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Woody biomass utilization trends, barriers, and strategies

A survey of USDA Forest Service managers

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Public and private forest managers, renewable energy advocates, and community leaders across the United States are increasingly interested in woody biomass for its potential to increase energy independence, mitigate climate change, offset the costs of hazardous fuels and forest restoration projects, and create opportunities for community-economic development.[1] Woody biomass derived from logging, fuels treatments, and forest products manufacturing can be utilized for heat and electrical energy as well as value-added wood products (see Table 1, below), although much of the current policy discussion in the United States around biomass has focused on using minimal value biomass for energy purposes.[2]

Despite significant efforts to increase biomass utilization, development has been slow in many places. Areas with considerable federal land ownership, in particular, have found it difficult to create new utilization opportunities. In addition to the economic challenges facing biomass utilization, USDA Forest Service managers and staff members have to negotiate challenges related to public engagement and the planning processes fundamental to national forest management.[3] Although improving national forest management and ensuring that local communities benefit from their neighboring national forests are important public policy goals,[4] these goals also increase the complexity of biomass utilization efforts that would rely on federal lands for materials.

In a 2012 *Journal of Forestry* article[5], we report the results of a study that sought to understand the trends in, barriers to, and strategies for developing woody biomass utilization on and around the National Forest System by asking the following research questions:

1. How do trends in national forest biomass removal and local utilization vary across the United States?
2. What specific barriers have national forest managers and staff found most challenging?
3. What specific strategies have national forest managers and staff considered most important to overcome these barriers?

Table 1 Biomass utilization categories

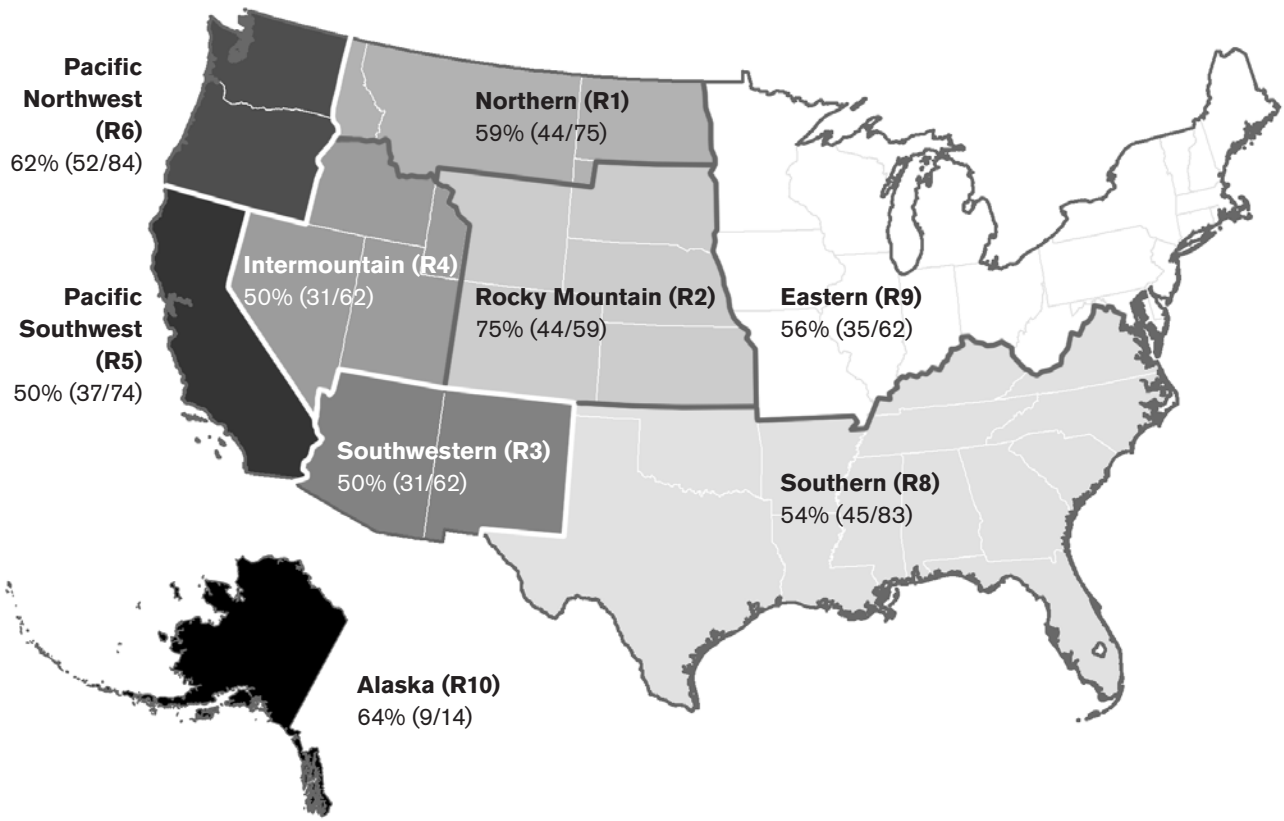
Amount of added value	Examples
High value products	Saw logs, veneer logs, house logs, etc.
Low value products	Paper pulp and chips for oriented strand board, other composite wood products
Value-added products	Posts and poles, tree stakes, trellises, rustic furniture, spindles, landscaping products, animal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

Adapted from USDA Forest Service 2007 (see endnote 2, page 7).

We sought to answer these questions by conducting a web-based survey of 339 Forest Service district rangers and technical staff from across the country. Many results of the survey are discussed in summary form in the journal article. The purpose of this working paper is to provide supplemental material that could not be reported in the journal article due to space limitation. In particular, we focus on reporting regional differences (see Figure 1, below) in the specific barriers to biomass utilization and the specific strategies for overcoming those barriers (in the journal article we used factor analysis to cluster similar type of barriers and strategies).

Although here we report differences between responses from district rangers and technical staff members for interested readers (see Tables 2–4, pages 9–13), similar to the journal article, we focus the results and discussion on regional differences between respondents. The data collection methods are described in detail in our *Journal of Forestry* article.

Figure 1 U.S. Forest Service administrative regions and regional response to the online questionnaire



Parenthetical notations indicate Forest Service region numbers.

Results

Trends in national forest biomass removal and local utilization

About a quarter of all respondents reported that they were unsure what general proportion of biomass utilized locally came from federally managed lands. Of the remaining respondents (n=241), more than half (56 percent) reported that less than a quarter of the biomass utilized locally came from federal lands, and only 20 percent reported that more than three-quarters of the biomass utilized locally originated on federal lands. More than 90 percent of respondents in the Southern and Eastern regions reported that less than a quarter of the biomass harvested for utilization in their area came from federal lands. In contrast, between one-third and two-thirds of respondents from the interior west and Alaska reported that more than half of biomass harvested for utilization came from federal lands.

National forest managers and staff members reported different trends in biomass utilization in their area for different types of materials (see Table 2, pages 10–11). Most participants in most regions reported no recent changes in the utilization of high-value materials, such as saw logs; although nationally, in seven of nine regions, more respondents reported a decreasing trend in high-value material utilization than reported an increasing trend. Only in the Southern and Eastern regions did more respondents report that high-value material utilization was increasing than reported it was decreasing. Nationally, the majority of respondents also reported that production of low-value (e.g., paper pulp and chips for composites) and value-added (e.g., posts and poles) materials was not changing; although, nearly twice as many respondents reported an increasing trend in value-added production as reported a decline. Respondents from the Northern region reported a decline in utilization of low-value materials, while respondents from the Pacific Northwest, Southern, and Eastern regions reported an increase in utilization of low value materials. Only in Alaska did more respondents report a decline in value-added production than reported an increase. Although nationally the plurality of respondents reported that the utilization of minimal-value materials like residues for electrical and thermal energy production was not changing, nearly as many reported an increase in utilization of these materials. The majority of respondents from the Pacific Coast states and the Southern and Eastern regions reported an increase in utilization of minimal-value materials, while respondents from interior Western regions reported no changes. Respondents from Alaska tended to report a decline in the utilization of minimal-value materials. The majority of technical staff reported an increasing trend, while the majority of district rangers reported no changes in the utilization of minimal-value material.

Finally, we asked respondents to report on the trend in removal of biomass from their national forest or ranger district for any purpose. Nationally, half of respondents reported removal of biomass from their forest or district was increasing, and only in two regions (Rocky Mountain and Intermountain) did respondents tend not to report an increasing trend in removal. Overall, relatively few respondents reported a decline in biomass removal from their national forest or ranger district, except in the Alaska and the Northern regions where nearly a third of respondents reported a decline. Roughly even numbers of district rangers reported an increase as reported no recent change in biomass removal from their ranger districts (more than 90 percent total). In contrast, more than twice as many technical staff members reported an increase in biomass removal from their forest than reported no change, and only 15 percent reported a decline.

Barriers to fostering biomass utilization

Respondents from across the nation rated the high cost of transportation, the low market value, lack of local markets, low financial returns, high cost of harvesting, and lack of existing utilization capacity for biomass as the largest barriers to fostering biomass utilization (see Table 3, page 11). Nationally, these six economic and market barriers were rated on average either as ‘somewhat’ or a ‘major’ barrier to fostering biomass utilization. With few exceptions, these six barriers were also among the largest barriers reported for each region. Only in the Eastern region was the lack of existing biomass

utilization capacity rated significantly less than somewhat a barrier to fostering biomass utilization. The decline in Forest Service budgets in the Pacific Northwest region and the lack of an existing wood products industry in the Intermountain West region were also rated significantly higher than somewhat a barrier to fostering biomass utilization.

Respondents also identified a number of barriers that on average were not seen as hampering efforts to foster biomass utilization. Nationally, issues that on average were rated less than a minor barrier to fostering biomass utilization were the nonmarket social items: the lack of a trained workforce for biomass removal, the need to acquire adequate public input, the need to cross private lands to access biomass on federal lands, the perception that biomass projects will not benefit local communities or create local jobs, concerns about traffic and noise, competition for labor, and occupational hazards. Regionally, however, there was more variation in issues that were not relevant. For example, disagreement about the need to remove hazardous fuels was not an issue that respondents from the Rocky Mountain and Southwestern regions considered even a minor barrier, while respondents from all other regions indicated that it was at least a minor barrier. Similarly, disagreement about the need for forest health treatments in the Rocky Mountain region and lack of trust in forest service managers in the Rocky Mountain, Southern, or Eastern regions were not identified as barriers to fostering biomass utilization. The lack of transportation infrastructure and lack of maintenance of Forest Service roads were also not perceived as barriers to fostering biomass utilization in the Southern and Eastern regions. Only in Alaska was air quality not reported as a concern.

Strategies for promoting local biomass utilization

The most highly rated strategies for promoting local biomass utilization were those that minimized the economic challenges in biomass utilization (see Table 4, pages 12–13). Nationally, respondents rated tax incentives for facility development, harvesting, and transporting biomass and cost share and grant programs for facility development and equipment purchases as the most important strategies. Regionally, other nonfinancial strategies were

also very important, including developing facilities that source from multiple suppliers in the Northern and Pacific Northwestern regions, using hazardous fuels and forest health funding in the Southwestern and Pacific Southwestern regions, and undertaking large-scale National Environmental Policy Act analyses in the Southwestern region. In the Alaska region, several other strategies were rated more highly than the tax incentive strategies, these included: public-private partnerships for facility development and a focus on small-scale facilities, partnerships that help to promote local capacity and ensure an adequate supply, government bonds and loans, and long-term stewardship contracts and agreements. In addition to tax incentives and cost-share programs, technical staff members were more likely than district rangers to report that developing facilities that source biomass from multiple suppliers and using hazardous fuels and forest health funding were highly important strategies to promoting biomass utilization efforts locally.

Relatively few strategies were rated lower than "somewhat important." The most common of these was developing agreements with private landowners for access to public land. Regionally, other low-importance strategies included sourcing biomass from mill residues in the Southwestern region, and developing projects that restore threatened and endangered species habitat in the Alaska region. Respondents from the Eastern region also rated as relatively unimportant a number of other strategies including improving forest road conditions, developing memorandums of understanding to secure federal biomass, procuring biomass from other sources like urban wood waste, and hiring Forest Service staff members to focus on biomass removal projects.

Discussion

Although Forest Service managers across the country generally reported increasing removal from national forest lands, trends for biomass utilization were highly variable, with increases mostly reported for the Pacific Coast, the Southeast, and the Northeast, where utilization capacity remains or has grown, while decreases were reported for much of the Interior West and Alaska, where utilization capacity remains limited or has disappeared. These distinctions highlight the importance of existing industry for promoting biomass removal and utilization[6] and the lack of sufficient markets and infrastructure to deal with pressing forest health and fuels reduction in the Interior West.[7] The general pattern of an increasing national trend toward utilization of minimal-value products mirrors the recent growth in renewable energy markets, such as biomass, that may assist the public investments needed for fuel reduction and forest health restoration across much of the country. We find the reported decline in utilization of minimal-value products in the Interior West of concern in the context of increasing fire risk in much of the western U.S.[8]

National forest staff members believe that economic challenges and lack of market development are the greatest barriers to promoting biomass utilization, although possibly slightly less challenging in regions with existing wood products industry and market infrastructure. Our results provide evidence that Forest Service staff members see high transportation costs, low-market value, and lack of existing industry as the most important challenges to promoting biomass utilization.[9] The results also indicate that Forest Service managers and staff members consider social factors as minimal barriers to biomass utilization when compared with the more technical, economic, and market barriers. Nonetheless, social barriers related to public participation, public perception, and not-in-my-backyard (NIMBY) attitudes are consistent in case-specific literature about biomass development.[10] Although specific social issues may not individually rise to the level of the economic and market barriers, concerns about pollution, nuisances, and forest management together can jointly result in delays or shifts in support for utilization projects. Research has suggested that NIMBY challenges can raise development costs for new facilities by as much as 30 percent.[11]

The high relative importance rating of a broad array of strategies to promote the utilization of biomass suggests that forest managers and staff members are working on multiple fronts to increase biomass removal and utilization. Policy incentives and in-

frastructure development were most important, reinforcing the importance of the "business" of biomass removal and utilization and concurring with previous research that has identified the importance of government assistance for developing biomass utilization capacity.[12] Although many of the social issues were not rated as significant barriers, many of the strategies related to building partnerships and agreement among stakeholders were rated as important strategies. Partnerships and agreement-building also reflect the historic importance of public engagement processes within the Forest Service and efforts to move beyond conflict over forest management.[13]

In the Southwest, the importance of existing funding mechanisms and conducting large-scale restoration planning on public lands reflects well-publicized experiences with community wildfire protection planning and long-term stewardship planning in the Arizona White Mountains.[14] The predominance of public land in the Intermountain and Southwest regions may also help to explain why diversification of supply is less important in those regions. The wide diversity of highly important strategies focused on partnerships, small-scale facilities, and stewardship in Alaska potentially reflects current collaborative planning efforts in that region. Also notable for nonsignificance is the lack of highly important strategies in the Intermountain West and the Southeast. Respondents in these regions rated all strategies with relatively low importance, possibly reflecting the relatively low use of materials from federal lands for biomass utilization in the Southeast and the historic and existing lack of forest industry in the Intermountain West.

Conclusion

In this working paper, we add to the material presented in our *Journal of Forestry* article by providing more detailed information about trends in biomass utilization across the country and the wide range of barriers and strategies important for fostering biomass utilization in and around the National Forest System. Although economic and market barriers were clearly in the forefront of most national forest manager and technical staff member evaluations, most respondents rated most strategies highly, suggesting their need to pursue a broad variety of opportunities to make new utilization efforts successful. Study participants also clearly pointed to the value of partnerships and forest management and contracting mechanisms as important tools to address local challenges to biomass utilization.

We found that the trends, barriers, and strategies varied considerably from region to region. This regional variation reflects considerable differences in forest products and energy sectors, land tenure, culture, and social concerns and support for various land management practices and biomass uses. The importance of these regional differences in both barriers and solutions suggests that policies oriented towards fostering biomass will need to be reflective of or adaptable to local and regional circumstances. Although there are many reasons to pursue woody biomass utilization opportunities, it is likely that federal and state energy policy will be a leading factor in the size of the market for woody biomass materials,[15] especially in areas with limited existing markets and industry for utilization. Ensuring that energy policy allows for local variation in feedstock and provides stakeholders with the appropriate tools to make decisions that address forest health needs, community concerns, and economic constraints will be important.

Responses to our survey reflect the need for biomass utilization policy to have a broader focus than just energy policy. Fostering appropriate utilization of biomass from the National Forest System will require a basket of strategies rather than a single approach both to meet the diverse challenges and the diverse needs across the country. Continuing this line of inquiry with other stakeholders including biomass and forest products industry representatives, environmentalists, and local community leaders would produce a more holistic understanding of the issues associated with biomass in the context of the National Forest System.

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Appendix

Table 2 Trends in woody biomass utilization: district ranger (DR) and technical staff (TS) average ratings by region

	Local trends in biomass utilization				Local trend in biomass removal from respondents' national forest
	High value materials	Low value materials	Value-added products	Minimal value materials	
Nation (all respondents)					
Increasing	19	25	29	39	**50**
Not changing	**54**	**54**	**57**	**45**	39
Decreasing	28	21	14	16	11
Northern (R1)					
Increasing	20	15	22	23	**44**
Not changing	**51**	32	**61**	**38**	26
Decreasing	29	**54**	17	**38**	30
Rocky Mountain (R2)					
Increasing	17	8	37	30	40
Not changing	**48**	**84**	**51**	**57**	**50**
Decreasing	36	8	12	14	10
Southwestern (R3)					
Increasing	11	0	37	27	**62**
Not changing	**70**	**88**	**44**	**65**	24
Decreasing	19	12	19	8	14
Intermountain (R4)					
Increasing	14	0	25	13	31
Not changing	**47**	**74**	**61**	**68**	**61**
Decreasing	39	26	14	19	8
Pacific Southwest (R5)					
Increasing	12	29	30	**55**	**53**
Not changing	**62**	**55**	**60**	33	39
Decreasing	26	16	10	12	8
Pacific Northwest (R6)					
Increasing	16	**45**	24	**55**	**64**
Not changing	**55**	41	**63**	33	32
Decreasing	29	14	13	12	4

Table 2 continues on next page

Table 2, continued

	Local trends in biomass utilization				Local trend in biomass removal from respondents' national forest
	High value materials	Low value materials	Value-added products	Minimal value materials	
Southern (R8)					
Increasing	36	**45**	33	**46**	**54**
Not changing	**50**	36	**52**	43	44
Decreasing	14	19	15	11	2
Eastern (R9)					
Increasing	29	**48**	31	**60**	**58**
Not changing	**61**	42	**62**	37	39
Decreasing	11	9	7	3	3
Alaska (R10)					
Increasing	0	0	22	22	**44**
Not changing	33	**56**	**44**	33	22
Decreasing	**67**	44	33	**44**	33
District rangers					
Increasing	20	21	27	28	45
Not changing	**53**	**56**	**57**	**53**	**47**
Decreasing	27	23	16	18	8
Technical staff					
Increasing	18	33	32	**53**	**58**
Not changing	**55**	**49**	**57**	33	27
Decreasing	27	18	11	14	15

Bold indicates the greatest percent of respondents for that category. Percentages may not add to 100 due to rounding.

Table 3 Barriers to woody biomass utilization: district ranger (DR) and technical staff (TS) average ratings by region*

Barriers	US	N	RM	SW	IM	PS	PNW	S	E	AK	DR	TS
1. High cost of transporting biomass	**3.61**	**3.70**	**3.49**	**3.69**	**3.67**	**3.83**	**3.65**	**3.45**	**3.47**	**3.67**	**3.52**	**3.74**
2. Low market value of biomass	**3.47**	**3.77**	3.24	**3.50**	**3.56**	**3.45**	**3.51**	**3.29**	**3.50**	3.25	**3.43**	**3.54**
3. Lack of local markets for biomass products	**3.36**	**3.60**	**3.56**	**3.42**	**3.58**	**3.42**	3.02	**3.26**	3.06	**3.67**	**3.43**	**3.21**
4. Low financial returns to investors	**3.32**	**3.46**	3.09	**3.38**	**3.68**	**3.45**	**3.30**	3.16	3.08	**3.38**	**3.28**	**3.39**
5. High cost of harvesting biomass	**3.19**	3.15	3.20	**3.36**	**3.20**	**3.31**	**3.24**	3.10	2.97	**3.44**	3.10	**3.35**
6. Lack of existing biomass utilization capacity	**3.13**	**3.38**	**3.38**	**3.36**	**3.38**	3.17	2.76	2.95	2.60	**3.63**	**3.18**	3.02
7. Declining Forest Service budgets	2.91	2.83	2.58	2.96	3.08	3.26	**3.26**	2.65	2.79	2.22	2.86	2.98
8. Declining Forest Service staffing levels	2.91	2.93	2.59	2.93	3.19	3.00	3.19	2.72	2.79	2.22	2.86	2.94
9. Lack of a guaranteed supply from federal lands	2.90	2.90	2.34	2.85	3.07	3.20	3.16	2.98	2.52	3.22	2.83	2.99
10. Low energy prices	2.60	2.60	2.15	2.39	2.53	3.11	3.14	2.39	2.48	1.63	2.50	2.76
11. Lack of existing wood products industry	2.54	2.23	3.22	3.26	**3.30**	2.88	1.92	2.02	1.72	3.44	2.72	2.22
12. Lack of existing transportation infrastructure	2.24	1.95	2.38	2.72	2.73	2.47	2.02	2.00	**1.58**	3.33	2.22	2.24
13. Lack of Forest Service staff expertise in managing biomass projects	2.45	2.37	2.23	2.70	2.68	2.51	2.37	2.63	2.12	2.56	2.55	2.24
14. Lack of agreement about harvesting biomass on public lands	2.24	2.48	1.97	1.89	2.40	2.17	2.48	2.03	2.25	2.33	2.18	2.31
15. Public perception that industry needs will drive forest management	2.24	2.46	1.94	2.19	2.14	2.53	2.42	2.11	1.90	2.38	2.16	2.32
16. Disagreement about forest health treatments	2.23	2.71	**1.70**	2.07	2.42	2.65	2.40	1.98	1.93	1.88	2.19	2.23
17. Negative perceptions about the impacts of removal to the landscape	2.16	2.32	1.83	1.96	2.00	2.20	2.38	2.07	2.38	2.44	2.18	2.12
18. Lack of maintenance of Forest Service roads	2.16	2.13	2.10	2.67	1.97	2.40	2.42	**1.76**	1.82	2.44	2.13	2.18
19. Lack of trust in biomass facility developers	2.10	2.33	1.82	2.00	1.97	1.97	2.26	2.24	2.04	2.63	2.02	2.24
20. Lack of continuity of agency staff members	2.09	1.98	1.79	2.26	2.19	2.15	2.17	2.17	1.97	2.22	1.98	2.23
21. Lack of a trained workforce for biomass utilization	2.04	1.82	1.86	2.48	2.77	2.07	**1.53**	2.10	1.90	2.89	2.09	1.94
22. Proposed location of utilization facilities	2.03	1.94	1.88	2.04	2.00	2.48	1.93	2.12	2.00	1.75	1.94	2.14
23. Air quality concerns	2.02	2.08	1.90	1.86	1.85	2.39	2.12	2.00	2.03	**1.44**	1.96	2.08
24. Lack of stewardship contracts and agreements	2.02	1.88	2.20	2.00	1.95	2.23	1.90	2.02	1.81	2.78	2.10	1.87
25. Water quality concerns	2.01	2.15	**1.76**	1.96	2.03	2.24	1.94	1.98	2.03	2.11	2.01	2.01
26. Lack of trust in forest service managers	2.01	2.22	**1.79**	1.89	2.06	2.03	2.33	**1.69**	**1.74**	2.78	1.92	2.14
27. Disagreement about the need to remove hazardous fuels	1.96	2.39	**1.58**	**1.68**	2.14	2.19	2.00	1.80	1.87	1.50	1.94	1.93
28. Competition with existing markets	1.91	**1.65**	**1.71**	2.15	2.03	1.77	1.95	2.18	1.97	1.67	1.91	1.93
29. Lack of a trained workforce for biomass removal	**1.82**	**1.56**	**1.58**	2.34	2.50	1.88	**1.38**	1.97	**1.60**	2.22	**1.86**	**1.74**
30. The need to acquire adequate public input	**1.72**	1.85	**1.46**	**1.55**	1.88	**1.61**	1.84	1.79	**1.68**	1.75	**1.67**	**1.77**
31. Need to cross private lands to access biomass on federal lands	**1.66**	1.83	1.92	1.72	**1.62**	**1.53**	**1.34**	**1.65**	1.82	**1.33**	**1.71**	**1.55**
32. Projects not perceived to benefit local communities	**1.61**	**1.56**	**1.49**	**1.57**	1.74	**1.48**	**1.58**	1.89	**1.53**	1.63	**1.62**	**1.59**
33. Lack of local job creation	**1.59**	**1.62**	**1.39**	1.82	1.78	**1.47**	**1.52**	**1.71**	**1.52**	1.56	**1.61**	**1.54**
34. Traffic concerns	**1.57**	**1.53**	1.83	**1.59**	**1.33**	1.82	**1.49**	**1.41**	**1.61**	**1.22**	**1.52**	**1.64**
35. Noise concerns	**1.52**	**1.51**	**1.71**	**1.59**	**1.32**	1.76	**1.45**	**1.48**	**1.48**	**1.11**	**1.47**	**1.60**
36. Competition for labor	**1.34**	**1.14**	**1.50**	**1.46**	**1.39**	**1.34**	**1.24**	**1.29**	**1.52**	**1.11**	**1.34**	**1.35**
37. Occupational hazards	**1.27**	**1.08**	**1.30**	**1.57**	**1.24**	**1.38**	**1.17**	**1.37**	**1.14**	**1.22**	**1.28**	**1.25**

Bold numbers indicate mean values statistically greater than 3.0 (somewhat of a barrier) and less than 2.0 (a minor barrier) at the alpha = 0.10 significance level (one-side t-test).

* Responses range from not a barrier (1) to major barrier (4); regions are coded: US = United States (sample size ranges from 260 to 318 for individual barriers), N = Northern, RM = Rocky Mountain, SW = Southwestern, IM = Intermountain, PS = Pacific Southwest, PNW = Pacific Northwest, S = Southern, E = Eastern, AK = Alaska.

Table 4 Strategies for woody biomass utilization: district ranger (DR) and technical staff (TS) average ratings by region*

Strategies	US	N	RM	SW	IM	PS	PNW	S	E	AK	DR	TS
1. Tax incentives for facility development	**4.33**	**4.42**	**4.32**	**4.45**	4.07	**4.55**	**4.31**	4.18	**4.35**	4.38	**4.29**	**4.35**
2. Tax incentives for harvesting and transporting biomass	**4.27**	**4.29**	4.24	**4.30**	4.10	**4.43**	**4.35**	4.11	**4.33**	4.38	**4.27**	**4.24**
3. Cost-share and grant programs for facility development and equipment purchases	**4.26**	**4.37**	**4.28**	**4.43**	4.00	**4.33**	**4.35**	4.06	4.21	**4.75**	**4.21**	**4.30**
4. Developing facilities that source from multiple suppliers	4.06	**4.41**	3.74	3.96	3.94	4.06	**4.24**	4.18	3.71	4.13	3.99	**4.12**
5. Using hazardous fuels and forest health funding	4.01	4.22	4.07	**4.31**	4.21	**4.38**	4.04	3.83	3.43	2.56	3.85	**4.20**
6. Developing small-scale facilities	3.98	4.18	3.92	4.13	3.97	4.03	3.91	3.86	3.83	**4.38**	3.95	3.99
7. Renewable energy standards and renewable profile standards	3.87	3.94	4.03	3.85	3.61	4.08	3.93	3.55	3.71	4.38	3.86	3.87
8. Developing partnerships to ensure adequate supplies of biomass	3.83	4.00	3.68	3.64	3.83	4.03	3.98	3.49	3.68	**4.44**	3.77	3.83
9. Colocating new facilities with existing industrial infrastructure	3.81	4.10	3.53	3.65	3.70	3.58	4.00	3.92	3.59	3.89	3.69	3.97
10. Encouraging use of biomass in existing wood products industry	3.78	4.03	3.84	3.67	3.55	3.79	3.76	3.85	3.70	3.78	3.79	3.74
11. Utilizing mobile and on-site processing	3.77	4.05	3.65	3.88	3.82	3.79	3.92	3.47	3.57	3.63	3.78	3.75
12. Developing partnerships to promote local harvesting and utilization capacity	3.75	3.85	3.80	3.92	3.80	4.03	3.58	3.48	3.48	**4.44**	3.76	3.63
13. Building agreement on acceptable fuels reduction and forest health treatments	3.75	4.12	3.60	3.88	3.77	3.94	4.18	3.48	3.03	3.22	3.67	3.84
14. Technical assistance programs for business	3.72	3.91	3.79	3.77	3.73	3.92	3.59	3.50	3.67	4.22	3.83	3.55
15. Government bonds and loans	3.70	3.52	4.10	3.72	3.54	3.77	3.70	3.16	3.75	**4.86**	3.64	3.74
16. Developing alternatives to electricity production (e.g., heating, animal bedding, etc.)	3.69	3.64	3.62	4.05	3.58	3.70	3.80	3.51	3.66	4.33	3.66	3.67
17. Undertaking large-scale NEPA analysis	3.68	3.83	3.49	**4.32**	3.77	3.65	3.77	3.57	3.26	3.56	3.61	3.76
18. Developing long-term stewardship contracts and agreements	3.67	3.50	3.95	3.88	3.81	3.88	3.59	3.56	3.00	**4.56**	3.69	3.62
19. Developing public-private partnerships for facility development	3.57	3.85	3.65	3.50	3.74	3.87	3.25	3.26	3.26	**4.44**	3.57	3.49
20. Building agreement on project scale	3.56	3.76	3.62	3.64	3.64	3.71	3.60	3.15	3.15	4.00	3.46	3.65
21. Mandates or incentives for use of green products in construction, energy, vehicles, or equipment	3.51	3.39	3.58	3.50	3.40	4.15	3.39	3.29	3.64	3.11	3.50	3.46
22. Developing short-term stewardship contracts and agreements	3.50	3.30	3.51	3.69	3.59	3.79	3.55	3.38	3.00	4.33	3.49	3.44
23. Developing programs to explain how public concerns about biomass removal and utilization are being addressed	3.43	3.68	3.38	3.52	3.19	3.59	3.41	3.27	3.20	3.89	3.42	3.40
24. Developing large-scale facilities	3.41	3.24	3.24	3.30	3.32	3.74	3.43	3.53	3.38	2.67	3.41	3.37
25. Improving forest road conditions	3.40	3.41	3.41	3.85	3.05	3.60	3.48	3.20	**2.55**	3.56	3.26	3.41
26. Net metering	3.40	3.50	3.40	3.27	3.00	3.79	3.58	3.45	3.30	3.33	3.37	3.43
27. Sourcing a portion of biomass from non-federal forest land	3.40	3.58	3.11	3.09	2.91	3.55	3.77	3.41	3.35	4.22	3.36	3.42
28. Increasing the intensity of biomass harvesting in specific areas	3.39	3.45	3.08	3.48	3.47	3.48	3.51	3.40	3.11	3.78	3.30	3.49
29. Developing projects that restore threatened and endangered species habitat	3.37	3.15	2.90	3.50	3.37	3.80	3.61	3.64	3.24	**2.11**	3.29	3.47

Table 4, continued

Strategies	US	N	RM	SW	IM	PS	PNW	S	E	AK	DR	TS
30. Focusing on projects that best meet performance targets	3.36	3.46	3.03	3.40	3.29	3.33	3.33	3.50	3.36	4.11	3.21	3.55
31. Training Forest Service staff in biomass utilization technologies and logistics	3.33	3.10	3.15	3.52	3.38	3.38	3.29	3.52	3.17	4.00	3.34	3.25
32. Building agreement on facility siting	3.31	3.46	3.21	3.38	3.53	3.61	3.23	3.10	2.93	3.78	3.29	3.30
33. Harvest guidelines	3.31	3.26	3.31	3.52	3.14	3.27	3.28	3.15	3.58	3.89	3.31	3.27
34. Developing MOUs with stakeholders to secure federal biomass	3.26	3.24	3.21	3.28	3.43	3.56	3.42	3.10	**2.50**	4.11	3.31	3.19
35. Developing programs to explain how concerns about public health are being addressed	3.24	3.39	3.13	3.46	3.06	3.55	3.30	3.17	2.79	3.44	3.24	3.21
36. Sourcing a portion of biomass from mill residues	3.14	3.39	2.86	**2.50**	2.81	3.15	3.39	3.46	3.04	3.50	3.06	3.25
37. Developing programs to explain concern about facility development and siting related to biomass utilization are being addressed	3.12	3.26	3.03	3.33	3.15	3.42	3.02	3.08	2.71	3.22	3.10	3.13
38. Developing workforce training programs for biomass utilization facility workers	3.08	2.97	2.92	3.33	3.38	3.13	2.95	3.03	3.04	3.56	3.17	2.89
39. Developing workforce training programs for biomass harvesters	3.07	2.92	2.94	3.38	3.32	3.06	2.89	3.24	3.00	3.22	3.19	2.85
40. Hiring Forest Service staff to help develop utilization capacity	3.05	2.90	3.18	3.46	3.18	3.23	2.78	2.98	2.76	3.78	3.14	2.85
41. Sourcing a portion of biomass from other sources (e.g., urban wood waste)	3.05	2.89	3.03	2.82	2.94	3.50	3.21	3.32	**2.56**	3.00	3.08	2.99
42. Hiring Forest Service staff to focus on biomass removal projects	3.03	2.92	3.05	3.29	3.18	3.11	3.08	2.78	**2.67**	3.89	3.07	3.90
43. Developing programs to explain how concern about public nuisances related to biomass utilization are being addressed	2.95	2.97	3.08	3.38	2.83	3.18	2.81	2.83	2.66	2.78	2.95	2.93
44. Developing agreements with private landowners for access to public lands	**2.73**	2.93	3.10	2.77	**2.64**	2.81	**2.33**	2.88	**2.60**	**2.00**	**2.76**	**2.61**

Bold numbers indicate mean values statistically greater than 4.0 (very important) and less than 3.0 (somewhat important) at the alpha = 0.10 significance level (one-side t-test).

* Responses range from not at all important (1) to extremely important (5); regions are coded: US = United States (sample size ranges from 260 to 318 for individual barriers), N = Northern, RM = Rocky Mountain, SW = Southwestern, IM = Intermountain, PS = Pacific Southwest, PNW = Pacific Northwest, S = Southern, E = Eastern, AK = Alaska.

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