Ecosystem Workforce Program
WORKING PAPERS

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A Review of the Literature

EWP WORKING PAPER NUMBER 20, SUMMER 2009

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Acknowledgements

This report was made possible by funding USDA Forest Service, Northern Research Station under joint venture agreement 07-JV-11242300-080 and the Ford Foundation. We particularly appreciate the support of Sarah McCaffery of the Northern Research Station.

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Social Issues of Woody Biomass Utilization:

A Review of the Literature

Woody biomass is used in many ways, and is the longest standing form of energy and heat resources in the history of human civilization. Today, the primary resources for biomass include agricultural crops and residues and woody residues and small diameter trees from commercial and non-commercial forest management activities. Using biomass to generate electricity, heat, and other products has increasingly become an international goal. Driving factors include international policies to address global climate change and increase energy independence. In Europe, emissions trading schemes, non-renewable energy taxes, and other regulatory inducements provide incentive for the utilization of biomass (McKay 2006). In the United States, the development of biomass markets has been driven in part by a national discourse over energy independence and climate change as well as the adoption of renewable energy portfolios by over half of the states (United States Department of Energy [USDOE] 2008). In addition, forest restoration and fire hazard reduction projects have increased the opportunities for woody biomass utilization. Over the past 10 years, an average of 6.5 million acres of wildfires have burned across the United States each year (National Interagency Fire Center [NIFC] 2008), contributing additional carbon dioxide to the atmosphere and consuming natural resources. Escalating fire fighting costs and global climate change have led to an increased focus on biomass utilization as part of a strategy to mitigate these risks.

Forest biomass utilization is also considered a promising approach to rural community development and sustainable energy production (Becker and Viers 2007, Upreti 2003). On public lands, woody biomass is being generated as a byproduct of non-commercial fuels reduction treatments, forest habitat restoration projects, and forest harvest activities (Becker and Viers 2007, Haynes 2002, Neary and Zieroth 2007). On private lands, woody biomass is being generated around communities and residential developments through fire hazard reduction projects developed through community wildfire protection plans and commercial timber harvests (Butry and Donovan 2008, Fleeger 2008, Gan and Smith 2007). Despite the fact that policy makers, land managers, and community groups are seeking to increase utilization to achieve *multiple* community, administrative, and ecological goals, the main focus of biomass policy and scholarly research has been on the technical issues, business models, and financing of biomass utilization (U.S. Government Accountability Office 2005, U.S. Government Accountability Office 2006). The praises for biomass utilization and its potential benefits at local, national, and global levels have been widely catalogued; however, there has been relatively little exploration of the social dynamics associated with biomass utilization. With prospects for growth in the utilization of woody biomass from forests, anticipating the social dynamics and conflicts that may arise will be critical to navigating socially just, fair, and effective biomass outcomes.

In this paper, we review the literature to shed light on the social dynamics associated with the utilization of woody biomass generated from forests managed for timber products and other social and ecological values. Our aim is to organize the literature on social issues related to woody biomass utilization activities associated with forest management according to common themes and to identify key gaps in the knowledge structure that require additional research. Although our perspective specifically concentrates on the woody biomass utilization in the United States, we recognize that many regions internationally are working to utilize woody biomass using similar applications and that other biomass applications and forest management literature may provide insight into the social issues associated with woody biomass utilization. Therefore, we include literature from a range of substantive fields and geographic origins.

Approach

We sought to identify and synthesize the literature about the social issues related to all phases of woody biomass utilization, from planning and removal of material from the woods to a wide range of potential end uses including small diameter value-added materials, products made with chips, and the conversion of biomass to heat and other energy products such as electrical power and cellulosic ethanol. To gather scholarly literature we relied on several sources including library databases, the International Symposium on Society and Resource Management 2005-2008 conference abstracts, and key informant suggestions.

In general, we found that the scholarly literature on the social concerns over biomass utilization is thin. Much of the peer-reviewed literature comes from case studies of European biomass projects. We found only a few peer-reviewed articles and scholarly book chapters focused on the American social context of biomass utilization. Although the European experience is instructive, the American cultural relationship with public lands and forest management is unique and warrants a deeper search. A review of unpublished scholarly work revealed several relevant graduate theses and conference abstracts related to the American biomass experience.

To check for gaps in the existing scholarly literature that we found, we conducted a brief review of the grey literature. Grey literature can be helpful in identifying unanswered research questions, untested hypotheses, and suppositions promoted in the biomass utilization arena from the conventional wisdom of popular culture. We contacted key biomass utilization experts in the Pacific Northwest, Interior West, Upper Midwest, the Northeast, and the Southeastern United States, and requested that each informant forward to us their top five pieces of peer-reviewed or grey literature related to biomass utilization. We reviewed included grey literature to help define the scope of emergent social issues not yet discussed in the scholarly literature.

We begin with an overview of the uses of woody biomass to provide a foundation from which to understand the social dynamics of utilization. Both the scholarly and the grey literature on the social context of biomass utilization suggest that there are legitimate social opportunities and concerns that may affect the success or failure of biomass utilization efforts. We organize these opportunities and concerns along the following themes: community development, facilities siting, project scale, public perception, public participation, and supply-chain displacement. We also recognize that regional differences in forests and the forest products sector may lead people in different parts of the country to understand the problem of woody biomass development differently. This may mean that that the social issues of biomass utilization may differ from place to place and are not easily generalized from one region to another. We use a regional framework to discuss how structural differences in forests and forest resources frame the biomass problem. We conclude by discussing the implications of social context for the development of biomass policy

Woody Biomass Uses

Woody biomass can be generated directly from forests and urban wood waste such as construction waste, landscape debris, and pallets. Among sources directly from forests, woody biomass is generated from activities related to commercial and pre-commercial forest management and forest restoration and fuels reduction projects. Effective utilization of forest woody biomass focuses on the highest and best use of the product, which may be determined in the field or at a sort yard (Levan and Livingston 2001).

Although much of the recent policy discussion has been focused on using woody biomass for energy, small diameter trees and other forest residue can have a wide variety of uses. These uses are distinguished by the added value of the products created (Table 1). High value biomass products typically involve the use of capital-intensive equipment for making saw logs or veneer from small diameter trees of appropriate species or niche markets for products such as house logs. Value-added biomass products often include, roundwood fencing, posts and poles, tree stakes, landscaping products, animal bedding, engineered wood products, and wood pellets for heating. Value-added biomass products may come from salvage of materials not suitable for saw logs, materials from fuels reduction and forest restoration projects focused on small diameter trees, or slash piles. Low value biomass products primarily focus on paper pulp and chips for composite wood products. Minimal value products typically include hog fuel for cogeneration of electricity and heat at sawmills, and other woody residues for use in producing liquid fuels, electricity, heat, or other combined heat and power ventures. The value of minimal-value products often hovers at the margin, and may be negative or slightly positive depending on market conditions, available subsidies, or other factors.

Typically, low- and minimal-value products are only economically viable if they are derived from projects that create value through the removal of higher value products and share the fixed costs of removal of the materials from the forest (USDA Forest

Table 1. Biomass Utilization Options

Amount of added value	Examples
High-Value Products	Saw logs, veneer logs, house logs, etc.
Medium-Value Products	Posts and poles, tree stakes, trellises, rustic furniture, spindles, landscaping products, animal bedding, engineered wood products, wood pellets, etc.
Low-Value Products	Paper pulp and chips for oriented strand board, and other composite wood products.
Minimal-Value Products	Hog fuel chips and residues for electricity, heat, cogeneration, or liquid fuels.

Source: Adapted from USDA Forest Service. 2007. Woody Biomass Utilization Desk Guide. National Technology and Development Program. Washington, D.C.

Service 2007). Markets for minimal-value products probably have the most potential for growth given the national interests in energy independence, renewable energy, and fire hazard reduction and the low rates of utilization of minimal-value products. Social issues associated with the creation of a minimal-value products market are the focus of this literature review since the social dynamics of utilization of these products that have heretofore had no value or negative value have not been explored.

Structural Variations in the Biomass Utilization – A Geographic Perspective

Both the scholarly and the grey literature suggest that the social issues associated with biomass utilization depend upon the cultural, economic, and natural organization of forest lands and their resources. For example, issues like supply chain displacement may be more relevant in places with active chip markets, where traditional uses may face competition from emerging biomass uses for energy development. We provide an overview of the structural differences we encountered in the literature by organizing these differences regionally. These differences should be interpreted as heuristic propositions describing how the cultural, economic, and natural organization of forests influence the social context of biomass utilization rather than a fundamental statement of knowledge about regional differences of the social context related to biomass utilization. We propose that the degree to which a particular issue is prominent and widely salient in a particular region depends on differences in forest land tenure, infrastructure, and the biogeography of forest lands.

Privately owned industrial forestland dominates the organization of forest resources in the South. With its extensive timber production and energy infrastructure and its large wildland-urban interface, much of the focus has been on large-scale electricity production by leveraging existing forest management, transportation, and energy production infrastructure (e.g., Gan and Smith 2007, Langholtz 2008, McDonell and Monroe 2008). Supply of biomass in the South is expected to come primarily from logging residues and forest thinning operations conducted for commercial forest management and fuels reduction in wildland urban interface zones (Perez-Verdin et al. 2007, Langholtz 2008). While certainly other alternative applications of woody biomass exist in the South (e.g., district level sawdust combustion heating; O'Leary and Monroe 2007), recent literature suggests that large-scale energy production is the dominant force in biomass development in the southern United States.

In contrast, the northern United States are dominated by privately owned forestland with a high proportion of non-industrial private forestland (NIPF). While forest growth is estimated to continue to exceed harvest levels, indicating a potential surplus of material that could be utilized, relatively few NIPF landowners actively manage their forestlands constricting the supply of biomass materials (Germain 2008). Biomass utilization has been framed positively in the media as a sustainable source of energy production and other value-added renewable resource-based products (Leahy et al. 2008). The positive framing of biomass in the northern United States coupled with a potential supply constraint sets up the potential concern over displacement of existing uses of wood products without developing new sources of supply.

The West, dominated by public forest lands where forest practices have been subject to intense debate and local forest management capacity has declined over the past two decades {Becker, 2008 #3}, presents social issues around public perception and participation, community development, and project scale (Almquist 2006, Stidham 2007). Due to the history of conflict over forest management in much of the West and the growth in amenity-driven residential development adjacent to public forestlands, it is likely that many fire hazard reduction projects that will create a potential biomass supply will be based on public-private partnerships. These partnerships will require biomass utilization proponents, public land managers, and their collaborators to be attentive to the social context of forest management to be successful in designing projects appropriate in scale for developing utilization capacity and fostering trust.

Regional differences in the organization of forestland tenure, forest products infrastructure, and the biogeography of forest lands allow for broad generalizations in the social context of biomass utilization. While regional differences are a convenient organizing framework, it is important to recognize that these differences are driven by the structural organization of forests and their resources. There are as many counter examples to the regional framework as there are variations in the organization of forestland within any given region. For example, the forest products infrastructure and productive private industrial forestland in western Oregon, western Washington, and Maine may make the social context of biomass utilization in those areas more similar to that of the timber producing South rather than to that of the fire-prone West or non-industrial North.

Understanding the Social Issues of Minimal Value Woody Biomass Utilization

Community Development

The majority of the social issues of woody biomass utilization in the scholarly and the grey literature are focused on the benefits of biomass utilization to jobs creation, value- added production, sustainable economic development, and forest restoration. Becker and Viers (2007) identify biomass utilization as a component of sustainable community development in rural forested communities and highlight the linkages between biomass development and community capacity, community identity, and social acceptability of forest restoration. Gan and Smith (2007) focus on the economic benefits of biomass utilization modeling job creation in 43 counties of East Texas. The authors find the potential creation of more than 1,000 jobs through residue procurement, transportation, and electricity production. Utilization can also reduce forest management costs by adding value to previous waste products and reducing electricity production costs by displacing greenhouse gas emissions relative to fossil fuel sources (Gan and Smith 2007). Neary and Zieroth (2007) focus on the development of new community-based enterprises based on biomass utilization. And several studies from the South, Northeast, and West discuss the benefits to jobs creation, forest restoration, and value- added production for rural communities (Becker 2007, Germain 2008, Langholtz 2008, McDonnel and Monroe 2008, Saleh 2008, Becker et al. 2008). Internationally, the utilization of woody biomass has been heralded as an important opportunity to mitigate climate change, create new green jobs, and improve local import substitution, reducing dependence on foreign gas and oil (Domac et al. 2005, Illsley et al. 2007, Krajnc and Domac 2007, McKay 2006, Parris 2003, Rakos 2003, Sims 2003). In addition, the utilization of biomass for small-scale heating is viewed as an opportunity to reduce fuel poverty (i.e., households in which greater than 10 percent of disposable income is spent on fuel; McKay 2006).

Only a very small amount of literature suggested negative impacts to communities. For example, Cantor and Rizy (1991) and Pimentel et al. (1984) suggest that an increased shift in employment to forestry in the development of biomass feedstock may increase occupational hazards and risks and reduce labor supply to other industries. Pimentel et al. (1984) suggest that the development of a large-scale biomass program in the United States may cause inflationary pressure on agricultural land prices and result in difficulty for new farmers to enter the market and existing farmers to endure higher production costs. The transferability of the potential negative impacts of biomass development on agricultural land prices is unclear, but may be most applicable to non-industrial private forest (NIPF) land managed by family forest owners. Public health costs of biomass development in Sweden and Switzerland are discussed by Miranda (2001) and Madlenera and Vogtli (2008), respectively, and focus on the localized potential for air pollution from transportation of forest residues to utilization sites. Other potential nuisance issues include traffic and noise (Madlenera and Vogtli 2008, Miranda and Hale 2001), which may be relevant particularly in amenity-based communities in the vast wildland-urban interface of the United States where community identity may be based on aesthetic values rather than production values.

Public Participation

In regions like the western United States, much of the feedstock for biomass projects will come either from public lands or fuels treatments conducted through public-private partnerships like those exemplified by Community Wildfire Protection Plans, both of which face the unique scrutiny of public involvement (Stidham 2007). These types of projects are often created by collaboratives that bring together stakeholders to identify common ground, common objectives, and the boundaries of acceptable actions in the forest. For example, Fleeger (2008) and Neary and Zieroth (2007) describe the implementation of the Community Wildfire Protection Plan (CWPP) in the White Mountains of Arizona on the Apache-Sitegraves National Forest. Both authors identify collaboration and the identification of acceptable fuels treatment prescriptions as important factors to successfully implementing the CWPP (Fleeger 2008, Neary and Zieroth 2007), the residues from which are being used in both small- and large-scale biomass energy facilities, biomass heating facilities, and co-fueling existing power plants.

Biomass projects also have the potential to create a need for public participation in private land management through public-private partnerships. Fleeger (2008) and Neary and Zieroth (2007) discuss the CWPP process and identify public participation as an important success factor. CWPPs are intended to address fire hazard in the wildland-urban interface (WUI). Nearly 90 percent of the WUI nationwide is privately owned and more than half the WUI in the West occurs in forests where fuels treatments would be considered mitigation rather than forest restoration (Theobald and Romme 2007). Given environmental group perceptions discussed in Pelle (2000), Almquist (2006), and Stidham (2007), biomass projects that depend in part on feedstock that is generated from private lands through public-private partnerships may be subject to scrutiny not regularly experienced on projects occurring on private lands. This scrutiny may be heightened in those forests where biomass utilization may be considered fire hazard mitigation rather than forest restoration.

Trust can be built through active stakeholder engagement where stakeholders have a legitimate role in crafting management plans, although national environment groups tend to begin the conversation on biomass development with only hesitant and cautious support (Stidham 2007). Stidham (2007) also suggests that cautious entry of environmental groups into biomass collaborations may challenge successful and expedient collaborative public participation on biomass projects, requiring public agencies involved to pay special attention to the transparency of decision making. In contrast, Almquist (2006) suggests that although many local environmental group representatives in Oregon have been involved in collaborative hazardous fuels reduction projects, some environmental groups were still in the early stages of learning about biomass utilization in the mid 2000s.

Public Perception

The success or failure of biomass projects may hinge upon public trust of forest managers and biomass project developers (Stidham 2007). Mistrust of forest managers is strong among people who hold an ecocentric perspective on the environment, while only weak levels of trust tend to exist from other segments of the population (Ribe and Matteson 2002). Environmental groups in the early stages of learning about biomass utilization may tend to react negatively to proposed projects (i.e., from a precautionary perspective) until trust is established. Most of Almquist's (2006) environmental group representatives did indicate that they felt the federal government should not make supply guarantees of feedstock to biomass projects. Almquist (2006) also notes that if biomass projects fall substantially out of the range of environmental group philosophies "supply levels [for biomass feedstock] are likely to be much more unpredictable" (p.68). Public participation in collaborative processes is clearly important; however, public participation alone will not supplant stakeholder options for administrative appeals and litigation if projects do not address stakeholder concerns.

Acceptable forest management prescriptions vary geographically and depend upon individual experience and beliefs (Brunson and Shindler 2004). A study of stakeholder perceptions of biomass development in Oregon showcases how the diversity of existing perceptions on forest management and public agency trust can challenge projects that may create biomass feedstock on public lands and projects developed through public-private partnerships (Stidham 2007). For example, environmental groups were likely to only be cautiously supportive of biomass projects to the extent that the project was focused on forest restoration rather than a raw material for energy project development. Pelle (2000), in a study of environmental groups and trade associations in the eastern United States, found similar concerns from environmental groups that were cautious about the use of forest residues for biomass projects and supportive only to the extent that any environmental impacts were socially acceptable.

Public perception about the impacts of biomass projects on surrounding landscapes is not uniquely associated with the American experience. In England, public perception about ecological risks posed by biomass power plants to the landscapes from which their supply comes have presented challenges to biomass development (Upreti 2004). To illustrate why public perception conflicts escalate, Upreti (2004) identifies four important perceptions about biomass projects:

1. The project implementation or technology is unfamiliar or untrusted
2. The project is imposed on the locality without local participation
3. The public does not have a formal role in decision making
4. The project is primarily oriented toward external profit rather than local benefit

These perceptions are certainly applicable to the American experience with biomass, especially related to those projects where biomass feedstock is generated from public lands or through public-private partnerships.

Project Scale

The issue of project scale is multifaceted and is best summarized as 'there is no one-size-fits-all solution.' Much of the grey literature suggested that smaller-scale biomass utilization projects were more likely to be economically feasible and provide more direct benefits to forest dependent communities. In contrast, much of the peer-reviewed literature focuses on the efficiency of large-scale biomass electricity facilities (e.g., 200 megawatts or greater), but cautions that these facilities are not yet competitive with other forms of electricity without some form of government intervention (Kumar et al. 2003, Kumar et al. 2008). Some authors view the centralized industrial model of large-scale bioenergy facilities as concentrating benefits away from the woods and reducing the value-added capacity of local communities (e.g., Madlenera and Vogtli 2008). Borsboom et al. (2002) cite studies from Sweden and northern Canada showing that smaller community to farm scale biomass heat and energy systems have a greater positive impact on local community development and employment than do large-scale systems. Community forestry groups, while generally supportive of biomass development, have also expressed concerns with the scale of facilities and social equity in the distribution of subsidies and other development assistance (Rural Voices for Conservation Coalition 2005).

Almquist (2006) adds that environmental group representatives fear that large-scale biomass utilization will allow demand for biomass to control forest management decision-making rather than forest management leading the decision-making and resulting in the production of woody biomass as a byproduct of forest restoration. This apprehension about large-scale biomass utilization is also suggested by Stidham (2007) in her review of national environmental group positions on biomass utilization in Oregon. These types of concerns may manifest specifically in the facilities development process, making small-scale facilities more socially feasible and large-scale facilities open to uncertainties about the politics of siting and feedstock supply. The Rural Voices for Conservation Coalition (RVCC; 2008), a collaboration of rural western local, regional, and national community and conservation organizations, proposes community-scale integrated biomass facilities that sort materials to highest and best uses and that focus energy production on thermal applications. Thermal facilities tend to be smaller-scale, have higher efficiencies, require more local sources of feedstock, and are more socially feasible to implement on a shorter time scale than electrical applications (RVCC 2008).

Displacement of Existing Uses of Low Value Wood Products

In markets with a constrained amount of feedstock for woody biomass, supply chain displacement may be a concern. Markets with considerable existing wood processing capacity and lower risks from fire hazard appear to be where displacement concerns are most prevalent (Holt 2008, Lilieholm et al. 2008, Germain 2008). In these markets, concern that the total available supply of woody biomass material is already saturated prompted one participant in Holt's (2008) study to comment that biomass may "put at risk … existing industry" (p.31) including landscaping, particle board, pellets, hog fuel, and briquettes. The displacement issue tracks the same long-standing concern over the use of existing agricultural crops in the creation of ethanol (Pimentel et al. 1984, Cantor and Rizy 1991). In these instances, the addition of biomass utilization projects for energy to the marketplace may either cannibalize existing markets for low- and minimal-value material or cause minimal-value products to be economically infeasible without an increase in the supply of biomass. Furthermore, the negative perception that biomass utilization will cannibalize existing markets, whether true or not, may pose a political challenge to forwarding favorable biomass utilization policy.

Facility Siting

Identifying acceptable locations for biomass facilities can pose a variety of challenges commonly identified with the development of industrial energy generation facilities, which tend to increase with the facility scale (Upreti 2004). The challenges include public perception about externalities such as emission and pollution, noise and nuisance, road traffic and accident risk to bring feedstock to the facility, and other concerns, which can cause delays or revocation of local political approval and administrative permits (Madlenera and Vogtli 2008, Mangan and Coombs 2003, Upham and Shackley 2006). Rakos (2003) estimates that not-in-my-backyard (NIMBY) challenges to facilities siting can raise the development costs of new biomass facilities by close to 30 percent. In addition to public opposition challenges, the need for a continuous stream of biomass feedstock in biomass energy applications can strain existing transportation infrastructure, especially when facilities are sited in rural areas (Euken 2003).

NIMBY responses to forest biomass utilization may not simply be related to facility siting, but may also be directed to the landscape from which biomass feedstock is derived. Upham and Shackley (2006) find that public opposition to biomass facilities in Austria is related more deeply to perceptions of threat to the values and sense of place people hold for the landscape. Upreti (2004) notes that developers of biomass facilities often disseminate information about their proposed facilities from a utilitarian ethics perspective (e.g., focused on the economics and technical feasibility of the proposal), while opposition tends to come from a rights-based or equity perspective focused on the public risk perception. "People don't want to be 'losers' by bearing the costs associated with bearing an undesirable development" (Upreti 2004, p.788). This distributional concept of winners and losers, especially in relation to facility siting, is well established in the environmental justice literature, focusing on "the accumulation of wealth created at the expense of someone else's health or quality of life" (Bryant 1995, p.8).

Several authors discuss opportunities for avoiding biomass utilization facility siting problems. Larger facilities – especially electrical generation biomass plants – can benefit from colocating with existing industry or in urban industrial areas where transportation infrastructure, economies of scope, and simplified approval processes exist (Tupper 2003). In contrast, there is a growing discourse on the benefits of small-scale facilities – be they thermal energy plants or value-added production facilities – where siting issues may be simplified and the benefits of small-scale facilities may more likely accrue to local communities (Rural Voices for Conservation Coalition 2008). Almquist (2006) notes that many of the environmental group representatives interviewed in his study believe that "locating facilities in communities where hazardous fuels reduction is needed the most would create a more sustainable economy and benefit local communities" (p.53). Finally, Upreti (2004) discusses the importance of incorporating stakeholder participation early in the biomass facility development process to earn trust, identify perceived risks, and collaborate on potential solutions to siting biomass facilities.

Discussion: Management Recommendations And Further Research

Our goal in this paper is to use existing literature to identify the potential social concerns over the utilization of minimally valuable forest biomass. Understanding these concerns is important to forest managers, biomass project developers, and community stakeholders since forest biomass utilization is increasingly looked to as an opportunity to generate local economic benefit and provide a potential revenue stream to support wildfire hazard reduction and forest restoration projects.

We find six primary social and community issues associated with minimally valuable woody biomass utilization: community development, public participation, public perception, project scale, displacement of existing uses of low value wood products, and facility siting. The opportunities and challenges associated with each of these issues are critical for stakeholders involved in woody biomass utilization projects and processes. We suggest that the type of attention paid to each of these issues can help foster or potentially hinder the process.

We recommend that forest managers, project developers, and community stakeholders pay attention to each of these issues in the very early phases of any biomass utilization project. Attention to social issues early in the process can help to identify concerns and develop a strategy to mitigate them, thereby allowing project momentum to build around the suite of benefits associated with any given project rather than be hindered by unforeseen social concerns. Addressing social concerns early can also serve to help build common ground from which a project or process can be framed. Collaborative community-based natural resource management (CBNRM) groups and processes are an appropriate venue for building a project that will naturally tend to address these types of issues. Many national forests have existing CBNRM groups that can help to facilitate a community-based woody biomass utilization discussion. However, we recognize that many woody biomass utilization projects will be developed through private sector groups that don't typically have a breadth of experience dealing with public sector concerns. For these groups, we recommend identifying and partnering with an individual or group who can help navigate the public sector intricacies of woody biomass utilization in the private sector context. Attending to social issues is clearly a cost of doing business in an arena that strikes the potential for polarization and politicization.

Finally, the literature suggests several relevant issues that are clearly ripe for further research. First, the state of knowledge about the impacts of project scale and competitive displacement is weak at best. Most research about project scale has occurred in the economics of biomass electricity generation where large-scale plants have often been considered necessary to achieve economic efficiencies. However, for non-electric utilization or co-generation, most of our knowledge about the impacts of project scale is speculation and conjecture. Displacement of competing uses for woody biomass feedstock is similar. Conducting a comparative analysis of different types of utilization would generate a robust understanding of the conditions in which project scale, displacement, or other issues become challenges for woody biomass utilization. Two other questions arose in our review: (1) How does ownership structure for biomass utilization project impact the potential for keeping wealth local and maximizing local benefits, and (2) what are the equity dimensions of woody biomass utilization opportunities. For example, do low-income communities have less access to the resources or infrastructure (e.g., transmission capacity) necessary to capitalize on emerging opportunities, and what alternatives might help level the playing field? Attending to the social issues we have outlined above, and answering these questions will further our ability to respond to and develop woody biomass utilization projects that integrate market demands, community needs, and ecological objectives.

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