The Impacts of the Woody Biomass Utilization Grant Program in Eastern Oregon and Eastern Arizona

EMILY JANE DAVIS, ANNE MOTTEK LUCAS, YEON-SU KIM, CASSANDRA MOSELEY, MAX NIELSEN-PINCUS, AND TED BILEK

ECOSYSTEM WORKFORCE PROGRAM WORKING PAPER NUMBER 46

UNIVERSITY OF OREGON

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Ecosystem Workforce Program

NORTHERN ARIZONA UNIVERSITY
Ecological Restoration Institute

About the authors

Emily Jane Davis is a faculty research associate, Ecosystem Workforce Program, Institute for a Sustainable Environment, University of Oregon.

Anne Mottek Lucas is the principal of Mottek Consulting.

Yeon-Su Kim is a professor in the School of Forestry and affiliated scientist for the Ecological Restoration Institute at Northern Arizona University.

Cassandra Moseley is director of the Ecosystem Workforce Program and the Institute for a Sustainable Environment, University of Oregon.

Max Nielsen-Pincus is an assistant professor of environmental science and management at Portland State University.

Ted Bilek is an economist with USDA Forest Service Research and Development.

Acknowledgements

Thank you to the interviewees who provided their time, as well as Ron Saranich, Marcus Kauffman, Phil Chang, Jesse Abrams, Susan LeVan-Green, Jerry Payne, and Molly Pitts for their additional information and guidance. Kate MacFarland, Larry Swan, Diane Vosick, Bruce Greco, and John R (Rusty) Dramm provided content reviews. Autumn Ellison provided proofreading services. This research was supported by the USDA Forest Service's Forest Products Laboratory.

Maps by Branden Rishel and Greg Oldson—Ecosystem Workforce Program.

All photos by Emily Jane Davis—Ecosystem Workforce Program.

For more information
Ecosystem Workforce Program
Institute for a Sustainable Environment
5247 University of Oregon
Eugene OR 97403-5247
541-346-4545
ewp@uoregon.edu
ewp.uoregon.edu

UNIVERSITY OF OREGON

Executive summary

From 2005–10, the USDA Forest Service's Woody Biomass Utilization Grant program provided grants for equipment acquisition and technical assistance to rural businesses and other entities. These grants were intended to encourage enterprise development, address market barriers to biomass utilization (ranging from small-diameter sawtimber to chips and logging residues), and decrease forest restoration costs by adding value to biomass products. At the request of the USDA Forest Service – State and Private Forestry's Forest Products Technology Marketing Unit at the Forest Products Laboratory, we evaluated the impacts of this program in eastern Oregon and eastern Arizona (see Table 1, page 2). These areas both have extensive public lands, high wildfire risk, and limited biomass businesses. We analyzed the program's effects on enterprise and industry capacity, state economies, and acres treated and green tons removed. We found that this relatively small ($5 million authorized nationwide annually) program's most clear accomplishments were its significant contributions to regional biomass processing capacity, which occurred despite challenging market and economic conditions. Outcomes such as increased acres treated and reduced costs were less discernible, and there was no concurrent investment in agency capacity to implement biomass removal projects. Given the complexities of public land management and associated business development, strategies such as the Woody Biomass Utilization Grant program are critical to increasing biomass utilization, but are likely to achieve greater outcomes when incorporated with other tools to improve federal agency and stakeholder capacity, active land management, and long-term industry sustainability.

Specifically, we found that:

The Woody Biomass Utilization Grant program increased individual enterprises' capacities to process biomass from national forests and diversify product lines

In both case study areas, the majority of the grants were for processing equipment, which substantially enhanced grantees' capacities to diversify supply and product lines. Some enterprises were able to access biomass from national forestlands for the first time; others improved their ability to use smaller-diameter logs for value-added products, increasing the amount and types of forest biomass supply they could use. Many grantees diversified the types of products that they made and were better able to

Table 1 Woody Biomass Utilization Grants in eastern Oregon and eastern Arizona, 2005–10

	Eastern Oregon	Eastern Arizona
Number of grants	14	12*
Total grant funds	$3.2 million	$2.6 million
Total matching funds	$3.4 million	$4.9 million
Percent of total funds spent on equipment	48	54
Total one-time spending impacts		
Jobs created or retained	51	45
Wages generated	$3.9 million	$3.7 million
Economic activity generated	$6.1 million	$6.6 million
Tax revenues	$1.1 million	$0.93 million

* 12 awarded; 2 unsuccessful grants were eliminated for economic analysis

weather the recession of 2008–10 by shifting toward products that were less dependent on the housing industry.

The Woody Biomass Utilization Grant program substantially contributed to overall biomass industry capacity

The Woody Biomass Utilization Grant program provided grants for many different activities related to biomass utilization including providing technical assistance, purchasing additional harvesting equipment, upgrading existing wood product processing facilities, and building new small-diameter sawmills. This broad scope meant that it was simultaneously investing in multiple places in the biomass supply chain in both case study areas. The program sustained and accelerated the biomass industry across eastern Oregon by adding numerous pieces of new harvesting and processing equipment to its capacity. In eastern Arizona, the program was the primary source of investment in the redevelopment of the entire forest products industry's capacity to treat the land. In both cases, the program added and expanded multiple processing businesses, increasing capacity to produce diverse value-added materials near national forestland.

In-state economic impacts arose from equipment purchases and use of matching funds for labor and services

An average of 70 percent of grants in both study areas went to equipment purchases and installation. Oregon grantees purchased some of their equipment from Oregon vendors, while Arizona grantees purchased no equipment in state, because few equipment vendors were available in Arizona. Yet economic impacts generated per 10,000 green tons were actually larger in eastern Arizona than in eastern Oregon, suggesting that biomass utilization is more labor intensive in Arizona and more mechanically intensive in Oregon. In both cases, grantees spent matching funds on labor and services within the case study areas, which created important local economic activity.

Intermediary assistance was key to program delivery

In both case studies, intermediaries including nonprofit organizations, Forest Service personnel, state agency personnel, and others provided technical assistance to grantees that improved overall program delivery. They identified prospective grantees with strong business models and opportunities to innovate, offered grant writing assistance, and contributed significant technical, financial, and networking

skills in grant implementation. Without these intermediaries, many grantees would likely have faced greater challenges and less success. In addition, the presence of collaborative groups and community-based organizations that had worked on social agreement and agency capacity issues prior to the grants helped make biomass supply available.

Program impacts on public lands management were not clear

Grantees in both cases faced difficulty obtaining consistent biomass supply from national forests and grant impacts on acres treated and costs were not clear. National forest management often did not appear to be coordinated with or accelerated on behalf of the Woody Biomass Utilization Grant program. In eastern Arizona, grantees operated on one national forest with a large stewardship contract for service work and biomass removal that a single contractor held, which grantees felt limited their access to raw material. In eastern Oregon, grantees operated across six national forests that did not share any particular strategy or commitment to biomass utilization; but the forests used more diverse, flexible mechanisms for biomass access. In addition to business capacity, the ability of national forest and Regional Office staff to plan and implement land management projects with biomass utilization components is important for treating acres and reducing costs. However, a monitoring report on the White Mountain Stewardship Project suggests that the effects of increased biomass utilization capacity on the Apache-Sitgreaves National Forest were notable because costs per acre remained stable during an unprecedented downturn in the wood products markets; and, further, because costs did not increase even though contractors began to treat more complex areas.

Challenges to program success included market conditions and grantee capacity

Grantees in both cases faced significant technical and market challenges, including new and little-understood biomass utilization applications and a depressed housing market and recession. Some grantees did not add enough value to their products, create a specialty product niche, have strong understanding of and access to the right markets, or select the most efficient and effective use for small-diameter pine. In eastern Oregon, grantees that sought to enter markets that were well beyond their control and relatively weak during the study period, such as the electricity market, were severely challenged and could not complete their grants.

The Woody Biomass Utilization Grant program provided unique investment that does not seem to be available through other programs and policies

The Woody Biomass Utilization Grant program was unique in that it allowed a land management agency to fund equipment acquisition, fill gaps in regional industry, and support networks of technical assistance and learning. Grantees in both cases expressed disappointment that the Woody Biomass Utilization Grant program shifted its focus (after 2010) to funding engineering studies for energy projects, noting that 1) there was less interest in this type of assistance in their regions, and 2) other grant programs did not fit their need to increase capacity to utilize biomass from public lands.

Lessons

Careful grantee review and intermediary engagement improved grant success

Intermediary assistance both before and during grants may increase enterprise capacity and the likelihood of grant success. A robust review panel including external participants with diverse expertise (e.g. technical, financial, etc.) could be useful for examining grant proposals for equipment viability, grantee experience, legal authority/licensing issues, and sustainable business plans. During the grants, deliberate investment in technical assistance to help grantees understand equipment, technology, and markets in particular may help increase the viability of grants.

Coordination and engagement with National Forest System managers are as important as business investment

The Woody Biomass Utilization Grant program directly built enterprise capacity, but not agency capacity for biomass utilization. The ability of national forest and Regional Office staff to plan and implement land management is essential to increasing acres treated and reducing costs. Deliberate, coordinated investment in agency capacity at local levels, particularly on how to use stewardship contracting and how to build working relationships with local businesses to understand their abilities and needs, might help improve land management outcomes.

Lack of monitoring limited measurement of impacts

Requesting information and measures that grantees will readily know and that are focused on the business outcomes may increase reporting and understanding of impacts. Further, more close contact and guidance on measurement between the Forest Products Laboratory, the Regional Offices, and national forest units may help improve the availability and accuracy of data on broad interest measures such as acres treated and costs.

Forestland restoration and hazardous fuels reduction are critical land management objectives of the USDA Forest Service. Removing and utilizing woody biomass[1] and creating value-added products from these activities can help defray land management costs, enhance community wildfire protection, and provide business and economic opportunities in rural public lands communities.[2] However, harvesting and removing biomass from the forest is expensive, and there are challenges to starting woody biomass enterprises or adding biomass utilization to existing business models. These include limited access to capital and markets, technical assistance, and supply from public lands.[3] Where woody biomass is already being utilized, it often is a combination of private land and mill residuals, rather than byproducts of restoration and fuels reduction on national forests.[4]

To help meet forest restoration goals across all landscapes, the Forest Service articulated a strategy for addressing enterprise and technical obstacles and increasing the effectiveness and efficiency of fuels reduction through woody biomass utilization. This included funding for the Woody Biomass Utilization Grant program, administered by the State and Private Forestry's Technology Marketing Unit located at the Forest Products Laboratory (FPL).[5] Founded in 2005, program objectives aimed to 1) reduce market barriers to biomass utilization, 2) decrease costs of forest restoration by increasing value-added production from biomass, and 3) encourage enterprise development.[6] From its inception until 2011, the program provided grants for equipment acquisition and technical assistance for an array of biomass uses. Since 2011, it has shifted to grants for engineering studies for bioenergy facilities.

The Woody Biomass Utilization Grant program was unique in that it provided investment opportunities for the woody biomass industry, and achieved USDA Forest Service fuels reduction and land restoration objectives through economic and industrial development. Direct investment in biomass enterprises has not been the primary intent of many granting programs or policies.

Although other federal grant sources such as USDA Rural Development's Business and Cooperative program do exist, it is not clear if restoration and forest products businesses are successfully accessing them. A study of this Rural Development program in Oregon found that less than one percent of all funds from 2007–11 (about $230,000 in total) went to these types of businesses.[7] Policies such as the National Fire Plan of 2001 also provided resources for an ar-

ray of hazardous fuels reduction-related activities, but these policies also were not specifically directed at biomass enterprises.

To examine the impacts of this unique program, the FPL asked the Ecosystem Workforce Program at the University of Oregon and Northern Arizona University to conduct case studies of Woody Biomass Utilization grants awarded in eastern Oregon and eastern Arizona. Both regions have significant forest restoration and wildfire protection needs, high percentages of public land, and active collaborative efforts around land management and business development. In particular, the FPL wished to understand how the Woody Biomass Utilization Grant program had affected enterprise capacity, improved cost-per-acre and biomass utilization opportunities on public land, and generated jobs and other economic impacts.

We first separately present results from the eastern Oregon and eastern Arizona case studies on the following topics: enterprise impacts, industry capacity impacts, intermediary roles, Forest Service dimensions, and policy dimensions. We then comparatively discuss lessons learned, including insights into successful grants, and other cross-case observations.

Methods

We studied grants awarded between 2005 and 2010 in eastern Oregon and the White Mountains region of eastern Arizona. We employed mixed methods including document analysis, semi-structured interviews, and economic impact analysis and modeling.

Qualitative analysis

The Woody Biomass Utilization Grant program provided documentation including grant proposals with requested and matching budget information, progress and final reports, and some biomass utilization data from national forests. However, grant records were incomplete as grantees and national forest personnel were not consistent in returning or entirely completing reports. We reviewed these documents and entered available data about grant amount, duration, use, benefits and outcomes, challenges, and other dimensions into a standardized profile for each grantee, and identified information gaps to pursue through interviews.

We conducted interviews between February and May 2013. In Oregon, one researcher conducted interviews with ten grant recipients, and five key informants from the Forest Service's Region 6 Office, national forests, and the Oregon Department of Forestry. Interviews were not conducted with four grant recipients who were not available. Our analysis excluded one of the harvesting grants as no data were available. Although two bioenergy grants did not result in successful facilities, we discuss them briefly to the extent that information was available. One researcher from northern Arizona conducted interviews; ten with grantees, two with Forest Service personnel, and one with a regional stakeholder who provided assistance to grantees. Interviews were not conducted with two of the grantees; one was unsuccessful and transferred the equipment to another company and the other became ill. Interviews were conducted primarily in person. We used the profiles for each grantee to guide our interview questions. In the Oregon case, we took structured, detailed notes during the interviews, and added further field notes afterward to capture additional impressions and themes. In the Arizona case, interviews were audio-recorded and transcribed. We organized interview data into matrices to develop, compare, and contrast findings within and across the case studies in the following categories, which mirrored interview questions: use of grant; enterprise and industry context; new enterprise developments and opportunities due to the grant; effects on industry and markets; role of the Forest Service, challenges and limitations; and comments on regional biomass utilization successes and challenges. The research team used the matrices to discuss interview findings and integrate them with results from IMPLAN and other data sources.

Economic impact analysis

We used the economic impact modeling software IMPLAN 3.0[8] to describe impacts of the Woody Biomass Utilization Grant program on the economies of Oregon and Arizona (see Appendix A, page 34). We analyzed impacts from: 1) purchases of goods and

services, and 2) utilization of biomass from operation of new equipment as reported by grantees.

Economic impacts for both the grant awards and subsequent biomass utilization are reported as a total and annual average for the study period and annually (for grants from 2005 to 2010, and for utilization from 2006 to 2011). We estimated the impacts of grant purchases by developing an expenditure profile for both grant expenditures along with reported matching funds. Since one measure of grant effectiveness is whether a grant triggers a project that requires spending of some non-grant dollars that would not otherwise occur, match impacts are important to analyze. We estimated biomass utilization impacts using an existing IMPLAN model of biomass utilization that the University of Oregon had previously developed to estimate the impact of the Oregon Biomass Producers or Consumers Tax Credit.[9] We adapted this model for the Arizona economy. The utilization model focuses on collection of forest biomass and its delivery to a biomass utilization facility, based on the volume of material harvested. The model, however, does not estimate the impact of the sale of finished goods produced from forest biomass (e.g. electricity, heat, posts and poles, animal bedding, etc.) in the marketplace. Rather, IMPLAN measured how demand for biomass processing equipment and other goods and services required for the collection and transport of forest biomass traced through the economies of Arizona and Oregon to create broader changes in employment, wages, economic output, and taxes.

We did not estimate jobs or economic activity generated through the production and sales of end-consumer finished goods (e.g. energy, small-diameter posts and poles), nor did we estimate quantity or value of these finished goods in our economic impact analysis. Adding these jobs and economic activity to the analysis would likely substantially add to the economic impact we estimated. For example, if we assumed that wages paid to employees of the grantees were paid not for equipment set up but to operate the purchased equipment in the production of finished goods, we would report more than 100 jobs produced per year in each state from the production and sale of finished goods alone. As such, our estimates represent conservative estimates that are in line with previous studies of the economic impacts of forest and watershed restoration.[10,11]

Eastern Oregon case study

Case study area

Eastern Oregon is an informally-defined region that we considered as the 18 counties east of the Cascade Mountain Range. Its diversity of ecosystems includes the Blue Mountains and foothills, Eastern Cascade Mountains, Northwestern Basin and Range, and smaller portions of the Modoc Plateau and Southern Cascade Mountains. Forest types range from moist mixed-conifer to sage-steppe shrublands.[12] Historically, wildfire was a frequent occurrence in much of this landscape.

Eastern Oregon is a rural region with 22 percent of the state's 3.8 million people, and only one county (Deschutes) that is a census-designated metro area. The majority of the communities are small with limited transportation and market connections to urban areas, although the city of Bend has over 90,000 residents. Within the greater eastern Oregon study area, we focused on three subregions: northeastern Oregon, the Blue Mountains, and central Oregon.

A recent study of forest products processing capacity in eastern Oregon suggests that there were 45 operational primary processing facilities at the end of 2012, defined as "manufacturers who produce wood products directly from logs, such as lumber, veneer, plywood, posts and poles, timbers, clean chips, hog fuel, and shavings; manufacturers who make products from bark, sawdust, and planer shavings, such as pulp and paper mills, composite panel plants, mulch and soil amendment producers, densified wood fuel plants, animal bedding plants, and thermal and electrical energy facilities."[13] This is a more extensive and diverse capacity than that of eastern Arizona. However, eastern Oregon's industry has also contracted significantly in the past two decades; 30 sawmills and nine other facilities have closed since 1990.[14]

Forest management context

Eastern Oregon contains the Wallowa-Whitman, Malheur, Umatilla, Ochoco, Deschutes, and Fremont-Winema National Forests, as well as extensive Bureau of Land Management ownership that together constitute 84 percent of Oregon's federal lands.[15] The region is home to at least ten established forest collaborative groups and several community-based organizations that support biomass utilization efforts on federal lands. Collaborative groups in Oregon are organized around national forests or specific landscapes and include diverse interests that work together to identify shared goals on public lands and play varying roles in the development, implementation, and monitoring of land management projects. At the start of the study period (2005), collaborative efforts included the Central Oregon Partnerships for Wildfire Risk Reduction (COPWRR), the Lakeview Stewardship Group, the Wallowa County Natural Resources Action Committee, and the Blue Mountains Forest Partners. By the end of the study period, collaborative groups had formed or were about to form on every national forest in eastern Oregon. Community-based organizations are small nonprofit entities that support integrated natural resource management and economic development in their local areas. They perform diverse tasks such as staffing collaborative groups, providing technical assistance to enterprises and land management agencies, or organizing community wildfire protection planning. Collaboratives and community-based organizations often support biomass utilization on national forests by seeking the social agreement and agency capacity necessary to design and implement projects wherein biomass supply will be produced from the forest, recruiting entrepreneurs, assisting enterprises with obtaining grants and other resources, or exploring market development. In the study period, there were two active community-based organizations in the region: Wallowa Resources, founded in 1996 in northeastern Oregon, and the Lake County Resources Initiative, founded in 2002 in southern-central Oregon. Regional-scale intermediaries, such as Sustainable Northwest, Oregon Solutions, and The Nature Conservancy have also been active in providing technical support and resources to encourage active forest restoration and increase biomass utilization and economic activity in eastern Oregon.

Eastern Oregon forest products processing capacity (2012)

- **11** sawmills
- **2** plywood plants
- **5** stationary or semi-stationary pulp log chipping facilities or locations
- **3** major mobile chipping or grinding operations
- **1** hardboard plant
- **4** post/pole manufacturers
- **2** whole log shaving operations
- **3** major firewood processors;
- **3** smaller specialty sawmills
- **7** plants that use processing residuals (e.g., particleboard, MDF and densified wood fuel)
- **1** biomass cogeneration plant (temporarily closed)

Source: Swan 2012

Case study findings

Overview of grants

The Woody Biomass Utilization Grant program supported 14 recipients in eastern Oregon during our study period: 11 enterprises, two nonprofits, and one regional government entity (see Table 2, page 9, and Figure 1, page 11). Three grants were for harvesting equipment, seven grants were for processing capacity, two were for bioenergy facility development, and two were for technical assistance and other intermediary activities. Recipients included logging contractors, existing enterprises that were already utilizing biomass for small-diameter wood products, firms proposing bioenergy facilities, a regional council of governments, a regional nonprofit organization, and a community-based organization. All recipients performed biomass utilization or related work on both national forestland and private land in eastern Oregon.

Grants in eastern Oregon totaled $3.2 million in the study period, and were matched with an additional $3.4 million of funding from other sources (mostly private sector) (see Table 3, page 10, and Figure 2,

Table 2 Eastern Oregon Woody Biomass Utilization Grants, awarded 2005–10

Business name	Grant year	Grant award	Project description
Dodge Logging, Inc.	2005	$250,000	Install single pass saw and wood pellet mill
Warm Springs Forest Products Industries	2005	$250,000	Upgrade existing biomass energy plant
Wallowa Resources	2005	$250,000	Expand existing post and pole plant to include production of clean mill chips, hog fuel, and firewood
Central Oregon Intergovernmental Council	2005	$220,000	Develop and implement scheduling protocols for Forest Service and BLM units to predict five-year programs of work and biomass
M&L Enterprise	2005	$236,500	Install new log peeler, upgrade existing peeler, and purchase firewood processor
Roseberry Timber, Inc.	2006	$243,500	Purchase horizontal grinder
Ochoco (Malheur) Lumber Company	2007	$250,000	Purchase and install a whole-log shaver, rotary drum dryer, and log material handling systems for bagged wood shavings
Sustainable Northwest	2007	$249,560	Provide strategic financial and technical assistance to four separate sub-grantees
JTS Animal Bedding	2007	$250,000	Launch a green shavings animal bedding production facility with purchase of a loader, debarker, and shaver
Quicksilver, Inc.	2008	$250,000	Purchase a portable chip trailer tipper, mobile scales, and a scale shack for reloading chip trailers
Marubeni Sustainable Energy, Inc./ Iberdrola Renewables, Inc.	2009	$250,000	Build fuel handling equipment at planned 26.8 MW biomass plant
Community Smallwood Solutions, LLC	2009	$249,819	Purchase a horizontal wood hog for processing slash and wood waste
T2, Inc.	2009	$243,000	Purchase excavator and road grader to increase access and efficiency of in-woods processing (included ARRA resources)
Foothills Firewood, LLC	2010	$250,000	Obtain harvesting and processing equipment to expand firewood production

page 12). Grantees used more than 63 percent of grant dollars and more than 48 percent of total Woody Biomass Utilization Grant project spending in eastern Oregon to purchase equipment (see Table 4, page 10). They purchased the majority of equipment in Oregon. Marketing and consulting services were the second largest grant expenditure category, followed by wages paid to employees of grantees. Grantees spent matching funds in somewhat different proportions than grant dollars. Although equipment purchases and wages remained the top two categories of spending, relatively less of the matching funds were spent on equipment and relatively more was spent on wages. Furthermore, installation costs (25 percent), related to the installation and construction of utilization facilities, were the third largest category of match spending. Another difference between grant and match spending was that a substantially greater proportion of grant funds went to marketing and technical consulting services.

Table 3 Eastern Oregon Woody Biomass Utilization Grant project expenditures per year, 2005–10 (in $1,000s)

Grants	2005	2006	2007	2008	2009	2010	Total	Annual avg
Number of grants	5	1	3	1	3	1	13	2.17
$Grant per year	$1,179	$250	$727	$250	$494	$325	$3,224	$537
$Match per year	$901	$571	$1,401	$141	$272	$86	$3,374	$760
Total dollars	**$2,080**	**$821**	**$2,128**	**$391**	**$766**	**$411**	**$6,598**	**$1,100**

Table 4 Eastern Oregon Woody Biomass Utilization Grant project expenditures by category, 2005–10

Category	Sector description	Grant (%)	Match (%)	Total (%)
Equipment	**Wholesale trade (319)**	**63.2**	**33.2**	**47.8**
	In Oregon	43.5	30.3	36.7
	Outside of Oregon (leakage)	19.6	3.0	11.1
Marketing and consulting	**Management, scientific, and technical consulting services (374)**	**11.4**	**2.3**	**6.7**
	Technical consulting services	8.2	0.7	4.4
	Marketing, training, travel	3.2	1.6	2.4
Wages and benefits	**Employee compensation**	**9.3**	**28.3**	**19.1**
	Other miscellaneous wood product manufacturing (103)	0.2	9.0	4.7
	Logging (16)	0.0	0.8	0.4
	Civic, social, professional, and similar organizations (425)	3.5	2.2	2.8
	Other state and local governmental enterprises (432)	4.7	1.5	3.1
	Wood product production (95)	0.9	14.8	8.1
Other expenses		**16.1**	**36.1**	**26.4**
	Construction of new nonresidential manufacturing structures (35)	8.1	24.5	16.5
	Wholesale trade—supplies and materials (319)	3.1	3.3	3.2
	Architectural and engineering services (369)	2.0	0.4	1.2
	Other state and local governmental enterprises (432)	1.1	0.2	0.6
	Wood product production—sawmills (95)	0.9	7.6	4.4
	Civic, social, professional, and similar organizations—NGOs (425)	0.7	0.1	0.4
	All other miscellaneous wood product manufactruring (103)	0.2	0.1	0.1
Total (%)		**100**	**100**	**100**
Total ($1,000s)		$3,224	$3,374	$6,598

Figure 1 Eastern Oregon Woody Biomass Utilization grantees

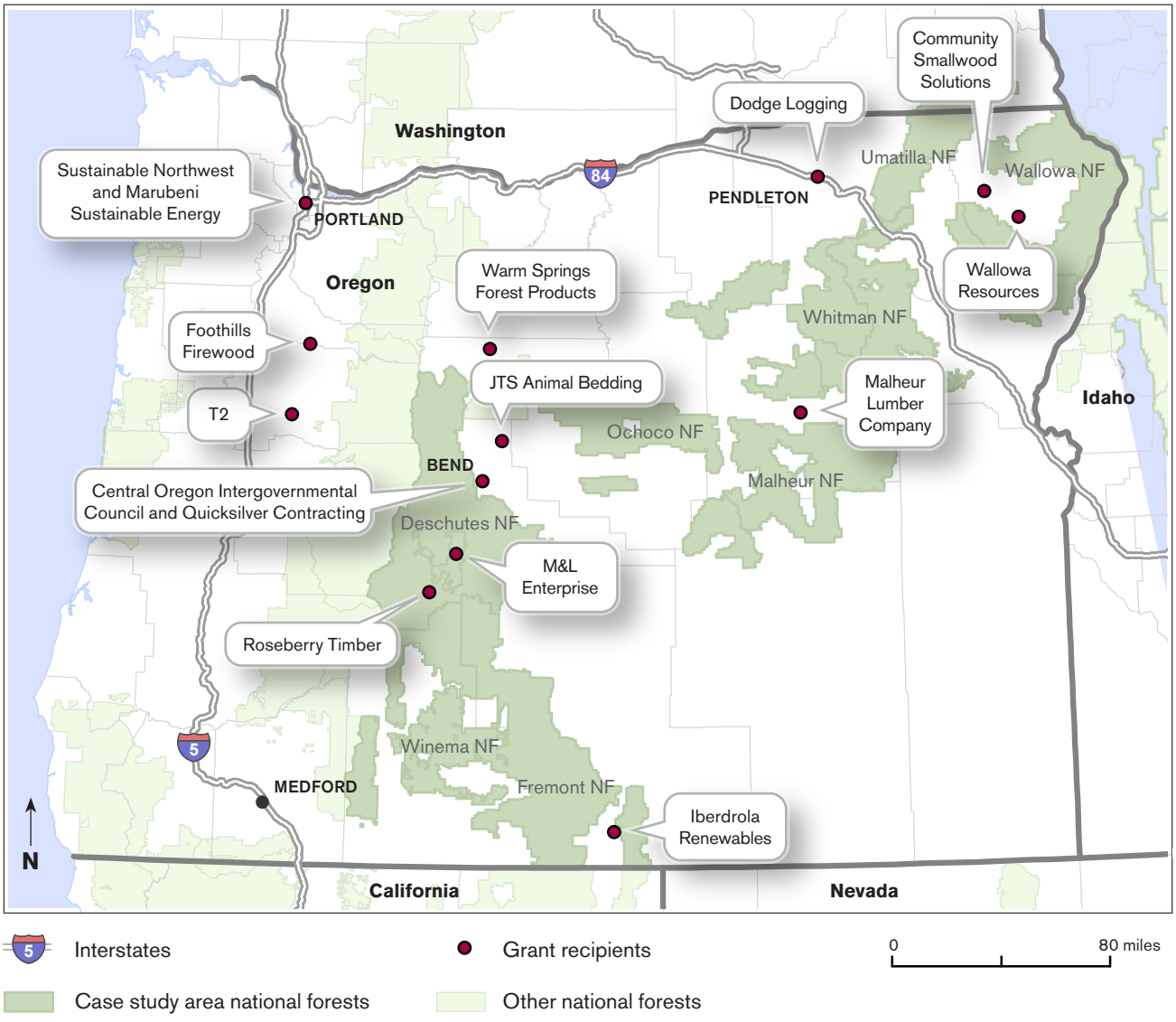
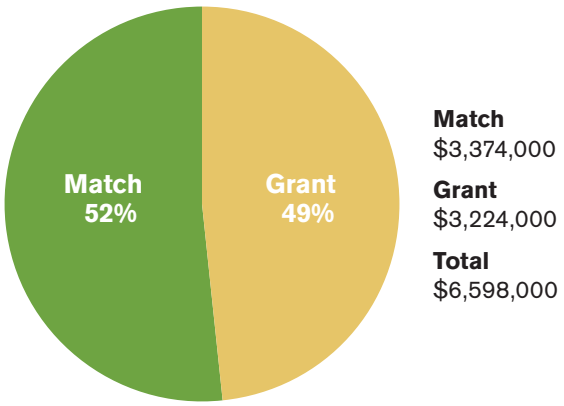


Figure 2 Proportion of eastern Oregon Woody Biomass Utilization grant and match dollars, 2005–10



Grant impacts at the enterprise scale

We examined program impacts on individual enterprises, which included: creating jobs and other economic impacts; and improving their ability to access supply, diversify product lines, obtain capital, and use matching resources.

Grant and match purchases impacts

Woody Biomass Utilization Grant spending between 2005 and 2010 in eastern Oregon generated one-time impacts of over 51 jobs (about nine jobs per year for six years), $3.9 million in wages ($0.7 million per year), $6.1 million in economic activities ($1.0 million per year), and $1.1 million in tax revenues ($0.2 million per year) (see Table 5, page 13). Matching funds, which were mostly spent on labor and services, generated 36 percent more jobs, 73 percent more wages and benefits, and 41 percent more economic output than grant funds. Grant spending generated less economic impact per dollar because it was focused on equipment purchases, roughly a third of which were outside of Oregon, and the remainder of which occurred through wholesalers (which add relatively little economic value over and above the cost of the equipment). The potential for ongoing impacts of the Woody Biomass Utilization Grant program is addressed next.

Increased capacity to harvest and remove biomass

Two of the studied enterprises were contractors who invested in harvesting equipment to more efficiently remove biomass from the forest. Traditional logging contractors can perform some biomass harvesting and removal, but these tasks often require different equipment to selectively cut and handle small-diameter material ("slash" such as brush, tree tops and branches; or very small logs). One grantee, an established biomass removal business that harvested, ground, and transported biomass to power plants, acquired a new grapple that efficiently grabbed more slash at once. The grantee was able to remove an average of 30 loads a day using this equipment, which increased the scope and scale of their work on the Deschutes National Forest. Another grantee, a logging and firefighting contractor, purchased a horizontal grinder and several other pieces of equipment to add biomass chipping to their existing capacity. Chipping broke the biomass into smaller pieces, enabling transport of more material at less cost. This grantee reported removing an estimated 2,100 green tons of biomass from 670 acres on the Winema National Forest, but utilized their equipment far more on California national forests and private timberland.

Diversification of supply and product lines

In line with the goals of the Woody Biomass Utilization Grant program, ten enterprises purchased equipment that allowed them to add value to forest biomass and diversify both their supply and product lines. All enterprises interviewed stated that without the Woody Biomass Utilization Grant program, they would not have been able to initiate or expand biomass utilization.

Although there are numerous factors in successful supply diversification, such as the ability of national forest units to offer biomass material, enterprise capacity and equipment type also mattered. We found that one grantee, an animal bedding business, was able to access in-woods biomass supply for the first time. By acquiring a new log shaver, the grantee was able to transition from utilizing only sawmill residuals from a Weyerhaeuser facility in western Washington to obtaining pine shavings from forest management activities on the Deschutes

Table 5 Eastern Oregon Woody Biomass Utilization Grant annual project economic impacts, 2005–10 (2013 dollars)

		Grants	2005	2006	2007	2008	2009	2010	Total	Annual avg
Number of jobs	Grant	Direct effect	3.77	0.80	2.33	0.80	1.58	1.04	10.32	1.72
		Indirect effect	0.94	0.20	0.58	0.20	0.40	0.26	2.58	0.43
		Induced effect	2.83	0.60	1.75	0.60	1.19	0.65	7.61	1.27
		Total effect	8.01	1.60	4.65	1.60	3.16	2.08	21.11	3.52
	Match	Direct effect	3.61	2.28	5.61	0.56	1.09	0.35	13.50	2.25
		Indirect effect	1.08	0.69	1.68	0.17	0.33	0.10	4.05	0.67
		Induced effect	3.61	2.28	5.61	0.56	1.09	0.31	13.46	2.24
		Total effect	8.29	5.02	12.33	1.24	2.40	0.73	30.02	5.00
		Total	**16.31**	**6.62**	**16.99**	**2.84**	**5.56**	**2.81**	**51.12**	**8.52**
Wages	Grant	Direct effect	$372,010	$76,446	$216,063	$72,679	$142,319	$92,434	$971,951	$161,992
		Indirect effect	$51,552	$10,526	$29,383	$9,891	$19,739	$12,785	$133,876	$22,313
		Induced effect	$114,201	$23,449	$66,174	$22,262	$43,697	$28,370	$298,153	$49,692
		Total effect	$537,759	$110,422	$311,620	$104,832	$205,755	$133,589	$1,403,977	$233,996
	Match	Direct effect	$509,795	$312,808	$746,033	$73,476	$140,652	$44,059	$1,826,821	$304,470
		Indirect effect	$48,170	$29,786	$71,956	$7,176	$14,332	$4,412	$175,832	$29,305
		Induced effect	$150,046	$92,130	$219,976	$21,690	$41,680	$13,035	$538,556	$89,759
		Total effect	$708,011	$434,723	$1,037,965	$102,341	$196,664	$61,506	$2,541,209	$423,535
		Total	**$1,245,770**	**$545,145**	**$1,349,585**	**$207,173**	**$402,418**	**$195,095**	**$3,945,186**	**$657,531**
Economic output	Grant	Direct effect	$465,913	$95,125	$265,735	$89,332	$177,403	$115,513	$1,209,021	$201,504
		Indirect effect	$140,449	$28,667	$80,003	$26,922	$53,726	$34,795	$364,562	$60,760
		Induced effect	$347,130	$71,278	$201,149	$67,670	$132,823	$86,237	$906,286	$151,048
		Total effect	$953,491	$195,071	$546,887	$183,924	$363,951	$236,544	$2,479,868	$413,311
	Match	Direct effect	$428,430	$261,648	$624,015	$61,413	$120,066	$37,726	$1,533,298	$255,550
		Indirect effect	$133,141	$82,306	$198,794	$19,821	$39,590	$12,187	$485,839	$80,973
		Induced effect	$456,079	$280,039	$668,640	$65,927	$126,691	$39,623	$1,636,998	$272,833
		Total effect	$1,017,650	$623,993	$1,491,443	$147,161	$286,348	$89,535	$3,656,130	$609,355
		Total	**$1,971,141**	**$819,064**	**$2,038,330**	**$331,085**	**$650,298**	**$326,079**	**$6,135,998**	**$1,022,666**
State and local taxes	Grant		$61,277	$12,583	$35,505	$11,943	$23,450	$15,226	$159,985	$26,664
	Match		$66,289	$40,712	$97,264	$9,594	$18,470	$5,773	$238,103	$39,684
		Total	**$127,567**	**$53,295**	**$132,769**	**$21,537**	**$41,921**	**$20,999**	**$398,088**	**$66,348**
Federal taxes	Grant		$103,222	$21,195	$59,805	$20,118	$39,492	$25,638	$269,470	$44,912
	Match		$133,592	$82,025	$195,862	$19,311	$37,116	$11,608	$479,515	$79,919
		Total	**$236,815**	**$103,220**	**$255,667**	**$39,429**	**$76,608**	**$37,246**	**$748,985**	**$124,831**
Total impacts on tax	Grant		$164,500	$33,778	$95,310	$32,061	$62,942	$40,865	$429,456	$71,576
	Match		$199,882	$122,738	$293,126	$28,905	$55,587	$17,381	$717,618	$119,603
		Total	**$364,381**	**$156,516**	**$388,436**	**$60,966**	**$118,529**	**$58,245**	**$1,147,074**	**$191,179**

and Ochoco National Forests. This meant that they were less vulnerable to fluctuations in supply from Weyerhaeuser, which is affected directly by housing markets and other external factors, and had access to more local material.

We also found that the grants allowed enterprises to create new kinds of products. One grantee's new log peeler allowed the firm to process larger and longer logs, reach new value-added post and pole markets such as hops poles, and double their production off both Forest Service and private lands. A sawmill grantee was able to substantially diversify its business by shaving small-diameter logs for a new market; the mill previously did not have equipment to process this type of material. This allowed the grantee to sell lighter, fluffier pine shavings, which are in demand in the bagged animal bedding industry, and contributed to their further expansion in 2009 to add a pellet mill. Two integrated biomass production facilities also restructured their systems and merchandizing to add greater value to forest biomass products.

Enterprise capacity to obtain capital and leverage match

Forest Service employees and others familiar with the grants noted that Woody Biomass Utilization Grant funding provided enterprises with the opportunity to obtain other resources and combine them with the grant to maximize impact. Obtaining capital is often challenging for small natural resource-based businesses, but grantees were able to use their grant applications to leverage additional access to capital that would not otherwise have been possible. For example, with its grant to start a small-diameter post and pole facility, a community-based organization was able to secure a line of credit from Northeast Oregon Economic Development District and develop a limited liability corporation business model. In total, the grant allowed the organization to acquire $320,000 in additional investments to continue development of multiple components of a biomass utilization campus model; today, this is a successful enterprise that has continued to expand its capacity. Further, nearly all studied grantees used significant matching dollars to complete work associated with their grants, such as covering staff time or constructing buildings to house new equipment.

Grant impacts and issues at the regional/industry scale

We examined the impacts of these grants on overall industry capacity and biomass markets. We considered industry capacity to include the strength, diversity, and distribution of harvesting and processing enterprises, bioenergy facilities, and intermediaries.

Overall industry capacity

The studied grants helped add numerous pieces of new harvesting and processing equipment to the biomass industry in eastern Oregon. We consider how these grants affected dimensions of overall industry capacity, and then capacity in each of the studied sub-regions.

We found that the Woody Biomass Utilization Grant program invested the most (in both dollar amounts and numbers of grants) in processing capacity in eastern Oregon. The seven grants to processing enterprises were distributed across the study region, and had different effects depending on location as we discuss below by subregion. They added or expanded production of animal bedding, shavings, posts and poles, and firewood.

The second-largest amount was spent on grants to intermediaries. The three grants and one sub-grant to nonprofit and governmental organizations greatly helped increase the abilities of staff to understand biomass business needs and provide technical assistance. They also supported the overall strength and resiliency of these organizations by contributing to their budgets and helping to build successful grant writing records. Moreover, these entities already had working relationships, and with a common source of support, they were able to grow their collective focus on regional industry growth and build shared knowledge about biomass utilization.

Three grants for harvesting equipment went to grantees primarily active on the Deschutes and Fremont-Winema National Forests in central and southern-central Oregon. Investment in harvesting capacity was thus fairly concentrated in one sub-region. It is not clear if there was already adequate harvesting capacity in other sub-regions and businesses from those areas did not apply for grants, or if they

did and were not competitive. Two of these grantees continue to operate in the sub-region, but one grantee that had purchased a horizontal grinder and numerous other pieces of equipment relocated the business out of the state toward the end of the grant period, taking its new capacity outside Oregon.

Despite extensive interest in building biomass cogeneration and electricity facilities in eastern Oregon, the two grants for bioenergy projects did not lead to increased capacity. One grant was repurposed for investments in a sawmill, while the other for a planned 26.8-megawatt plant in Lakeview has not resulted in a new facility being built. Harvesting grantees ground biomass and transported it to plants in southern Oregon and northern California, outside of the study area. There continues to be no active capacity for larger-scale biomass electricity use in eastern Oregon.

Northeastern Oregon
Although a sawmill and several other forest products facilities exist in Union County, Wallowa County has no processing infrastructure and there have been longstanding efforts since the closure of its remaining sawmills to institute an integrated biomass utilization campus. The two grants awarded in northeastern Oregon for an emerging integrated biomass utilization campus business contributed significantly to the redevelopment of processing capacity in northeastern Oregon. Another grant to a regional nonprofit for technical assistance included a sub-grant for moving biomass utilization ideas forward with a landowner cooperative in Baker County (see Intermediary roles and impacts, page 16). This sub-grant helped increase knowledge and understanding of the challenges of biomass utilization among members of this cooperative, but has not resulted in the development of any new biomass infrastructure in the area to date.

Blue Mountains
The two grants awarded in this area expanded the capacity of the existing lumber industry to process small-diameter logs for new uses. The ability of one sawmill grantee to use small-diameter logs for bagged shavings created an end use for this material off the Malheur National Forest where there previously had been none. Another grant improved a small-log sort and merchandizing yard project of an enterprise based in Pendleton, enhancing the firm's ability to process small-diameter material from several national forests in Oregon and Washington.

Central Oregon
Central Oregon's industry capacity at the time of the grant program was diverse and included two sawmills and several value-added and other biomass enterprises. Seven grants went to entities for biomass utilization in national forests in the central Oregon area for an array of activities that included harvesting, processing, bioenergy development, and technical assistance. All the grants for harvesting equipment were focused on this sub-region although one of the grantees relocated the business after the grant. Investments in processing were for the diverse purposes of firewood, animal bedding, and post and pole equipment. Sub-regional capacity to produce firewood and post and poles from activities on national forest lands was enhanced and new capacity to produce animal bedding from these activities was created, adding a new end user for forest biomass to the industry. As a result of intermediary investments in technical assistance and relationship building, the profile of biomass utilization and its role in restoring federal lands in central Oregon has grown. One downstream effect has been the successful installation of a biomass boiler for heat at an area school. Although the demand for biomass is small with such thermal projects, this was an innovative development. In sum, the Woody Biomass Utilization Grant program invested in multiple facets of the biomass utilization industry in this sub-region.

Market effects and challenges
Market conditions for housing and broader economic trends affect forest products businesses. Biomass processing enterprises are closely linked to other kinds of forest products facilities such as sawmills, where they often obtain residuals, and to logging and restoration contractors who remove material from the woods. Demand for forest products was low during the study period due to poor housing markets. As a result, several projects wherein grantees planned to remove biomass from public lands did not occur, and biomass material was left piled at landings. Reduced energy demand and low natural

gas prices meant that there was less need for biomass electricity from existing plants and less impetus to build new plants. Further, low chip prices made it difficult for biomass end users and businesses to compete for this fiber. These diverse market drivers affected biomass utilization in eastern Oregon in the study period, yet were largely beyond the control of grantees. Several interviewees suggested that grants were more successful when the recipients were operating in smaller markets in which there may have been less variability, such as animal bedding, and more ability to work directly with customers and understand their preferences.

Several interviewees also remarked that the woody biomass industry in eastern Oregon faced challenges because no entities were working specifically on helping to grow markets (e.g. trade associations, nonprofit partners). They suggested that despite the supportive work of intermediaries to help enterprises understand new markets or expand their markets, there has been no sustained investment in this aspect of biomass utilization.

Intermediary roles and impacts

Grants for intermediary organizations and functions were an important component of Woody Biomass Utilization Grant program investments in eastern Oregon. We examined both the direct grants to intermediaries as well as the roles that other intermediaries such as the Forest Service Regional Office played in program delivery.

Direct investment in intermediaries

The Woody Biomass Utilization Grant program provided grants to two regional intermediaries to work on technical assistance and marketing issues. A regional council of governments in central Oregon used their Woody Biomass Utilization Grant resources to partner with the National Forest System to address public lands supply, a crucial barrier as investors can be unwilling to support enterprises with uncertain future material supply. They researched and built a Coordinated Resource Offering Protocol ("CROP") database to track available volumes of biomass and coordinate supply offering across the central Oregon region. The council of governments was able to provide this information to several potential investors in bioenergy and small-diameter wood products to help them further plans to locate new facilities in the region. For several years, this helped keep conversations about and interest in biomass utilization alive in the region. However, there have been several challenges and the database is currently not as frequently used. National forest units in central Oregon are supposed to submit data on planned biomass projects and predicted amounts annually, but reporting is inconsistent.

A regional nonprofit organization also received a grant to act as an intermediary that 1) served as a pass-through for several sub-grantees and 2) provided technical assistance to grantees and any others working on biomass utilization in eastern Oregon. This regional NGO administered sub-grants on behalf of several entities that did not have the capacity or scale of proposed projects alone to be competitive. The NGO made four sub-grants, two of which were in eastern Oregon. One was to the council of governments described above to provide direct technical assistance to central Oregon businesses interested in biomass utilization. With this support, the council of governments helped a secondary manufacturing business in Prineville install a new wood-fired dryer system, and led several explorations of potential thermal biomass use in facilities such as schools and recreational buildings. The other sub-grantee was a landowner cooperative in northeastern Oregon that had longstanding interest in creating local infrastructure to aggregate and process biomass from private nonindustrial forestland. This sub-grant helped this entity and the regional nonprofit work together through a series of meetings to better articulate their interests and explore possible facility designs with an engineering study. With the remainder of its funds, this regional nonprofit undertook other intermediary activities that included hosting a regional workshop on thermal energy opportunities.

In addition, a nonprofit in Wallowa County received a grant to initiate an integrated biomass business in 2005. After several years, this business itself applied for and received a second grant. However, at the time of the first grant, there was no existing business entity able or willing to apply to the Woody Biomass Utilization Grant program and take on the risk of

starting this enterprise. The nonprofit acted as an intermediary that obtained and held the grant, organized a for-profit subsidiary of their organization as a limited liability corporation, and took on significant risk and uncertainty in order to move toward building small-diameter processing infrastructure in the county.

Intermediary roles in program delivery

These funded intermediaries, as well as staff from the Forest Service's Region 6 Office and biomass specialists from Oregon's state forestry and energy agencies, were also important in providing technical assistance to grantees and improving overall program delivery. They first helped identify prospective grantees with strong business models and opportunities for innovating, and encouraged them to weigh costs and benefits and apply if appropriate. This higher-level view of the biomass industry was essential; the intermediaries built an understanding of what capacities existed, and what pieces of equipment and types of enterprises might fill gaps in different places across eastern Oregon, and strategically recruited grantees according to this vision.

Intermediaries also supported grantees that lacked experience in grant writing, particularly in making the case for investment, identifying market gaps, and articulating how they would fill them for their proposals. This helped ensure not only that grantees had strong applications, but also that they were more prepared to successfully implement grants if they did receive them because they had the opportunity to think through possible issues, build relationships, and learn more about biomass utilization. In addition, many grantees encountered unexpected issues during implementation and needed to alter plans or otherwise adapt. Intermediaries also assisted with these issues by, for example, strategizing with grantees and each other, or researching possible alternative technologies and equipment.

National Forest System dimensions

We explored the effects of grants on number of green tons removed and utilized, acres treated, and reduction of treatment costs, as well as the role that national forest units played in making biomass accessible to grantees.

Providing access to biomass

National forests in eastern Oregon made biomass available through two different competitive mechanisms: stewardship contracts for forest restoration service work that included biomass removal, and timber sales to remove goods. Stewardship contracts allow the Forest Service to combine multiple tasks in a single contract and can include the exchange of goods for services. We found that grantees in all three sub-regions described challenges in obtaining biomass supply from national forests. Numerous interviewees suggested that the Forest Service's ability to plan and administer for biomass utilization was nascent, limited, and inconsistent. One repeated observation was that the slow rate of the environmental planning process meant few hazardous fuels reduction projects were ready to implement by the time grantees installed equipment. At least two grantees utilized their new equipment far more frequently on private industrial lands and hardly at all on national forest lands. However, the grantee near the Malheur National Forest, who purchased biomass as part of timber sales, worked with the national forest staff to help them understand their business needs and did not report the same challenges.

National forest interviewees emphasized that Forest Service personnel often lacked experience with stewardship contracting, and that it was used inconsistently across the study region. One national forest interviewee did explain that beginning to administer for biomass was a positive capacity-building experience for contracting and personnel because it allowed them to learn new skills and tools, as well as improve their understanding of and relationships with regional contractors and biomass enterprises. For the Deschutes National Forest, an increase in the use of stewardship contracting, particularly on the Sisters Ranger District, occurred during the study period and expanded that forest's ability to use more diverse and flexible tools to implement hazardous fuels reduction projects. In particular, personnel from this forest learned to offer contracts and sales of a variety of sizes that could be accessible to the different businesses operating in their area. On the Wallowa-Whitman National Forest, the nonprofit that was building a new biomass enterprise was able to initiate discussions with agency staff about how

to better plan and structure future work to include cost-effective biomass removal.

Impacts on hazardous fuels reduction and costs

The Forest Products Laboratory asked local national forest personnel and grantees to report on acres treated and costs per acre. Grant reporting for eastern Oregon, however, was inconsistent. Eight of the studied grantees reported national forest acres treated, while two others reported only private acres and one reported tribal acres. Grantee and Forest Service personnel interviews revealed that biomass availability through stewardship contracts and timber sales varied between national forests. Forest Service interviewees from the Deschutes and Malheur National Forests noted understanding the biomass suppy demand of local enterprises spurred them to plan projects accordingly.

However, it was not fully possible to attribute a precise number of acres treated to the grants. Grantees and Forest Service interviewees indicated that the ways in which the Forest Service tracks and reports acres treated made it difficult to evaluate grant effects on acres and costs. Further, many factors—not just the presence of biomass business capacity—affect costs, such as location, terrain, or forest type. Mechanically removing biomass for utilization may be less expensive than hand piling and burning if an end user purchases it.[16] On the Deschutes and Malheur National Forests, Forest Service interviewees reported that piles were removed that would otherwise have been burned, and indicated that avoided costs for piling and burning ranged from $125–$800/acre depending on the specifics of the project. On the Malheur, agency staff described treatment costs of approximately $500 per acre for pre-commercial thinning prior to a local sawmill receiving a grant. Following implementation of the grant, many of the stewardship projects on the Malheur National Forest cost $300-$450 per acre, which interviewees attributed directly to the expansion of biomass capacity in the Blue Mountains area. However, without detailed analysis of Forest Service records for each contract and timber sale, it is not possible to provide cost/acre outcomes for each grantee.

Impacts on green ton removal

The Forest Products Laboratory also requested that grantees report green tons removed and utilized, but this was challenging for several of the processing grantees as they purchased biomass from contractors rather than harvesting it themselves, and were not certain of the total amounts of green tons being harvested. Grantees in eastern Oregon reported a total of 490,321 green tons of woody biomass harvested and utilized in the study period. Collection from these grantees increased in eastern Oregon from un-

Table 6 Economic impacts from Woody Biomass Utilization Grant program-generated biomass collection and delivery in eastern Oregon, 2006–11

(Dollar-adjusted to 2013 price; biomass utilization reported as of November 22, 2011)

		2006	2007	2008	2009	2010	2011	Total	Annual average
Green tons		3,785	38,685	41,029	64,565	169,642	172,616	490,321	81,720
Bone dry tons*		1,892	19,342	20,514	32,283	84,821	86,308	245,161	40,860
Jobs	(5.1 jobs/10K BDT)	0.97	9.86	10.46	16.46	43.26	44.02	125.03	20.84
Wages ($1,000s)	($241,007 wages/10K BDT)	46	466	494	778	2,044	2,080	5,909	985
Economic output ($1,000s)	($867,984 output/10K BDT)	164	1,679	1,781	2,802	7,362	7,491	21,280	3,547
Taxes ($1,000s)	/10K BDT)	7	68	72	113	298	303	861	143

* Assumed moisture contents at 50 percent and the average delivered price per BDT at $30.94

der 10,000 green tons in 2006 to over 170,000 green tons in 2011 (see Table 6, page 18). This large growth is likely due to errors or overlapping reporting by Oregon grantees in early years. Moreover, other factors such as markets and business decisions affect rates of harvest. However, it is likely that the growth of biomass utilization enterprises in the region as a result of the Woody Biomass Utilization Grant program did cause some increase in green ton utilization as opposed to business as usual. The collection and delivery reported during the study period generated a total of 125 jobs and over $21 million in new economic activity in the state of Oregon, but again, these impacts likely appear larger due to reporting errors.

Policy and program dimensions

We found that some grantees, especially the nonbusiness entities, viewed their Woody Biomass Utilization Grant as a helpful investment that was part of a larger set of federal and state biomass policies and programs they were using to accomplish their goals. They indicated that it was a combination of policies and programs rather than any "silver bullet" that made biomass utilization on public lands possible in eastern Oregon. For example, these interviewees described using National Fire Plan resources prior to the Woody Biomass Utilization Grant program (2001–04) to support more active hazardous fuels reduction and community wildfire protection on their national forests, conduct research, develop their cases and proofs of concept, and make business plans. The Woody Biomass Utilization Grant program was a "perfect" follow-up to the National Fire Plan grants because it allowed grantees that had laid this groundwork in previous years to then invest in equipment.

All grantee interviewees commented upon the shift in program focus from equipment to engineering/study grants, expressing disappointment that there was no longer a Forest Service program that supported equipment acquisition and technical assistance. They indicated that other programs such as USDA Rural Development loans and grants could not serve the same function as the Woody Biomass Utilization Grant program as they did not seem to be well-funded, focused on forest products, or in line with their specific needs. Several interviewees also explained that a network of intermediaries and helpful individuals from the Forest Service and nonprofit organizations were present to assist with all stages of the Woody Biomass Utilization Grant program, which improved program delivery, grant access, and learning and relationships across the region; and they did not see a similar network and resources available with other grant programs. However, three grantees had become successful during the study period in obtaining USDA Rural Development resources (Rural Business Enterprise Grants and a grant for a large collaborative project focused on dry forest management and economic development) for biomass utilization-related work.

Further, interviewees from the Forest Service who were knowledgeable about the shift in Woody Biomass Utilization Grant program focus reported multiple reasons. First, the Forest Service had received direction to fund engineering energy plans for wood energy projects from USDA because USDA leadership saw the Woody Biomass Utilization Grant program as redundant with existing Rural Development grants and loans. USDA requested that the Forest Service instead support these studies because they appeared to be an important niche and pivotal point in the biomass supply chain that was not being funded by any other USDA program. Second, challenges with the arrangements for leasing equipment, particularly with a lack of understanding of lease terms on the part of grantees, and the time that Forest Service employees spent managing equipment paperwork due to Federal Acquisition Regulations (which required federal tracking of the equipment until the value would be less than $5000) reportedly also contributed to the shift. Third, given the relatively small amount of funding for the Woody Biomass Utilization Grant program, USDA leadership were interested in seeking a larger "bang for the buck" by focusing on engineering and design at more locations, and leveraging public and private finance from other sources.

Eastern Arizona case study

Case study area

The study area of eastern Arizona is an informally-defined region of three counties—Navajo, Apache, and Greenlee—located in the eastern (north and central) portion of the state. There is no census-designated metro area within the study area. These counties together represent about two percent of the state's population, face persistent high unemployment and poverty, and have slower population and economic growth than Arizona state averages. Navajo and Apache County are among the top 100 lowest-income counties in the United States based on per capita income. They contain small, remote communities and several reservations. These towns are far from urban centers, limiting availability of resources, access to transportation, and market distribution channels.

Following the reduction in harvesting on regional national forests in the mid-1990s, most forest industry disappeared from the area along with timber-related workforce, equipment, and associated industries.[17, 18] For example, harvest from Arizona national forests in 1996 dropped to about one-tenth of the harvest in 1990 and was mostly fuelwood, not industrial timber products.[19] The timber-related infrastructure in eastern Arizona that did remain was relatively close to private and tribal forests. By 2002, the timber processing capability of the region rebounded briefly due to the availability of salvage sales, especially from the 2002 Rodeo-Chediski Fire. Prior to the Woody Biomass Utilization Grant program, however, the only substantial infrastructure remaining was a paper mill and a bioenergy power plant on the western side of the study area. By 1999, the paper mill used only recycled material, which further decreased the demand for wood byproducts, and the power plant closed in March 2013.

Forest management context

The Apache-Sitgreaves National Forest is the only national forest in the study area. It includes one-million acres of ponderosa pine and mixed conifer forests and has both dry and semi-arid climates. It lies within the White Mountains range, a transition zone south of the Colorado Plateau and north of the Arizona Basin.[20] This national forest has experienced overgrazing, logging, and fire suppression since the late 1800s, which has increased the risk of uncharacteristically severe wildfires.

Stakeholders and community members have come together around forest health and economic development concerns, beginning in 1997 with a diverse group of stakeholders forming the Natural Resources Working Group in an effort to build consensus on forest restoration issues.[21] Trade associations and nonprofit organizations such as Northern Arizona Wood Products Association (NAWPA), Little Colorado River Plateau Resource Conservation and Development (RC&D), and the Southwest Sustainable Forest Partnership (SWSFP) have also been involved in supporting the redevelopment of a regional forest products industry.

Two of the largest wildfires in Arizona's history (the Rodeo-Chediski Fire in 2002 and the Wallow Fire in 2011) burned about half a million acres each in the White Mountains. The Rodeo-Chediski Fire also spurred the Apache-Sitgreaves National Forest and stakeholders to take a new approach to forest health challenges. In August 2004, the Apache-Sitgreaves awarded a ten-year stewardship contract to treat 150,000 acres of primarily small-diameter ponderosa pine, with an emphasis on treating wildland-urban interface areas. The White Mountain Stewardship Project (WMSP) was the first ten-year stewardship contract in the nation.[22] The contract was awarded to a single contractor, and it paid on a per acre basis to perform fuels reduction and remove woody biomass from the national forest. The White Mountains' Multi-Party Monitoring Board formed to monitor the WMSP.

The WMSP has helped revive active forest management and has been a primary source of forest-related economic activity in the region. The WMSP contractor provided four types of materials through the contract: 1) clean chips, 2) dirty chips (commercial-grade pellets, biomass); 3) round wood (five to nine-inch diameter trees); and 4) saw timber (nine-inch

and greater diameter trees). From 2005–08, 20 small forest products enterprises utilized these materials for manufacturing (pallets, moulding, furniture, and small lumber), energy production (pellets), livestock bedding, and soil fertilizers.[23]

Once the White Mountain stewardship contract expires in August of 2014, the Four Forest Restoration Initiative (4FRI), issued in 2012, will succeed it and be the largest ten-year stewardship contract in the nation. The analysis area of the 4FRI spans 2.4 million acres across four forests in northern Arizona in the Apache-Sitgreaves, Tonto, Kaibab and Coconino National Forests, and is expected to provide 300,000 acres of restoration work over a ten-year period.

Case study findings

Overview of grants

Twelve grants were awarded in eastern Arizona from 2005–10, and one of the grants received additional investment from the American Recovery and Reinvestment Act (ARRA) (see Table 7, below). Grant recipients were located in or close to the WMSP area on the Apache-Sitgreaves National Forest (see Figure 3, page 22). Most grantees operated primarily in the White Mountains, with the exception of one located southwest of the White Mountains in San Carlos, and another that constructed a mill in the White Mountains but had its main office in Phoenix. Two of the Arizona grantees each received

Table 7 Eastern Arizona Woody Biomass Utilization grantees, 2005–10

Business name	Grant year	Grant award	Project description
Arizona Log and Timber Works	2005	$250,000	Install a wood pressure treatment plant at a post and pole facility
American West Structures LLC	2005	$250,000	Install wood-laminating press to produce laminated wood decking
W.B. Contracting, Inc.	2005	$250,000	Purchase whole tree log forwarder for hazardous fuels removal; forwarder has been used as a processor (with processing head added) for production of round wood and chips
Western Moulding Co., Inc.	2006	$243,500	Construct small-diameter mill
Round Valley Wholesale Lumber, Inc.	2006	$243,500	Construct small-diameter mill
High Country Green Waste, LLC	2007	$249,400	Upgrade grinder to convert biomass waste into mulch
Winner's Circle Soil Products	2008	$250,000	Install an automated wood shaving baler
Pure Wood Products, LLC*	2009	$250,000	Construct a wood straw (erosion control product) manufacturing plant
APC Pallets, Inc.	2009	$250,000	Expand small-diameter mill (also received ARRA resources)
Cooley Forest Products*	2010	$350,000	Acquire in-woods whole log canter, firewood and log chipping processes
Arizona Log and Timber Works	2010	$350,000	Install equipment to produce round wood posts and blocking for guardrail construction
San Carlos Apache Timber	2010	$272,770	Retool from large diameter to small diameter mill

* Unsuccessful grants that were eliminated from economic analysis.

Figure 3 Eastern Arizona Woody Biomass Utilization grantees

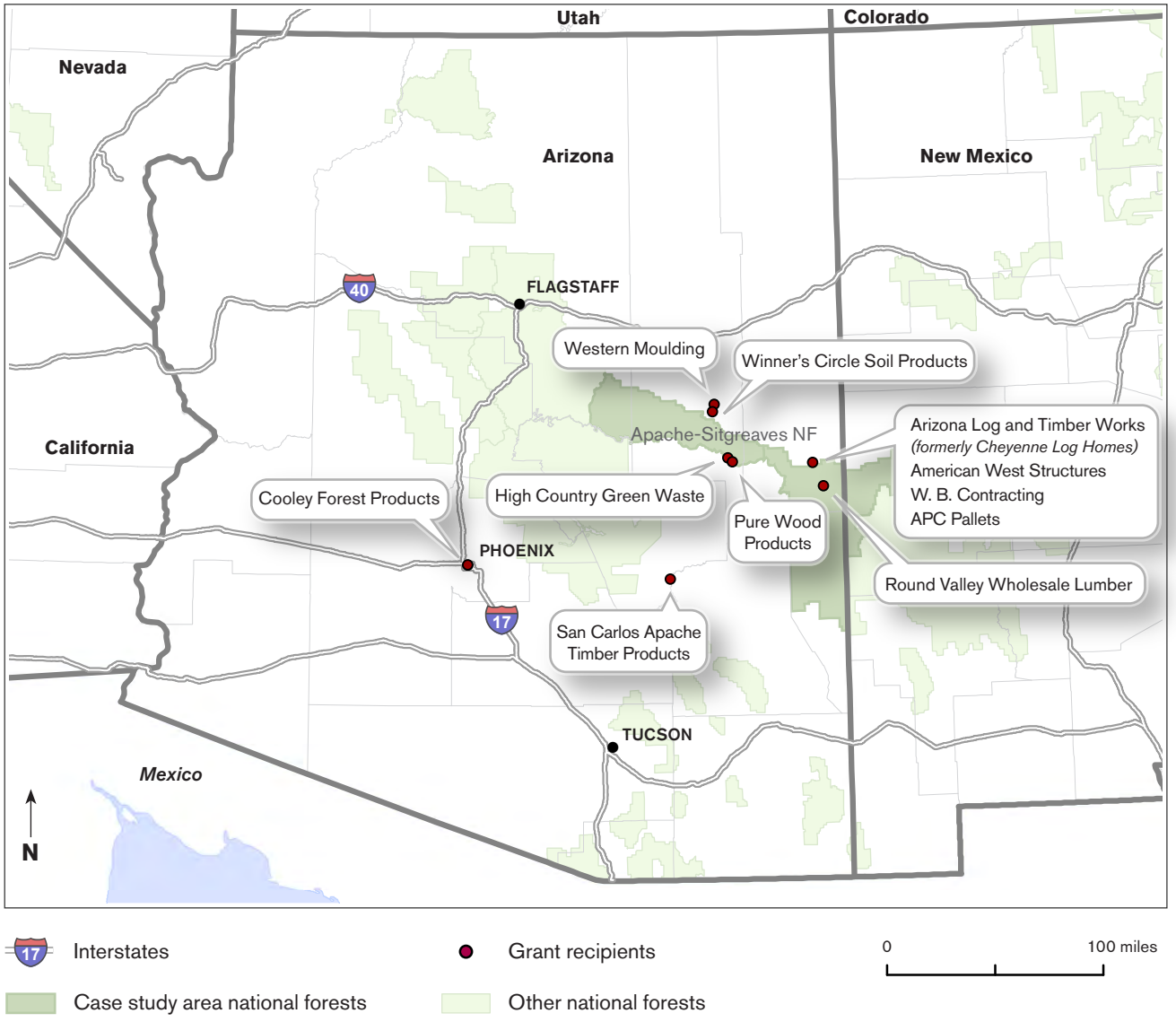
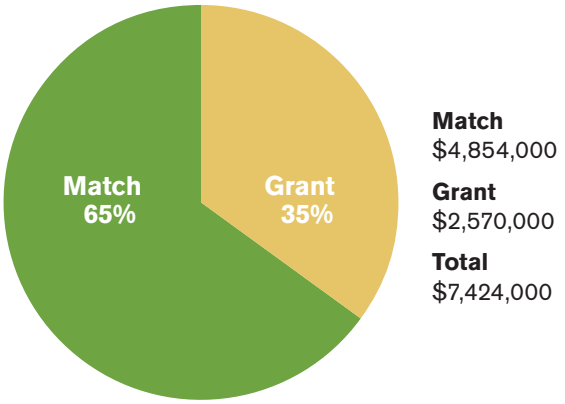


Table 8 Arizona Woody Biomass Utilization Grant project expenditures per year, 2005–10 (in $1,000s)

Grants	2005	2006	2007	2008	2009	2010	Total	Annual avg
Number of grants	3	2	1	1	2*	3*	10	1.67
$Grant per year	$613	$503	$312	$269	$250	$623	$2,570	$428
$Match per year	$202	$1,267	$632	$479	$2,038	$237	$4,854	$809
Total dollars	**$815**	**$1,769**	**$944**	**$748**	**$2,288**	**$859**	**$7,424**	**$1,237**

* Unsuccessful grants that were eliminated from economic analysis.

Figure 4 Proportion of eastern Arizona Woody Biomass Utilization grant and match dollars, 2005–10



two grants from the program. Interviews were not conducted with two grantees due to the early termination of the grant in one case, and grantee health concerns in the other. Four of the grantees used the funds to construct, upgrade or improve mills, and the remainder used the funding to purchase other processing equipment for animal bedding, mulch, and other non-saw timber products.

Of the twelve full-term grants in eastern Arizona, awards ranged from $243,500 to $350,000. We eliminated two unsuccessful grants from the economic impact analysis. Although the total awarded amount was $3.2 million, grant amounts actually spent were $2.6 million, matched with an additional $4.9 million of funding from other sources (see Table 8, above, and Figure 4, left). Most of the grant funds and nearly 54 percent of total spending were used to purchase equipment (see Table 9, page 24). Unlike eastern Oregon, there were few suppliers of forest products equipment in eastern Arizona. Consequently, grantees in Arizona reported that they purchased all of their equipment outside of the state (e.g. in Wisconsin and Minnesota) or the country (in Canada), and their budget requests often included travel expenses to research and buy the equipment. Similar to eastern Oregon, wages paid to employees of the grantees were the second-largest expenditure category. Construction of facilities to house the equipment was also a common expense.

Grant impacts at the enterprise scale

We examined program impacts on individual enterprises, which included: creating jobs and other economic impacts; and improving their ability to access supply, diversify product lines, obtain capital, and use matching resources.

Grant and match purchases impacts

The ten successful grants in eastern Arizona generated a total of $7.4 million in new expenditures ($1.2 million per year) (see Table 10, page 25). These grants have generated 45 full-time-equivalent jobs (about 7.5 jobs per year for 6 years), $3.7 million in wages ($0.6 million per year) and $6.6 million in economic activities ($1.1 million per year), and contributed $0.29 million to the state and local tax

revenue ($49,000 per year). Matching funds generated the majority of in-state economic impacts as grantees spent most grant funds outside of the state on equipment purchases. For example, there was no economic impact to the state of Arizona from grant expenditures in 2009, as the grantees reported that they spent all of their grant funds on equipment outside of the state. If a portion of the equipment purchase had occurred in the state, the economic impacts of the grants could have been much greater.

Diversification of supply and product lines

Grantees invested in diversifying both their supply and products. Four of the grantees used funds to construct sawmills or outfit existing sawmills to process small-diameter logs. This allowed small-diameter biomass to be used for higher-value outcomes as lumber. These grantees chose to invest in milling to recover more product and value from logs; diversify product lines and meet market demands; and to become more competitive by increasing vol-

Table 9 Arizona Woody Biomass Utilization Grant project expenditures by category, 2005–10

Category	Sector description	Grant (%)	Match (%)	Total (%)
Equipment	**Wholesale trade (319)**	**88.0**	**19.3**	**53.6**
	In Oregon	0	0	0
	Outside of Oregon (leakage)	88.0	19.3	53.6
Marketing and consulting	**Management, scientific, and technical consulting services (374)**	**2.6**	**1.4**	**2.0**
	Technical consulting services	0	0	0
	Marketing, training, travel	2.6	1.4	2.0
Wages and benefits	**Employee compensation**	**7.0**	**24.2**	**15.6**
	Other miscellaneous wood product manufacturing (103)	6.4	15.4	10.9
	Logging (16)	0	1.2	0.6
	Wood product production (95)	0.5	7.5	4.0
Other expenses		**2.4**	**55.2**	**28.8**
	New construction of nonresidential structure (35)	0	5.4	2.7
	Maintenance and repair construction of nonresidential structure (39)	0	11.8	5.9
	Wholesale trade—supplies and materials (319)	0	0.4	0.2
	Architectural and engineering services (369)	1.2	3.0	2.1
	Wood product production—sawmills (95)	1.0	25.2	13.1
	Equipment fuel and oil (service station/gasoline 326)	0.3	1.3	0.8
	Maintenance and repair (commercial/industry M R 417)	0	2.7	1.3
	Insurance (357)	0	2.4	1.2
	Utilities (state and local government electric utilities (431)	0	1.5	0.8
	Postage and shipping (post office 427)	0	0.1	0.1
	Other federal government enterprises (429)	0	0.3	0.2
	Depreciation (not included as expenditure)	0	1.3	0.6
Total (%)		**100**	**100**	**100**
Total ($1,000s)		$2,570	$4,854	$7,424

Table 10 Arizona Woody Biomass Utilization Grant annual project economic impacts

		Grants	2005	2006	2007	2008	2009	2010	Total	Annual avg
Number of jobs	Grant	Direct effect	0.29	0.24	0.27	0.05	0	0.717	1.02	0.17
		Indirect effect	0.10	0.11	0.09	0.04	0	0.06	0.40	0.07
		Induced effect	0.46	0.48	0.44	0.08	0	0.37	1.83	0.30
		Total effect	0.85	0.83	0.80	0.17	0	0.60	3.25	0.54
	Match	Direct effect	0.38	4.59	2.91	1.59	7.20	0.22	16.9	2.81
		Indirect effect	0.13	1.86	0.70	1.13	2.96	0.17	6.9	1.16
		Induced effect	0.85	4.05	2.84	1.81	7.55	0.99	18.1	3.02
		Total effect	1.36	10.51	6.46	4.53	17.70	1.37	41.9	6.99
		Total	**2.21**	**11.34**	**7.26**	**4.70**	**17.70**	**1.97**	**45.18**	**7.53**
Wages	Grant	Direct effect	$60,397	$62,577	$58,598	$8,606	--	$50,210	$240,388	$40,065
		Indirect effect	$4,657	$6,386	$4,164	$3,341	--	$2,521	$21,069	$3,511
		Induced effect	$19,533	$20,693	$18,842	$3,580	--	$15,830	$78,479	$13,080
		Total effect	$84,587	$89,656	$81,604	$15,527	--	$68,561	$339,935	$56,656
	Match	Direct effect	$115,710	$449,478	$370,114	$166,779	$873,2778	$126,627	$2,101,985	$350,330
		Indirect effect	$6,309	$130,556	$36,634	$92,452	$206,887	$14,447	$487,285	$3,511
		Induced effect	$36,597	$173,880	$122,047	$77,691	$323,896	$42,288	$776,400	$13,080
		Total effect	$158,615	$753,915	$528,795	$336,922	$1,404,061	$183,362	$3,365,670	$56,656
		Total	**$243,202**	**$843,571**	**$610,399**	**$352,450**	**$1,404,061**	**$251,922**	**$3,705,606**	**$617,601**
Economic output	Grant	Direct effect	$31,882	$33,839	$29,126	$12,957	$0	$17,700	$125,503	$20,917
		Indirect effect	$11,981	$15,329	$10,792	$7,478	$0	$6,705	$52,285	$8,714
		Induced effect	$58,378	$61,847	$56,315	$10,702	$0	$47,310	$234,553	$39,092
		Total effect	$102,241	$111,015	$96,233	$31,137	$0	$71,715	$412,341	$68,724
	Match	Direct effect	$48,024	$719,889	$341,135	$375,078	$1,138,848	$56,030	$2,679,004	$446,501
		Indirect effect	$16,307	$309,330	$97,754	$208,245	$490,087	$32,338	$1,154,060	$192,343
		Induced effect	$109,376	$519,752	$364,785	$232,241	$968,135	$126,386	$2,320,676	$386,779
		Total effect	$173,707	$1,548,971	$803,674	$815,565	$2,597,070	$214,754	$6,153,740	$1,025,623
		Total	**$275,948**	**$1,659,986**	**$899,907**	**$846,701**	**$2,597,070**	**$286,469**	**$6,566,082**	**$1,094,347**
State and local taxes	Grant		$5,569	$6,038	$5,484	$1,278	--	$4,382	$22,751	$3,792
	Match		$11,403	$63,639	$40,239	$30,078	$113,765	$12,427	$271,551	$45,258
		Total	**$16,972**	**$69,6775**	**$45,723**	**$31,356**	**$113,765**	**$16,809**	**$294,302**	**$49,050**
Federal taxes	Grant		$14,431	$15,285	$13,944	$2,632	$0	$11,710	$58,002	$9,667
	Match		$27,355	$128,965	$91,193	$57,119	$240,400	$31,238	--	--
		Total	**$41,786**	**$144,250**	**$105,137**	**$59,751**	**$240,400**	**$42,948**	**$58,002**	**$9,667**
Total impacts on tax	Grant		$20,000	$21,323	$19,428	$3,910	--	$16,092	$80,753	$13,459
	Match		$38,758	$192,604	$131,432	$87,197	$354,165	$43,665	$847,821	$141,303
		Total	**$58,758**	**$213,927**	**$150,860**	**$91,107**	**$354,165**	**$59,757**	**$928,574**	**$154,762**

ume, eliminating middlemen by tightening supply chains, and increasing quality controls. One mill increased its production from two- to six-million board feet annually over the six-year period. One grant recipient remarked that "the sawmill is one of the best tools we have" to manage and treat the forest. Another grantee described the importance of having a sawmill in the area for overall industry success, because a large mill could process large volumes and manufacture finished wood products at competitive prices.

Many grantees expanded and diversified their products to utilize different types of biomass through integrated strategies. For example, several enterprises processed mid- to lower-grade lumber from small-diameter logs into pallets, dimensional lumber, round wood, and laminated beams; used bark for mulch; and processed chips into pellets for energy. The profits from the higher-value goods allowed these companies to process and sell the lower-value products, thus providing economic incentive to process the byproducts and utilize more raw material.

Due to the depressed housing market, several enterprises also used their grants to adapt by diversifying away from products reliant on that industry. For example, changing the firm's product line from soil amendments used in the housing industry to animal bedding, one recipient said, "kept the lights on." For the same reason, a Woody Biomass Utilization Grant enabled the transformation of another grantee's production from manufacturing sill plates, vigas, and railings for homes to pressure-treated agricultural and highway guardrail posts.

Grant impacts and issues at the regional and industry scale

We examined the impacts of these grants on overall industry capacity and biomass markets. We considered industry capacity to include the strength, diversity, and distribution of enterprises and intermediaries.

Overall industry capacity

The Woody Biomass Utilization Grant program was the primary means of supporting the redevelopment of an eastern Arizona forest products industry. Many recipients stated that it was instrumental in increasing overall capacity in the area by either starting up or expanding numerous processing enterprises. Importantly, the location of new processing infrastructure within the White Mountains area decreased processing infrastructure's distance from harvesting operations on national forest land, reducing haul distances and associated costs.

One grant for processing equipment added several key pieces of equipment that had not been present in the region. New in-woods chippers and grinders reduced biomass volume, in turn reducing hauling costs that often limit successful utilization of low-value woody biomass. In addition, chippers and grinders were the first step in creating products such as mulch and stove pellets from material that traditionally had not been utilized. The Woody Biomass Utilization Grant program was also instrumental in supporting new mechanized harvesting approaches. A new piece of equipment purchased by one of the grantees, the Waratah processing head, was key in increasing utilization efficiencies and reducing costs by cutting material to length, sorting it in the woods, and decreasing overall handling, thereby increasing productivity and profits. One stakeholder interviewee stated, "It changed the way we did work in the woods." Once the Waratah processing head was tested and proven, other operators in the area also began using the equipment, and most were using it by the end of the study period.

The Woody Biomass Utilization Grant program also supported four grantees in building or increasing the capacity of sawmills. Expanded sawmill capacity was important to industry success in the area because increased processing of material volume helped maintain competitive manufactured wood products prices. In addition, sawmills that can process both large and small logs can increase value from biomass and generate residuals that can help biomass enterprises when supply from the forest is inconsistent.

Building facility and service networks

Grantees described how the Woody Biomass Utilization Grant program helped build a network of processing facilities and services that several biomass enterprises shared, which improved their efficiency.

For example, a "community kiln" was installed that could be used by multiple enterprises in the area to efficiently dry lumber, increase lumber quality, improve local wood utilization, and increase production. In addition, the Woody Biomass Utilization Grant program helped ensure that a pressure treatment facility was available to multiple grantees for treating wood for outdoor uses. Grantees also explained how these networks could be further expanded with the addition of a biomass plant that could fill a gap by processing pellets for energy. They also suggested that installation of other key equipment, such as truck scales, at strategic locations would improve efficiency for enterprises as a whole. A stakeholder interviewee described one area within the case study region, the town of Eagar, Arizona, on the eastside of the White Mountains, as a "microcosm" that had developed valuable networks and created a balanced system.

Market effects and challenges

Market conditions for housing and broader economic trends, as well as distance to markets, affect forest products enterprises. Despite the many positive effects that the Woody Biomass Utilization Grant program had on eastern Arizona's forest products industry, poor and distant markets presented a significant challenge. During the study period, grantees faced difficulty in sales and finding markets as most of the small-diameter wood products were tied to the housing market, which became more and more depressed and reached a low in 2009. One grantee that was primarily involved in construction at the time described a 70 percent drop in sales. Competing in the global market with larger companies added to the challenges that grantees faced in becoming established and gaining market share. High shipping, freight, and fuel costs for moving products to market from the rural region were also a challenge for the grantees, many of whom did not adequately budget for these expenses.

However, at the time of our study, grantees reported that these market limitations were beginning to dissipate because prices for material in other parts of the country and Canada were finally beginning to increase and local prices were more equitable. One grantee said that while the business had initially been a struggle, markets were now beginning to open for the firm's products, allowing the firm to pay more for the raw material (e.g. from $20 per green ton to $32 per ton), which will eventually reduce hazardous fuels treatment costs for the Forest Service.

Intermediary roles and impacts

Unlike eastern Oregon, there was no intermediary organization receiving a Woody Biomass Utilization Grant grant in eastern Arizona. However, intermediary organizations, as well as the Forest Service Regional Office played a role in Woody Biomass Utilization Grant program investments. We examined their roles in program delivery.

Intermediary business assistance

Three organizations with missions primarily focused on sustainable forests, wood utilization, and rural economic development helped provide intermediary business assistance: the Northern Arizona Wood Products Association, the Little Colorado River Plateau Resource Conservation and Development, and the Small Business Development Center at Northland Pioneer College. These organizations formed a team that assisted applicants with proposal development including financial projections, planning, and grant reporting and administration. Interviewees noted that the support and dedication of this team made a noticeable difference in program delivery and that the program's success was tied to their commitment. In addition, FPL staff provided technical assistance that aided grantees in achieving project success.

The Forest Service's Regional Office also assisted in all aspects of the Woody Biomass Utilization Grant program in eastern Arizona. A single biomass coordinator oversaw all of the grants (from 2005–2012), providing consistency throughout the grant process. The coordinator solicited potential grantees, helped craft and review proposals, and administered the grants. The coordinator worked with the Northern Arizona Wood Products Association and the Apache-Sitgreaves National Forest, which also helped recruit grantees. Together, they strategically sought applications from businesses that would bridge lacking components of woody biomass infrastructure in eastern Arizona.

National Forest System dimensions

We explored the effects of grants on acres treated and reduction of treatment costs on the Apache-Sitgreaves National Forest, as well as the role that national forest units played in assuring biomass was accessible to grantees.

Providing access to biomass

Of the ten grantees that we interviewed, nine utilized biomass directly from the national forest alone, and one business utilized approximately fifty percent each from sawmill residuals and the forest. The WMSP has been the sole source of biomass material from the national forest. The Forest Service hoped to treat 15,000 acres annually in this ten-year contract. But enterprises that utilized only forest biomass described challenges due to lack of supply, including limitations in production, delays in promoting their new product lines, inability to fill backlogs of orders, and difficulty in planning sawmill production without knowing the quantities and sizes of raw material that would be available. Stakeholders concurred, and noted that this supply issue existed prior to the stewardship contract, which made it difficult for biomass or wood products businesses in the area to secure financing. Grantees also expressed frustration about the lack of timely salvage logging prior to insect infestations and the subsequent lost value following the 2011 Wallow Fire. They reported that this compounded the lack-of-supply issues and the losses in sales and customers that they already faced due to poor market conditions.

Several grantees also pinpointed the limitations of the environmental planning (NEPA) process as one of the largest barriers they faced, suggesting that the Forest Service lacked capacity and funding to complete planning to match business demand for raw material supply. However, one grantee felt that the landscape scale 4FRI project might help with this capacity issue in the future as it includes significantly more acres in the analysis, and should require less time and resources than planning for several smaller projects.

Another supply challenge that grantees identified was that one contractor controlled access to biomass and its price under the WMSP. Several grantees described this as a "monopoly" and suggested that contracts should be divided among a larger number of contractors to allow for competitive bids, flexibility of supply, and competitive pricing. One grantee further suggested that the WMSP contractor's ability to manufacture end products gave the contractor a significant supply chain advantage and assured this contractor the best price on finished products for a finite consumer base. To alleviate these conflicting interests, several grantees suggested close oversight of the raw material stream from the WMSP contractor through the distribution and utilization channels.

Impacts on hazardous fuels reduction and costs

There were diverging views between stakeholder interviewees on whether treatment costs were reduced. In the short-term, because the WMSP was already in place, the price paid to the federal government for fuels reduction did not change. However, the WMSP contractor reduced treatment costs because the contractor was using material that had previously been piled and burned. Exact costs per acre prior to the program are not known, but costs after the Woody Biomass Utilization Grant program averaged $550 per acre.[24] A monitoring report on the WMSP suggests that the effects of increased biomass utilization capacity on the national forest were notable because costs per acre remained stable during an unprecedented downturn in the wood products markets; and, further, because contractors began to treat more complex areas, yet costs did not increase.

Impacts on green ton removal

The eastern Arizona grantees generally purchased biomass from the WMSP contractor rather than harvesting it themselves. Therefore, most were uncertain of the total quantities of green tons being harvested. However, the Forest Products Laboratory reported that the Woody Biomass Utilization Grant program spurred the collection of a total of 337,860 green tons of woody biomass in eastern Arizona during the study period. Collection increased from about 33,000 green tons in 2006 to over 80,000 green tons in 2011 (see Table 11, page 29). The collection and delivery reported during the study period generated 114 jobs (19 per year) and about $19 million ($3.2 million per year) in new economic activity in the state of Arizona.

Table 11 Economic impacts from Woody Biomass Utilization Grant program-generated biomass collection and delivery in eastern Arizona, 2006–11

(Dollar-adjusted to 2013 price; biomass utilization reported as of November 22, 2011)

		2006	2007	2008	2009	2010	2011	Total	Annual average
Green tons		33,263	51,310	52,085	53,473	66,980	80,749	337,860	56,310
Bone dry tons*		16,631	25,655	26,043	26,737	33,490	40,374	168,930	28,155
Jobs	(6.8 jobs/10K BDT)	11.29	17.42	17.68	18.15	22.74	27.41	114.70	19
Wages ($1,000s)	($661,885 wages/ 10K BDT)	$1,101	$1,698	$1,724	$1,770	$2,217	$2,672	$11,181	$1,864
Economic output ($1,000s)	($1,120,852 output/ 10K BDT)	$1,864	$2,876	$2,919	$2,997	$3,754	$4,525	$18,935	$3,156
Taxes ($1,000s)	$55,620 taxes/ 10K BDT	$93	$143	$145	$149	$186	$225	$940	$157

* Assumed moisture contents at 50 percent and the average delivered price per BDT at $30.94

Policy and program dimensions

Prior to the Woody Biomass Utilization Grant program, stakeholders in the White Mountains area had focused on collaborative resource management and enterprise development with the support of several programs and policies. Beginning in 1999, the Forest Service's Economic Action Program (EAP) supported the development of several regional and local intermediary entities that provided startup assistance and networking. By the time the Woody Biomass Utilization Grant program began, these entities had become key intermediaries for program delivery. These previous investments in both enterprise and intermediary capacity through EAP laid a solid foundation for the Woody Biomass Utilization Grant program to build on. Area stakeholders had also used resources from the National Fire Plan to develop community wildfire protection plans in 2004, which helped identify and prioritize wildland-urban interface areas for fuels treatments. This layering of policies and programs helped the Woody Biomass Utilization Grant program become an effective next step that allowed numerous startup enterprises to move from planning to equipment acquisition and operation.

As in eastern Oregon, grantees suggested that the Woody Biomass Utilization Grant program's shift to engineering and energy grants was abrupt, and they were disappointed that resources were no longer available for equipment purchases. There was relatively little outreach and explanation of the program's change, and stakeholder interviewees thought the business community had not been prepared for the change. One interviewee described how prior to the transition, Woody Biomass Utilization Grant program applicants were required to complete supply assessments and feasibility studies, which were useful to the types of enterprises in the region; but woody biomass energy studies were not a key need in the region. No businesses in the Southwest have received these grants since the transition (2011–12). One interviewee suggested that the Woody Biomass Utilization Grant program's new focus would allow better leveraging of funds and larger-scale investments in bioenergy projects in the future, but another described it as "a mistake." It is worth reiterating that, in the White Mountains, grantees faced the challenge of rebuilding a wood products industry while simultaneously adding enough value to low-quality wood to offset the expenses of thinning projects. The successful grants in this region contributed significantly to industry redevelopment; yet a shift from equipment purchase support to planning and engineering support leaves places like eastern Arizona without support for achieving value-added production, as they see a need to continue to develop their infrastructure rather than design new energy facilities.

Discussion

This research has examined the delivery and impacts of the Woody Biomass Utilization Grant program in eastern Oregon and eastern Arizona from 2005–10. Using both economic impact and qualitative analysis, we suggest several comparative findings and lessons learned from the case studies.

Economic impacts varied due to the differences in industry capacity in each case study area

Grants in both study areas were mostly (an average of 70 percent) for purchase of processing or utilization equipment, and the wages required to find, deliver, and operationalize it. Yet the economic impacts of these purchases and where they accrued differed. Oregon grantees purchased more of their equipment from Oregon vendors than did Arizona grantees (who purchased no equipment in state), perhaps because Oregon's forest resource industry is more intact than Arizona's and equipment dealers were more available within Oregon. The outcomes of utilization also varied because of the different nature of each industry. Economic impacts generated per 10,000 green tons were actually larger in eastern Arizona than in eastern Oregon, suggesting that biomass utilization is more labor intensive, which creates greater economic impact, in Arizona and more mechanically intensive in Oregon. In both cases, match dollars created more significant economic impact, as they were more likely to be spent on labor and services within the case study areas. Therefore, it was not only the grants themselves but also the concomitant investments made by businesses that created economic activity.

The Woody Biomass Utilization Grant program made diverse investments across the biomass supply chain

During the study period, the Woody Biomass Utilization Grant program supported many different activities related to biomass utilization as wide-ranging as providing technical assistance, increasing harvesting equipment, upgrading existing wood processing facilities, and building new sawmills. This broad scope meant that it was addressing multiple issues and simultaneously investing in multiple capacities in both case study areas. This approach was well-suited to the multi-faceted enterprise and industry challenges that biomass utilization from public lands poses. However, grants at the same places in the supply chain yielded different outcomes in each location. For example, grantees in eastern Oregon were able to add new equipment to scale up their harvesting capacity without seeking or building markets because the grantees were already established federal contractors with end users for their products. In contrast, grantees in eastern Arizona had to do the work of purchasing and building facilities, obtaining supply, and developing markets, all of which took significant time and resources yet was extremely important for rebuilding an industry in Arizona.

National forest management affected biomass availability

Grantees in both cases faced difficulty obtaining consistent biomass supply from national forests. As a result, in eastern Oregon many grantees used their equipment on private timberland instead, and some grantees in eastern Arizona removed biomass from reservations. However, this strategy is not sustainable for these enterprises, as large percentages of land in both case study areas are federally owned, and businesses need access to them to maintain long-term health. Grantees in both cases—but especially in eastern Arizona—expressed concern about their ability to continue to invest in their businesses when they were uncertain of future supply through the 4FRI project.

There were differences and similarities in why grantees faced public lands supply challenges. In both cases, grantees felt that national forest management often did not appear to be coordinated with or accelerated on behalf of the Woody Biomass Utilization Grant program. In eastern Arizona, grantees were operating on one national forest with a large stewardship contract for service work and biomass removal that a single contractor held, so the contractor's choices greatly affected grantee access to raw material on federal land. Thus, although there had been landscape-scale planning to help increase biomass utilization in this area, the centralized approach limited supply from federal lands to the grantees. In eastern Oregon, grantees were operat-

ing across six national forests that did not share any particular strategy or commitment to biomass utilization; yet there were more diverse, flexible mechanisms (both timber sales and stewardship contracts) for enterprises to access biomass without a single contractor mediating the relationship between federal lands and material supply.

Biomass utilization increased in both study areas as a result of the Woody Biomass Utilization Grant program

We found that biomass utilization increased in both Oregon and Arizona as a result of the Woody Biomass Utilization Grant program. More green tons were removed and utilized than prior to the program's existence. Other incentives like the WMSP and other large stewardship contracts, Oregon's Biomass Producers or Collectors Tax Credit, biomass utilization projects funded by the American Recovery and Reinvestment Act, and the federal Biomass Crop Assistance Program have also been applied in eastern Oregon to increase biomass utilization. This suite of policy tools during the study period may have provided sufficient incentives at the right leverage points to spur growth in utilization in that region. This also reflects how eastern Oregon's forest products industry has been more intact than eastern Arizona's. If eastern Arizona's industry can continue to grow, rates of utilization may increase in the future.

Lessons

Careful grantee review and intermediary engagement improved grant success

In both cases, grantee characteristics such as relevant skills, experience, and "good business sense" as well as the ability to learn from challenges and reach out for assistance when needed, were important to their success. In addition, having grant reviewers that included knowledgeable parties outside of the Forest Service to work extensively with potential grantees before submission or to recruit candidates helped ensure that most grantees had feasible plans, or the capacity to change plans and succeed. Intermediary assistance both before and during grants may increase business capacity and likelihood of grant success. It also suggests that a robust review panel including external participants with diverse expertise (e.g. technical, financial, etc.) could be useful to examine grant proposals for: 1) the background and history of the specific equipment, 2) assuring grantee's experiential levels match their proposed scope of work, 3) legal authority/licensing and, 4) sustainable business plans.

Deliberate investment in technical assistance to help grantees understand equipment, technology, and markets helped increase the viability of grants. In particular, investment in market education and development helped guide grantee investments and build capacity. Grantees in both cases faced significant technical and market challenges, given that many did not have prior experience operating in the biomass business environment. For example, some grantees in the Arizona case did not add enough value to their products, create a viable specialty product niche, or have strong understanding of and access to the right markets. Technical assistance about how to select the most efficient and effective use for small-diameter pine was provided in eastern Arizona to help ameliorate these issues. In the Oregon case, grantees who sought to enter markets that were not strong during the study period, such as the electricity market, were severely challenged and could not complete their grants. Grantees described the importance of obtaining technical assistance from intermediary nonprofits and Forest Service Regional Biomass Coordinators, in addition to the support, flexibility, and knowledge that Forest Products Laboratory personnel offered to overcome these challenges.

Coordination and engagement with national forest management is as important as enterprise investment

The Woody Biomass Utilization Grant program built enterprise capacity, but did not specifically invest in agency capacity to plan for biomass utilization. The ability of national forest and Regional Office staff to plan and implement land management is essential to increasing acres treated and reducing costs. Deliberate, coordinated investment in agency capacity at local levels, particularly on how to use stewardship contracting and how to build working relationships with local enterprises to understand their abilities

and needs, might help improve land management outcomes. Networking and peer-learning between the national forests in eastern Oregon, for example, could accelerate this knowledge and transfer skills more consistently across the region. Joint capacity-building between agency personnel and stakeholder entities such as community-based organizations and collaborative groups may also be useful in building more sustainable local knowledge bases, given that agency personnel frequently "turn over" and tend to not remain on any one forest for very long.

Lack of monitoring limited measurement of impacts
In both cases but particularly in eastern Oregon, grant reporting on measures such as green tons and acres treated was inconsistent. Interviews revealed that depending on the type of grantee enterprise, they did not have an accurate understanding of acres treated; e.g. in the White Mountains stewardship contract, where the sole contractor treated acres and the grantees purchased raw material. Although reporting from one national forest in eastern Oregon was fairly consistent due to one dedicated person, others provided little information. This suggests that what to measure, who measures what, and how reporting is administered matter. Requesting information and measures that grantees will readily know and that are focused on the business outcomes may increase reporting. Further, additional close contact and guidance on measurement between the FPL, the Regional Offices, and national forest units may help improve the availability and accuracy of data. This would allow for greater understanding of the impacts of programs on biomass utilization.

Conclusion

The Woody Biomass Utilization Grant program was a unique resource for accelerating biomass utilization in a public lands context. Unlike other policies and federal programs, it directly supported the acquisition of equipment, the growth of regional industry, and networks of technical assistance and learning. This relatively small ($5 million authorized annually nationwide) program sustained and accelerated biomass utilization across eastern Oregon, filling several gaps in industry capacity; and was the primary source of investment in the redevelopment of an entire forest products industry in eastern Arizona. Its most clear accomplishments have been its significant contributions to biomass processing capacity and associated rural economic development, which occurred despite challenging market and economic conditions. The program's ability to increase acres treated and reduce costs was less discernible, particularly because 1) numerous other factors beyond enterprise capacity affect these dynamics and 2) there was no systematic investment in agency capacity to accelerate project planning and implementation. It is also important to note that given the complexities of public land management and associated enterprise development, strategies such as the Woody Biomass Utilization Grant program are critical to increasing biomass utilization, but they achieve greater outcomes when incorporated with other tools to improve agency and stakeholder capacity, active land management, and long-term industry sustainability.

Appendix A

Economic Impacts Methods

Input-output model

We used an input-output model to measure the economic impacts of the Woody Biomass Utilization Grant program from 2005–10. An input-output model measures how any individual change in the economy ripples through the rest of the economy. Input-output models represent the complex set of inter-industry exchanges that occurs in the production and consumption of that economy's goods and services. Changes in one sector of the economy cause industries to respond by changing their production levels and adjusting their consumption of intermediary products purchased from industries in other sectors. Input-output analysis defines how inter-industry transactions between different components of regional production are translated into various components of regional income.[25] The general input output model for an economy in which each sector produces one product, x_i, can be written as:

$$\sum_{i=1}^{n} d_i = (I - A) \sum_{i=1}^{n} x_i \qquad \text{Where} \quad \sum_{i=1}^{n} d_i$$

is the total final demand for all i sectors in an economy, and A is a matrix of coefficients aij representing the requirements from sector j to produce one unit of product x in sector i. Roughly translated from mathematical notation, the above formula indicates that the total final demand in an economy is equal to the total value of the goods and services produced in the economy plus the total value of the inter-industry exchange needed to produce those goods and services.

We used the economic impact modeling software IMPLAN 3.0[26] to describe the impacts from Woody Biomass Utilization grants on Oregon and Arizona's economies. We used 2011 Oregon and Arizona data from the Minnesota IMPLAN Group (MIG) as the basic economic structure of the two states' economies. MIG data are calibrated to national and local data from a number of sources. The Bureau of Economic Analysis (BEA) develops national input-output matrices every five years using data collected from the Department of Census' U.S. Economic Census and other programs. MIG estimates local and state level input-output matrices by calibrating the BEA national input-output matrices with data from the Bureau of Labor Statistics, the Department of the Census, and the BEA. All national and local data are classified according to IMPLAN's industrial sectoring scheme, which has its origins in the North American Industrial Classification System sectoring scheme. We adjusted all results from IMPLAN to 2013 dollars.

Grant impact models

Most grants were used to purchase equipment that would increase biomass collection and utilization from national forests. We therefore divided the impact models into two components: 1) initial purchases impacts and 2) utilization impacts (through 2011). To develop the initial purchase impact model for Oregon and Arizona, we obtained grant proposals, including requested and matching budget information, all available grant progress and final reports, and biomass utilization data for each grant from the USDA Forest Products Laboratory. Requested grant budgets and matching funds were categorized into appropriate IMPLAN sectors (e.g., wholesale trade, employee compensation, wood product production). The expenditure profiles were averaged across all grants by state, and coefficients represent the proportion of total project dollars spent in budget category. Several modifications were made to the grant budgets to reflect deviations from the original grant proposals discovered during the course of qualitative interviews.

Utilization impacts were estimated using two methods—one for Oregon and one for Arizona. The Oregon utilization impact model was based on an existing biomass utilization impact model created to estimate the impact of the Oregon Biomass Producers or Consumers Tax Credit.[27] This model was estimated based on surveys of biomass utilization contractors in Oregon. The model shows the economic impacts to employment, wages, and overall economic output per 10,000 bone dry tons of biomass collected and delivered to a utilization facility

(e.g., a sawmill with a combined heat and electric generation facility). We obtained total utilization records reported by each grantee from the USDA Forest Products Laboratory and applied those records to the biomass utilization impact model to estimate the impact of biomass utilization from the Woody Biomass Utilization Grant program in Oregon.

The Arizona utilization impact model was developed using similar procedures. Because we did not have information to develop the production function, we used the from Oregon model, assuming production costs for forest biomass utilization in Arizona were similar to those for Oregon. Assuming 50 percent moisture content of delivered biomass and the average delivered price per bone dry ton to be $30.94, we calculated the average total logging, transportation and overhead costs per 10,000 bone dry tons of biomass utilization. From the total utilization records reported by each grantee from the USDA Forest Products Laboratory (as of 2011), we calculated the total production costs and their economic impacts in Arizona.

We used IMPLAN 3.0 to estimate the employment, economic, and tax impacts of the Woody Biomass Utilization Grant program. We present the results of our impact analyses in several ways. First, we disaggregated impacts to direct, indirect, and induced impacts. We defined direct effects as those economic impacts that arise directly from grant spending (e.g., the purchase of new utilization equipment) and from biomass utilization that was reported as the result of the grant. Indirect effects arise out of the patterns of trade in the directly-affected sectors as they demand goods and services from other businesses, government entities, and households. For example, new equipment creates a new demand for supplies and services required to run and maintain that equipment. Finally, induced effects represent the household consumption created by wages paid to employees in the sectors affected by direct and indirect effects. Induced effects are often considered somewhat differently than direct and indirect effects because of their dependence on macroeconomic conditions rather than on industrial patterns of trade.[28] Induced effects may be greater when unemployment is high because firms can easily fill new demand by hiring workers, but when the economy is robust and unemployment is low employers may seek to improve worker productivity and overall efficiency rather than allocate wages to new employees. Given the economic climate during the majority of our analysis period, we expect that induced effects derived from our models will adequately represent the impacts to the economy; however, we caution that expansions in productivity and efficiency would likely generate less induced effects than initial investments. As such, we suggest that readers view the induced effect as a guide rather than a definitive outcome.

Second, we broke grantee spending into direct grant spending and match spending. Grant dollars were leveraged with other non-grant dollars, or match. One measure of grant effectiveness is if a grant enables a project that requires spending of some non-grant dollars, in addition to the grant dollars, that would not otherwise occur. Grantees reported match dollars in addition to their grant dollars. We present economic impact results in terms of grant spending, match spending, and the economic impact leveraged by the grant.

Third, we present both annual impacts and total impacts. We used qualitative interview data and grant reporting data to identify the year in which equipment was purchased or other major expenditures occurred (this was not necessarily the year the grant was awarded because it took some grantees a year or more to identify and purchase equipment). Utilization impacts were estimated by dividing the total utilization reported (from the grant award date through 2011) by the number of years material was utilized. Although this approach assumes equal utilization per year when there were likely fluctuations by year, we had no better data on which to allocate the temporal flow of utilization. Examining the total impacts, which represent the sum of all annual impacts, circumvents any errors in annual impact this assumption created. Readers should be careful, however, interpreting total employment impacts and jobs are reported by job-years. For example, a total employment impact of 100 jobs is equal to ten jobs for ten years or fifty jobs for two years.

Endotes

1 Woody biomass can have a range of uses including various forest products and energy. See Sundstrom, Shiloh. 2009. *Defining Woody Biomass Uses*. Ecosystem Workforce Program Briefing Paper #19, Ecosystem Workforce Program, Institute for a Sustainable Environment, University of Oregon. http://aaa.uoregon.edu/images/userfiles/file/BP%2019.pdf

2 Sundstrom, Shiloh, Max Nielsen-Pincus, Cassandra Moseley, and Sarah McCaffery. Woody Biomass Use Trends, Barriers, and Strategies: Perspectives of US Forest Service Managers. *Journal of Forestry* 110(1): 16–24.

3 Davis, Emily Jane, Moseley, Cassandra, Nielsen-Pincus, Max, Abrams, Jesse, Brady, Cullen, Christoffersen, Nils, Davis, Chad, et al. 2010. *The State of the Dry Forest Zone and its Communities*. The State of the Dry Forest Zone and Its Communities. Ecosystem Workforce Program, Institute for a Sustainable Environment, University of Oregon. http://hdl.handle.net/1794/10802.

4 Davis, et al. 2010

5 We identify the Forest Products Laboratory as the grantor in this report as this is how grantees and others refer to it; however, technically granting authority comes through the Forest Products Marketing Unit (formerly the Technology Marketing Unit).

6 See program goals at: http://www.fpl.fs.fed.us/research/units/fpmu/fpmugrants_goals.shtml

7 Davis, Emily Jane, Sundstrom, Shiloh, and Cassandra Moseley. 2012. Federal Investments in Natural Resource-Based Economic Development in Oregon. Ecosystem Workforce Program Working Paper #40, Institute for a Sustainable Environment, University of Oregon.

8 Minnesota IMPLAN Group, Inc. Stillwater, MN. http://implan.com

9 Nielsen-Pincus, Max, Krumenauer, Matt, MacFarland, Kate, and Cassandra Moseley. 2011. Impacts of the Biomass Producer or Collector Tax Credit on Oregon's Wood Fuels Market and Economy. Ecosystem Workforce Program Working Paper #32, Institute for a Sustainable Environment, University of Oregon.

10 Hjerpe, Evan and Yeon-Su Kim. 2008. Economic Impacts of Southwestern National Forest Fuels Reductions. *Journal of Forestry*. 106(6): 311-316.

11 Nielsen-Pincus, Max, and Cassandra Moseley. 2012. The Economic and Employment Impacts of Forest and Watershed Restoration. *Restoration Ecology* 21:207-214.

12 Davis et al. 2010.

13 Swan, Larry. 2012. Eastern Oregon Primary Wood Products Processing Facilities and Operations: Final Draft. November 2012. USDA Forest Service, State and Private Forestry, in Cooperation with Oregon Business Development Department.

14 Ehinger, Paul F. 2012. Forest industry data, Oregon, Washington, California, Idaho, Montana. Operating Mills and Closed Mill History from 1990 to 2012. Paul F. Ehinger & Associates, Eugene, OR. 90p.

15 Davis et al. 2012.

16 Davis, Emily Jane, Christoffersen, Nils, Couch, Kyle, and Cassandra Moseley. 2011. Forest Restoration and Biomass Utilization for Multiple Benefits: A Case Study from Wallowa County, Oregon. Ecosystem Workforce Program Working Paper #29, Institute for a Sustainable Environment, University of Oregon.

17 Fight, Roger D., Pinjuv, Guy L., and Peter J. Daugherty. 2004. Small-Diameter Wood Processing in the Southwestern United States: An Economic Case Study and Decision Analysis Tool. *Forest Products Journal* 54(5): 85-89. And Jim Petersen. 2004. New hope in New Mexico. *Evergreen* August 2-7.

18 Morgan, Todd A., Dillon, Thale, Keegan III, Charles E., Chase, Alfred L., and Mike T. Thompson. The RB-7. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 64p.

19 Morgan, T.A., T. Dillon, C.E. Keegan III, A.L. Chase, and M.T. Thompson. *The Four Corners Timber Harvest and Forest Products Industry, 2002*. 2006. Resource Bulletin. RMRS-RB-7. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 64p.

20 Arizona Geography from NETSTATE. http://www.google.com/search?client=safari&rls=en&q=white+mountains+AZ+geographic+descritption&ie=UTF-8&oe=UTF

21 USDA Forest Service, Apache and Sitgreaves National Forests. *White Mountain Stewardship*. Retrieved 8/8/13 from: http://www.fs.usda.gov/detail/asnf/workingtogether/partnerships/?cid=STELPRDB5206733

22 USDA Forest Service, Apache and Sitgreaves National Forests. *White Mountain Stewardship*. http://www.fs.usda.gov/detail/asnf/workingtogether/partnerships/?cid=STELPRDB5206733

23 Sitko, Suzanne, and Sarah Hurteau, 2010. *Evaluating the Impacts of Forest Treatments: The First Five Years of the White Mountain Stewardship Project*. The Nature Conservancy, Phoenix, Arizona. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5362084.pdf.

24 Sitko and Hurteau 2010.

25 Bendavid-Val, Avrom. 1991. *Regional and Local Economic Analysis for Practitioners*. Praeger: New York.

26 Minnesota IMPLAN Group, Inc. Stillwater, MN. http://implan.com

27 Nielsen-Pincus et al. 2011.

28 Heintz, James, Pollen, Robert, and Heidi Garrett-Peltier. 2009. *How Infrastructure Investments Support the US Economy: Employment, Productivity, and Growth*. Amherst, MA: Political Economy Research Institute. University of Massachusetts-Amherst.

UNIVERSITY OF OREGON