgia, and Florida) to the eastern fringes of Oklahoma and Texas in the west, with Louisiana, Mississippi, and Alabama along the Gulf of Mexico and north to include the land-locked states of Arkansas, Tennessee, and Kentucky. In this paper, the SE US includes these 13 states (Figure 1). However, states that lead production of wood pellets for bioenergy are those with efficient access to large shipping ports such as North Carolina and Georgia.

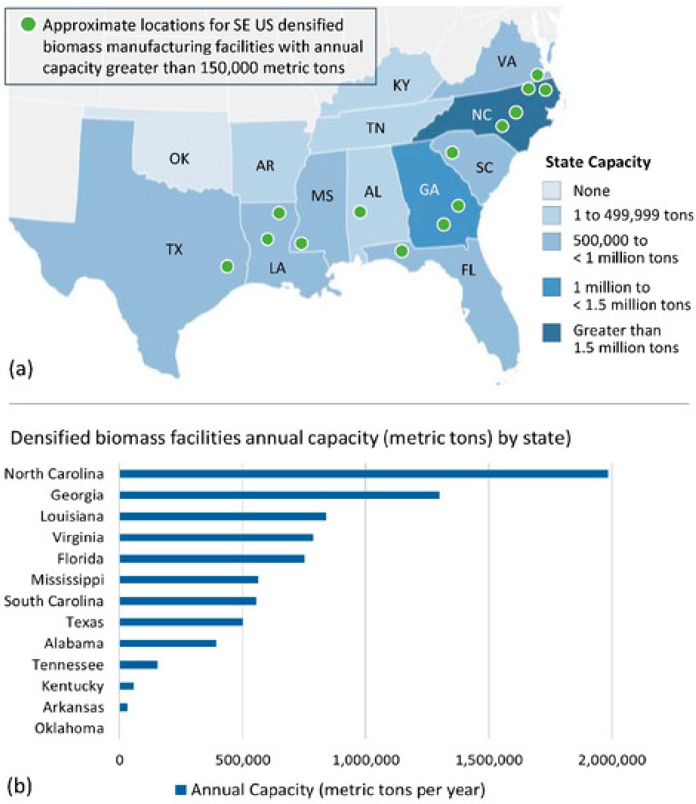

Figure 1. (**a**) SE US states and approximate locations of largest operating pellet mills; (**b**) annual operational production capacity by state reported by the US Energy Information Administration as operating in September 2020.

History of supply chain and land management in the southeast U.S.

Understanding the wood pellet supply chain requires some knowledge of the history of the timberlands in the SE US from which the pellets are sourced. Timberland is defined by the US Forest Service as "nonreserved forest land capable of producing at least 20 cubic feet of wood volume per acre per year"[1]. Timberlands are the primary source for woody biomass supporting SE forest industries. The timberland definition excludes reserved forest lands where logging is prohibited due to federal, state, or local restrictions. The definition includes land that is managed for forestry and meets the productivity threshold, even if land that has recently been logged or disturbed and temporarily lacks forest cover.

Before European settlement in the new world, SE US forests were actively managed by extensive and repeated use of fire for thousands of years by Native Americans[1][2][3]. Subsequent decades led to expanding settlements, large-scale logging, land clearing, and continued, widespread use of fire until the 20th century[4][5][6]. Up until the end of the Civil War in 1865, the landscape was dominated by large plantations for cotton, tobacco, rice, and other crops. Over centuries, as land was claimed for agriculture, accessible mature forest stands were logged, with a boom in timber removal from 1860 to the 1920s[7]. However, steep slopes, thin soils, and climatic conditions make much of the landscape unsuited to agriculture. Fields suffered from soil erosion and nutrient depletion and were abandoned over time to become secondary forests[8][9]. The composition and extent of secondary forests reflects historical disturbances, competing land uses, and anthropogenic enhancement or suppression of fire[4]. Over the course of the twentieth century, agriculture production in the US shifted to the midwestern states, and forests in the SE recovered (Box 1). Thus, this region supports more forests today than it did a century ago[1][7].

Box: Historic patterns and drivers of forest transitions in the SE US.

The land-cover changes that lead to current forest cover and composition in the SE follow a general pattern since the 1920s. Land-cover transitions from open or scrubland, to secondary pine forests, to mature pine stands or to southern mixed hardwoods, and, in recent decades, to developed uses[9]. The location and timing of developments such as dams, wetland draining, river dredging, establishment of highways, and other human disturbances related to settlements and infrastructure, as well as natural disturbances (hurricanes, tornadoes, floods, droughts, wildfire), also influence today's forests.

Unlike other regions where political, regulatory, and geophysical boundaries offer protection to forests, extensive private forest lands in the SE US have few restrictions to conversion to other uses[10]. Indeed, conversion of forests to development and other uses and effects associated with climate change are among the top threats to the SE forest ecosystems today[9][11].

Analyses of the region's timber sector help illustrate that the types and rates of transition from agricultural lands to secondary forests and plantations varied temporally and spatially, e.g.,[12][13]. From the 1920s to 1950s, areas undergoing transitions were relatively small and dispersed, and change was gradual. Large pine plantations were rare, and forest recovery occurred as abandoned farm fields returned to pine or mixed pine-hardwood forests via natural regeneration. From 1950-1960, pine plantations began to increase rapidly, peaking at over 400,000 hectares per year in new plantations (or expansionary planting as opposed to replacement planting following timber harvest) in the early 1960s. This 1960–62 spike in tree planting is attributed to subsidies under the US Department of Agriculture (USDA) Soil Bank program[13]. A similar and more prolonged spike in expansionary tree planting occurred from 1986 to 2000, again catalyzed by USDA subsidies, as low crop prices led to massive enrollment to plant trees in the SE through the USDA Conservation Reserve Program (CRP). Eligibility for the Soil Bank and CRP subsidies was limited to private, non-industrial landowners. Their investments in tree planting created a large group of stakeholders among family farmers and small landowners distributed throughout the region. In 2017, these non-corporate owners held 57% of total timberland in the region [7]. As these subsidized pine plantations mature, they require harvest or management interventions. However, many dispersed, privately owned woodlots on former fields received little management attention after initial tree planting and, therefore, have become timberland stands of mixed species and qualities.

Private industrial interests, meanwhile, were accumulating land and establishing plantations in strategic locations per business plans. Annual rates of tree planting by these industrial parties reflects a gradual expansion of plantations designed to align future harvests with expected demand. Over the decades since 1950, corporate and industrial plantations have grown to represent about 30% of total timberland in the SE [7]. Corporate plantations tend to be clustered around large mills or near rail and water transport facilities and are more actively managed and harvested than non-corporate timberland.

Land ownership, tax laws, and external economic factors influence SE forest management and markets. Since the 1970s, tax and investment incentives have encouraged the widespread sale of large timberland real estate assets by the traditional forest product industry (i.e., industrial landowners such as Weyerhaeuser). Large timberland blocks have been sold to timberland real estate investment trusts, known as REITs, or other large institutional investors (e.g., endowments, foundations, state pension funds) who, in turn, hire timberland investment management organizations, or TIMOs to manage the forests [14]. Four major forest management groups in the SE US can now be distinguished by their distinct ownership and investment goals: private, non-industrial, family owners; TIMOs; REITs; and forest product company, industrial owners[14]. Unlike most other parts of the world, the influence of public land policies on forest products and biomass supply is minimal, as less than 13% of timberland in the SE is owned by federal, state, or local governments[7]. Furthermore, most public timberlands in the SE are managed for multiple uses other than timber production. Harvests from federal timberlands represented just one percent of total removals in 2016 in the SE US[7].

In addition to the effects of changing land management across the region's forest systems, the SE US experiences frequent disturbances to forests including floods, fire, insect outbreaks, droughts, tornadoes, hurricanes, and invasion of nonnative species[15]. Furthermore, climate change is fostering salt-water intrusion into coastal forests. While the SE US forests often quickly reestablish after perturbations, these landscapes are a patchwork of tree ages and species composition depending on the type, intensity, and time since past disturbances. Forest resources have been harvested for timber, chips, and pulp for centuries. However, large-scale production of densified biomass, or wood pellets, for energy and export is a new enterprise that has been rapidly growing since 2008.

The aim of this paper is to evaluate how the production of wood pellets in the SE US affects the Sustainable Development Goals (SDGs) adopted in 2015 by the United Nations (UN) General Assembly[16]. Seventeen SDGs were developed through a multi-year process facilitated by the UN to provide a "blueprint to achieve a better and more sustainable future for all" [17]. The SDGs are intended to be achieved by the year 2030, and each goal has specific targets[18]. The goals and targets are designed to acknowledge that ending poverty and other deprivations must build upon strategies to improve health and education, reduce inequality, and foster economic growth while also addressing climate change and preserving our oceans and forests. Hence, evaluating how production of wood pellets in the SE US affects the SDGs provides insights about opportunities and constraints for similar supply chains to contribute to the achievement of international goals for social, environmental, and economic improvements.

The SDGs set ambitious 2030 targets to sustainably manage forests, stop land degradation and biodiversity loss, and increase the use of renewable energy twofold [16]. To achieve these goals, it is essential to improve the efficiency and effectiveness of forest management, because forests support the livelihoods of more than 1.6 billion people as well as more than 80 percent of all terrestrial species of animals, plants, and insects [19]. Furthermore, economical, renewable fuels need to be provided in a way that is environmentally sound and socially accepted. Woody fuels are used by more than 3 billion people worldwide to meet basic energy needs[20]. Thus, producing wood-based energy in a way that helps achieve environmental, social, and economic goals simultaneously is strategically important for achieving progress toward the SDGs.

Woody biomass for bioenergy is promoted to help mitigate climate change through displacement of fossil fuels and by increasing the resilience of forest ecosystems as carbon sinks through better management of natural resources[21][22]. However, bioenergy's climate mitigation potential, as well as effects on other SDGs, depends, in part, on local conditions[23], as well as on the scale and intensity of production for different types of feedstock and their supply chains[24].

This paper represents one example of over 30 distinct supply chain analyses that are being assembled by the IEA Bioenergy inter-task project on the "Role of Bioenergy in a WB2/SDG world"[25]. Each case study summarizes a specific supply chain and its relationships with selected SDGs. The aim of the inter-task project is to expand and disseminate knowledge about how biomass production systems can be designed to contribute to the SDGs by improving conditions for society, biodiversity, and continued provision of multiple ecosystem services[25]. This paper contributes to that aim.

Here, we summarize the supply chain for procurement of wood pellets in the SE US including their transport to Europe and use for electricity and heat. The effects of the supply chain on the selected SDGs and established SDG targets are discussed. The benefits and challenges of this approach to evaluate progress toward sustainability are also discussed. Major lessons about the use of SDGs to assess sustainability of wood pellets based on this review and preliminary results of the IEA Bioenergy analysis of 20 systems are also presented.

2. Strengths and Weaknesses of the SE US Pellet Supply Chain

The strengths and weaknesses of the pellet supply chain in the SE US create both opportunities and threats, summarized in Table 1. Strengths of this supply chain include the displacement of fossil fuels (primarily coal) with bioenergy; support for renewable energy goals; conservation of forests through sustainable, green economy jobs; and more efficient use of waste materials. These strengths relate to SDGs and their targets as discussed above.

Table 1. Strengths, weaknesses, opportunities, threats of SE US pellet supply chain.

Strengths	**Opportunities**
• Displacement of fossil fuels (primarily coal) with bioenergy supports renewable energy goals • Reduced probability of losses and emissions due to wildfire, disease, and pests • Increased forest values strengthen incentives to retain private land in forests • Conservation of forests through green economy jobs and more efficient use of residues	• Economic and social benefits from transition to low-carbon economy industries • Dispatchable power to complement other intermittent renewable energy sources • More efficient, decentralized options to meet needs for reliable and affordable energy • Rural jobs, investments, and innovations • Expansion of incentives for management designed to benefit water quality and wildlife
Weaknesses	**Threats**
• Accounts for small share of forest industry products and employment • Lack of domestic policies to support local use • Prolongs utilization of centralized and relatively inefficient, thermal-electric generation • Detrimental for short-term GHG emissions • Potential negative impacts on water, air quality, biodiversity and other ecosystem services if improperly implemented	• Exclusions of wood-based bioenergy from renewable energy and climate programs • Lack of awareness of local conditions, culture, and land ownership and the likely alternatives if biomass markets are eliminated • Public perspectives driven by passion to protect forests without adequate scientific analysis of options to conserve and manage SE US forest ecosystems

Weaknesses include the fact that wood pellets represent a tiny fraction of SE forest products industries and thus have limited influence on market-based incentives. Yet pellet mills must rely on good management practices across the industry and invest resources to ensure sustainable sourcing of feedstocks. Another weakness is that opportunities for larger local benefits are being missed because, with the right policy incentives, more fossil fuels could be displaced in the SE US with locally produced pellets. In addition, pellet supply chains, like most energy technologies, could cause many potential negative impacts on water and air quality, biodiversity, and other ecosystem services if improperly implemented. These are examples of weaknesses linked to the SE US context of pellet production that are not captured when assessing progress toward SDG targets.

Other weaknesses of the pellet supply chain include relatively inefficient conversion of wood energy to power in electric power plants. This drawback supports a perception that renewable biomass extends the life of centralized thermal-electric stations that should be replaced with cleaner alternatives, such as wind and solar. Critics ask if the pellet supply chain extends the life of inefficient thermal-electric plants that would otherwise be retired. We find no data to quantify this potential weakness. Yet, reasonable concerns arise under conditions that involve co-firing with fossil fuels and extending the utilization of an inefficient plant that would otherwise be replaced. The concern can be addressed by employing state-of-the-art technologies and combined-heat-and-power plants designed for efficient energy conversion, distribution, and utilization. Furthermore, the transition to replace infrastructure for the distribution of electricity from existing central plants will be costly and take several decades. Dispatchable green power generation is needed to fill-in when other intermittent renewable sources such as wind and solar are insufficient to meet demand. Requirements for dispatchable power on existing infrastructure provide a niche for bioenergy until cleaner, distributed, renewable systems can be established to provide generation and storage capacity with full-time reliability. Hence, biomass supply chains are an essential element for more sustainable, circular economies envisioned to support the SDGs.

The weakness (Table 1) that the pellet supply chain could be counterproductive to GHG emission reductions in the short term depends on several context-specific factors. Woody biomass generates considerable emissions at the time and place of combustion, creating an immediate climate-forcing effect that is temporarily counterproductive unless the biomass would have been burned for disposal anyway. This immediate impact is compared to the time required for carbon payback, which can be estimated as the number of years needed for a forest to sequester the amount of carbon that is released throughout the supply chain as biomass is harvested, transported, and used for energy. The carbon payback time depends on how an analysis is temporally framed and other variables, ranging from the alternative fates for the feedstock to the type and location of sourcing forests[26][27]. If, as many models assume, a forest plot is clear-cut for only bioenergy purposes, the carbon payback time for a typical managed pine plantation in the SE US is calculated to be about 18 years, while mixed pine-hardwood, naturally regenerating forest stands may require three times longer[28][29]. However, forests in the SE US are primarily harvested for higher-value markets. The forest harvest and management operations generate tops, unmerchantable stems, and other residues. Only a portion of total forest industry residues, less than 10%, is used for pellet production. The alternate fates for the remaining 90% include (1) local combustion for process heat, drying, and energy to produce other forest industry products; or (2) rapid decay as mulch, animal bedding, or inefficient use as firewood and charcoal[30][31]. The carbon payback period compared to these alternative residue fates is short, on the order of months to a few years.

In contrast, the fossil fuels displaced offer no payback, for they represent the one-way movement of carbon from stable underground storage to the earth's atmosphere. Thus, even though natural gas generates electricity with fewer emissions per MW than pellets, such efficiency advantages are inconsequential if the same energy could be produced by sustainably sourced biomass from SE forest residues. The key difference is that the emissions from biomass would soon occur regardless of whether the biomass is used to produce electricity or not; whereas there would be no emissions if fossil fuels are retained in the ground. This difference illustrates how the complexities of emission accounting and alternative fates for feedstocks are critical determinants of social and environmental impacts but are not adequately captured in targets established for either SDG 9 or 13. It is important to take into account such limitations of the SDG indicators when setting goals for carbon emission reductions.

Weaknesses associated with negative impacts on water and air quality can arise if the pellet supply chain is not properly implemented or when local regulations are insufficient or not enforced. Best forest management practices are adapted to local conditions based on lessons learned from prior decades when forestry activities caused erosion and other downstream impacts, particularly when new access roads were involved, e.g.,[32]. While best management practices (BMPs) are required for forest certification and help mitigate negative effects such as accelerated erosion and soil degradation, additional practices are required for pellets to be certified to meet sustainability requirements. Local governments must not relax environmental regulation to attract economic development, a practice that led to cases where specific mills were found to create excessive air pollutants, e.g.,[33]. Civil society organizations can play a valuable role in identifying problems and promoting corrective actions when environmental safeguards are not met by industrial actors including those in forestry and the pellet supply chain.

3. Threats to the SE US Pellet Supply Chain

Threats to the supply chain include reliance on policies and subsidies that could be eliminated at any time, which would result in major disruptions in demand. That threat is exacerbated by concerns raised by groups who believe the pellet supply chain will cause deforestation rather than investments in improved forest management. An underlying threat is a lack of understanding, or limited knowledge and documentation, about local conditions in the SE US, such as the alternative fates for residues and private forest lands in the absence of demand for low-value biomass. Another threat is related to local impacts that large industrial mills have on neighbors (traffic, dust, noise, and air pollution), as the impacts can foment opposition to new mills and increase costs associated with expansion of the supply chain. Local resistance generated by both real and perceived impacts can hinder future bioenergy development and undermine political support[34]. Passionate opposition to the concept of “burning forests for energy” and proposals to tax bioenergy emissions without adequate compensation for supply chain impacts on forest management and carbon sequestration are factors that further erode public support and, if reflected in policies, not only threaten the supply chain but could be counterproductive to addressing climate-change goals[35].

4. Opportunities for the Pellet Industry to Make Progress toward Sustainability

A limited understanding by some of SE US forest ecosystems—as well as social, political, and cultural conditions—have fostered opposition to pellets as a renewable energy source. Yet, the wood pellet supply chain offers valuable opportunities to transition toward low-carbon industries (SDG 9). Increased efficiencies in the utilization of residues and local bioenergy resources, creation of sustainable rural jobs, and investments in rural infrastructure, skills, and innovations, are among the positive effects that can be realized in support of multiple SDGs. We recommend transparent and timely reporting, effective monitoring, and accountability to build trust and support for managing forest landscapes to provide multiple services to society. A pellet supply chain should be considered as one small piece to be integrated with other landscape management goals.

To realize the stated vision for a "just transition towards environmentally sustainable economies and societies for all", the International Labour Organization (ILO) promotes the concept that "greening" should achieve social objectives and be considered within the context of poverty eradication[36] (p. 4). According to the ILO, low-carbon economies, such as those supported by the SE US pellet supply chain, have the potential to generate decent jobs, advance social inclusion, and enhance resilience. While some studies find that pellet supply chains support such goals, e.g.,[37][38], some stakeholders raise questions about environmental justice. We recommend that stakeholder engagement strategies be inclusive of all perspectives and consider potential costs, benefits, and tradeoffs associated with wood pellet production from the perspectives of those most directly impacted. Any supply chain effects attributable to forest conservation, environmental quality, and social and economic opportunities in communities affected by the supply chain should be documented.

While the scientific community may appear to disagree about the effects of the SE US pellet supply chain, there is an opportunity to build consensus around effects based on reliable data and monitoring, such as the Forest Inventory and Analysis [1][32][39]. Under some assumptions for supply chain attributes and alternative fates for feedstocks, increases in wood pellet production lead to increased harvest in timberlands in the SE US[40] and changes in forest structure[41]. Other studies suggest that robust pellet markets reinforce good management practices and help retain private lands in forest rather than transitioning from forest to other uses e.g., [11][35][42][43]. Effective monitoring of SE US forest conditions and mechanisms to quickly respond to undesirable changes are keys to a constructive path forward.

Government programs and policies that incentivize wood pellet production (e.g., production tax credits, renewable energy credits) should ensure transparent and balanced accounting for both emissions and sequestration. This role for clear policies and strong institutions relates to SDG 16 (justice and strong institutions). For example, carbon rental and carbon-tax-and-subsidy approaches have been identified as efficient and beneficial to forests [35]. Incentives should support technical assistance to small forest owners and innovation while assuring standards are met for social and environmental protections. Furthermore, incentives for better management of SE US forests that are linked to growing demand for wood-based pellets should support continual improvements in water quality and habitat for wildlife, while reducing risks of wildfires and insect outbreaks [44]. The role for good governance is important to hold the industry accountable through (1) monitoring supply chain emissions, (2) providing incentives to employ best available control technologies and equipment to minimize dust and pollutants, and (3) enforcing relevant environmental regulations across the wood pellet life cycle.

Caution is recommended with respect to government subsidies. For example, unless functional carbon markets are established for forest landowners and demand is provided for low-value biomass, subsidies for tree plantations without regard to future markets could result in supply bubbles and depressed stumpage prices, as occurred in the past[45]. Subsidies can distort markets and lead to reduced investments in management and increased conversion of timberland to non-forest use [35]. Market demand for low-value biomass is a key factor to conserve, manage, and expand SE forest estates.

5. Challenges in Assessing SDG Indicators for Wood Pellets

Several challenges arose when evaluating the effects of the woody pellet supply chain on the SDGs. First, the SDGs are global, and SDG targets and indicators are designed for national reporting. Thus, SDG targets refer to national or multi-national policies and broad measures, rather than to a particular region, and within that region, a specific supply chain. However, matching bioenergy feedstocks and management practices to local conditions and constraints is essential[46]. The disconnect between SDG indicators and the more specific metrics that are relevant for the context of a particular biomass supply chain, is a common challenge encountered among cases assessed by the IEA Bioenergy Inter-Task project[47].

Second, data to assess progress toward SDG targets are often insufficient to monitor the corresponding indicators, even at broad national scales. The United Nations Statistical Commission[17] reported that SDG progress monitoring was hampered by missing data, and, where data do exist, other problems such as timeliness and comparability often arose. Timely, reliable, and complete data necessary to assess the effects of a regional supply chain on SDG targets are difficult to assemble.

Third, multiple uncertainties and issues associated with attribution are ever present. Attribution of an observed effect to the bioenergy supply chain is challenging, for indicators are impacted by other variables and are often measured at national or regional scales. Furthermore, it is necessary to determine the proper reference scenario or counterfactual conditions that would have prevailed in the absence of the observed expansion of wood pellet production[48]. These issues are especially complicated when dealing with dynamic human economies and biological systems across landscapes that are subject to many different but simultaneous forces of change[49].

Fourth, several SDG targets are appropriately designed to address specific needs in developing countries, such as "universal access to modern energy services" under SDG 7, or access to financial services in developing nations under SDG 9. The needs in each nation are distinct, but the SE US forest sector has an advantageous foundation of science-based research and statistically-sound historical data with systematic and timely updates. Information about forest landowners and reliable data on forest conditions over recent decades is critical to understand and evaluate the effects of different policies, management practices, climate change, and other phenomena, e.g.,[50][1][7][12][51][39][52][53][50]. Reliable historical and current data sets such as the Forest Inventory and Analysis provide evidence to determine whether bioenergy from SE US wood pellets is achieving desired goals[54]. In addition, state and federal regulations, best management practices (BMPs), forest and fiber-sourcing certification programs, nonprofit conservation organizations, land trusts, and logger training programs provide a network of support and accountability for efficient management and protection of US forest lands[32].

SDG targets designed to support monitoring of progress toward development goals are limited in their ability to capture local, negative impacts, such as the noise and traffic associated with transporting biomass. There is also overlap and confusion about where to report some effects, e.g., supply chain GHG reductions could fall under SDG 9 (more sustainable industries) or SDG 13 (combat climate change). Several SDGs have limited direct linkages with bioenergy supply chains, such as SDG 14 (life below water), and SDG 16 (peace, justice, and strong institutions). Therefore, a process should be followed to develop indicators with stakeholders that are aligned with local needs and priorities[55].

6. Conclusions

The SE US pellet supply chain is important for forestry activities and investments in communities and ports servicing pellet processing mills[37]. While the supply chain represents a tiny share of the total biomass processed by SE US forest industries, sustainability requirements for pellets influence wider forestry practices and contribute to increased conservation investments in regions where feedstocks are harvested, e.g.,[56]. The SDGs and their targets provide broad goals for nations; however, context-specific objectives are more useful for considering effects on particular industries and regions. This specificity is particularly valid for the SE US pellet supply chain, which must adapt to site-specific social and environmental sensitivities as it responds to opportunities presented by high volumes of low-value forest resources lacking other markets.

Close cooperation between regional and local stakeholders—including small forest landowners, forest sector industries and service providers, and local communities—are critical for building the trust required to reap social, economic, and environmental benefits from the pellet supply chain. Reliable and timely data on forest conditions, including how pellet supply chains can be managed to increasingly support healthy and resilient forest ecosystems, are also important for marking progress toward the SDGs and local development priorities. Working with stakeholders, future research and investment can target initiatives designed to mitigate weaknesses and threats and to optimize the benefits from the strengths and opportunities provided by the woody biomass energy supply chain in the SE US.

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