United States Department of Agriculture

Forest Products Cluster Development in Central Arizona—Implications for Landscape-Scale Forest Restoration

David Nicholls

Forest Service
Pacific Northwest Research Station
General Technical Report PNW-GTR-898
August 2014

Authors

David Nicholls is a forest products technologist, Alaska Wood Utilization and Development Center, 204 Siginaka Way, Sitka, AK 99835.

Cover photographs: Apache-Sitgreaves National Forest, Arizona; logging operation; log deck after harvest.

Abstract

Nicholls, David. 2014. Forest products cluster development in central Arizona—implications for landscape-scale forest restoration. Gen. Tech. Rep. PNW-GTR-898. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

Since 2004, close to 50,000 ac of hazardous fuels have been mechanically treated in east-central Arizona as part of the USDA Forest Service's first 10-year stewardship project on national forest lands. The need for coordinated wood products and biomass utilization in Arizona is likely to increase as broad-scale restoration treatments across Arizona's national forests remove large amounts of wood fiber in coming decades. This research considers biomass availability and land ownership patterns for three potential wood products cluster sites in the Mogollon Rim region of Arizona (Show Low, Flagstaff, and Heber-Overgaard, Arizona). The formation of one or more wood products clusters in the Mogollon Rim region could create tangible benefits for communities in central Arizona as new businesses utilize increasing volumes of wood fiber. Land ownership patterns varied greatly between the locations, with federal lands predominating near Flagstaff and private ownership more common near Show Low. Regardless of the path forward, community support for forest restoration initiatives is likely to be a key to success, as is a shared vision held by stakeholders.

Keywords: Forest restoration, wood products, clusters, bioenergy, ponderosa pine, Arizona.

Contents

Introduction

The softwood forests of central Arizona are part of a unique ecosystem that includes the largest contiguous ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forest in North America (Neary and Zieroth 2007). However, the 2002 Rodeo-Chediski Fire altered this ecosystem by burning nearly 435,000 ac of forest, forcing evacuation of more than 30,000 local residents and destroying close to 500 homes. The White Mountain Stewardship Project (WMSP) in the Apache-Sitgreaves National Forest was established shortly thereafter, becoming the first 10-year stewardship contract in the National Forest System. In its first 5 years, the WMSP has provided many community benefits to Arizona's White Mountain region, including increased employment, small business development, enhanced recreational opportunities, improved wildlife habitat, and reduced wildfire risk (Sitko and Hurteau 2010). More than 49,000 ac have been treated or have treatments in progress, and 96 percent of this harvesting is of stems less than 12 inches in diameter (table 1). The WMSP is expected to cost the Forest Service an average of $6 million per year ($60 million over 10 years) which, although costly, is estimated to be only 25 percent of the financial burden of the Rodeo-Chediski Fire (Neary and Zieroth 2007). Forest Service expenditures during the first 5 years of the WMSP have led to a $40 million benefit in local investments, expenditures, and tax revenues (Sitko and Hurteau 2010).

Despite encouraging signs of growth and diversification in the wood products industry (in particular the wood pellet mill in Show Low), it remains to be seen whether the aggregate forest products industry can develop enough "critical mass" to use this small-diameter resource effectively. One obstacle is the high cost of harvesting and transportation. Pan et al. (2008) evaluated four fuel-reduction thinning treatment units in Arizona and found that when thinning stands from below

Table 1—Fiber classes and general uses for wood harvested from the White Mountain Stewardship Project, Arizona, 2004–2009

Fiber class/dimension	Stem diameter class	General uses	Percentage of total
	Inches		
Merchantable nonsawtimber logs or roundwood	5 to 8.9	Electrical generation, pellets, pallets, other small-dimension wood products	30
Merchantable stemwood	9 to 11.9	Electrical generation, pellets, pallets, other small-dimension wood products	25
Merchantable stemwood	> 12	Dimensional lumber, pellets, pallets, other wood products	4
Residue from all above merchantable and pulpwood	< 4.9	Electrical generation	41

Source: Sitko and Hurteau 2010.

(and harvesting trees 5 inches in diameter and smaller), harvesting and transportation costs averaged $55.27 per bone-dry ton for distances up to 36 mi. This is likely greater than the market value of raw material for most forest industries in Arizona.

In Arizona's White Mountain region, with arid nonforested regions to the north and south, economical transportation distances can be difficult to evaluate for potential biomass users located "on the edge of the forest and the edge of the desert." For example, the Snowflake Energy Facility (in Snowflake, Arizona) is within the pinyon-juniper region, and the Cholla Coal Facility (in Holbrook, Arizona) is even farther from forested areas; however, both of these facilities are either current or potential users of biomass harvested from the WMSP. The importance of transportation costs is underscored by the finding that average transportation costs represented more than 47 percent of total production costs for small-diameter stems (Pan et al. 2008). Economic restoration treatments are proving challenging because recent harvest costs in Arizona for mechanical thinning treatments yielding 600 to 1,200 ft3 per acre have been estimated between $557 and $836 per acre (Selig et al. 2010).

The cost challenges of harvesting and transporting biomass notwithstanding, a nascent wood products cluster is beginning to take hold in the White Mountains region of Arizona. From 2005 to 2008, between 13 and 15 known wood products firms purchased wood fiber from WMSP activities (table 2), indicating an ongoing demand to produce a variety of product types. However, a cornerstone of many successful wood products clusters, a production sawmill, has been conspicuously absent from this part of Arizona since the recent closure of a lumber mill in the White Mountains region (WMAT 2011). However, two other sawmills, both located in the northern White Mountains area, could potentially become leaders (or co-leaders) of a future wood products cluster, filling the void left by previous mill closures.

Larson and Mirth (2001) found that a simulated 16-in diameter cap on harvests within a 332-ac site near Flagstaff, Arizona, resulted in implementation cost increases of up to 19.4 percent and wood volume reductions of up to 39 percent. Thus, wood products clusters could be a key to economic use of WMSP materials. However, production of a broad mix of wood products—an important element of wood products cluster development—remains unclear. The lack of dry kiln capacity in Arizona could also hinder development of an integrated value-added wood products cluster.

Future restoration activities on broader scales in Arizona could favor a more diverse mix of wood products. The Four Forest Restoration Initiative ("4FRI") is a collaborative effort to treat up to 1 million acres over the next 20 years in four Arizona national forests (4FRI 2011). This volume of biomass and solid wood could create new opportunities for existing manufacturers, with the potential to create

Table 2—Businesses purchasing wood material from Future Forest, LLC, directly tied to the White Mountain Stewardship Project, 2005–2008

Business	Location	2005	2006	2007	2008
APC Pallets	Phoenix			X	
APC Lumber	Eagar				X
Arizona Log and Timberworks	Eagar	X	X	X	X
Cooley Forest Products	Snowflake				X
Forest Energy Corp.	Show Low	X	X	X	X
Future Forest	Pinetop	X	X	X	X
Mountain Top Wood Products	Snowflake		X	X	
Moulding Accents	Snowflake			X	X
Nutrioso Logging	Nutrioso		X	X	X
Reidhead Bros. Lumber	Nutrioso	X	X	X	X
Reidhead Bros. Remanufacturing Plant	Springerville	X	X	X	
Snowflake White Mountain Power	Snowflake	X	X	X	X
Round Valley Wholesale Lumber	Eagar	X	X	X	X
Snowflake Lumber Moulding	Snowflake	X	X	X	
Southwest Forest Products, Inc.	Phoenix	X			
TriStar Logging, Inc.	Snowflake	X	X	X	X
WB Contracting	Eagar	X	X	X	X
Western Moulding	Snowflake		X		
Western Renewable Energy	Eagar	X	X		
Winner's Circle Soils, Inc.	Taylor	X	X	X	
Total number of businesses		13	15	15	13

Source: Sitko and Hurteau 2010.

new industries. This is significant in that large-scale 4FRI-type restoration treatments could help expand regional wood production by up to 88 percent (Hampton et al. 2011).

Objectives and Methods

Research objectives for this report are to (1) review the broad range of forest activities centered around biomass utilization in central Arizona, and (2) evaluate key issues needed for a forest industry cluster to become self-sustaining. This report addresses some of the broader issues surrounding the formation of a wood products cluster. It starts with a discussion of cluster theory, followed by region-specific factors including biomass transportation, employment, and land ownership. This overview provides a framework for cluster potential in Arizona, and in doing so, links current and future forest restoration activities.

Discussion

The White Mountain Stewardship Project has been a notable success during its first 5 years, providing an array of biomass and solid wood products to local markets (table 2). During this period, 35,166 ac have been treated, with an additional 14,553 ac in treatment progress (Sitka and Hurteau 2010). Much of this biomass is being used for pellet manufacturing to supply residential heating systems. However, this success has been fostered by a subsidy, estimated to be more than $300 per acre (Selig et al. 2010). As the first 5-year period of the WMSP was drawing to a close, a major wildfire (the Wallow Fire) burned more than 520,000 ac in east-central Arizona and western New Mexico, adding uncertainty to the planned use of this material in future restoration activities. The following topical review considers current issues for the White Mountain Stewardship Project. A goal of this discussion is to identify relevant factors from the WMSP that could provide context for future wood products cluster development, as part of the 4FRI project or other Arizona initiatives.

Creation of New Forest Products Business Clusters

A considerable literature over the past several decades has described business industry cluster development; however, relatively few efforts have focused on wood products clusters. Clusters can generally be defined as regional agglomerations of companies, research institutions, government agencies, and others in a specific area of business activity related through various knowledge and economic linkages (Porter 1998). Clusters can also be thought of as critical masses of competitive success, linked together geographically and functionally. Others have defined clusters as "groups of establishments located within close geographic proximity of one another, which either share a common set of input needs, or rely on each other as supplier or customer" (Gibbs and Bernat 1997). A good example of this in the wood products industry is a sawmill (the supplier) that provides residue material to a pellet mill or bioenergy facility (the customer). In general, business clusters are geographic concentrations of companies that provide mutual advantages for their participants.

Rural industry clusters have the potential to create higher wages for workers compared to employment outside of clusters. Gibbs and Bernat (1997) found that the wage premium for workers in rural clusters (versus rural workers employed outside of clusters) was as high as 11 to 13 percent. When just the lumber and wood industry groups are considered, the wage premium for rural workers was 7.4 percent. This feature could benefit economic development of wood products clusters in rural Arizona by helping to attract qualified workers.

In east-central Arizona, a natural delineation for a wood products cluster region would be the ponderosa pine forests extending roughly from Nutrioso in the east to Williams in the west (fig. 1). Porter (2000) indicated that the boundaries of clusters can evolve as new firms emerge and established businesses decline. Technological developments, market conditions, and regulatory changes can also contribute to shifting cluster boundaries. Many of the communities along the Mogollon Rim are either located near national forests or in some cases embedded within federal lands. Cluster theory can be used to provide a framework for examining the microeconomic relationships between national forests and associated communities. National-forest-based clusters have the potential not only to help provide multiple uses of

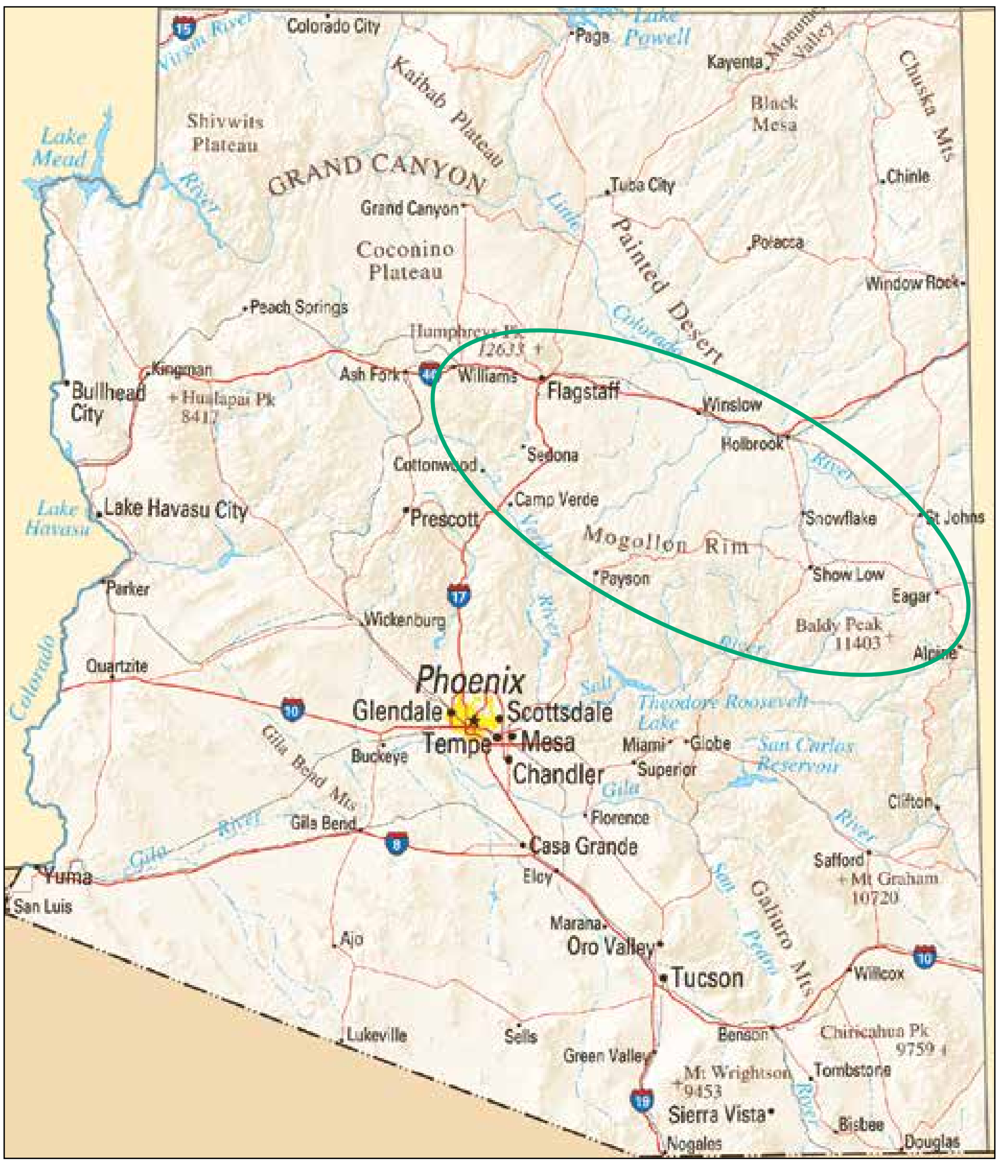

Figure 1—Map of Arizona with the Mogollon Rim region circled.

national forest lands, but also to diversify microeconomic environments and private sector policies (Rojas 2007).

Ready access to transportation corridors (including Interstate 40 and Interstate 17 in Arizona, and railheads) would be important for wood products clusters to reach regional markets while also providing access to support services and suppliers. Hagadone and Grala (2012) used spatial analysis techniques to find that the presence of railways had a significant positive impact on the number of secondary wood products manufacturers in a cluster. These transportation benefits are already seen in pellet production in Show Low, Arizona, where packaged wood pellets for residential heating are shipped throughout the Southwestern United States. Two logical locations for wood products clusters along the Mogollon Rim would be the greater Flagstaff area (west side), and Show Low/White Mountains area (east side). An intermediate location in Heber-Overgaard would be centrally located, but in a smaller community located farther from transportation corridors.

Proximity to population centers has been found important for wood products clusters. Aguilar and Vlosky (2006) found that population significantly influences the presence of secondary wood products industries in Louisiana and that primary manufacturers are more spatially dependent than secondary producers. In Arizona, there are few population centers within the forested regions in the northern and eastern parts of the state. Although higher value secondary products could potentially be produced by Phoenix-based firms (table 2), it is unlikely that enough critical mass could form there to create an effective wood products cluster.

Wood products clusters can sometimes be characterized by small firms. For example, a cluster of Amish furniture manufacturers in Ohio had a median of 4.0 employees in 2005 (Bumgardner et al. 2008). This is relevant for Arizona's wood products industry, which currently has few large producers. Important to the success of a wood products cluster in Arizona would be the diversity of firm sizes and product types, to ensure that woody material is being fully utilized

Role of Solid Wood Industry in Shaping Success

A significant challenge in the White Mountains region is the lack of a production sawmill or other high-volume wood products producer that could help provide critical mass needed to stimulate smaller niche producers, who alone might not be able to secure raw materials at a reasonable cost. A sawmill in Whiteriver, Arizona, operated by the White Mountain Apache Tribe, has stopped production within the past few years, leaving a gap in this part of the wood products infrastructure (WMAT 2011). Given that the price of fuel can greatly affect the viability of sawmills, the trend in Arizona's White Mountains has been for smaller sawmills to become established, taking advantage of shorter average transportation distances (versus larger mills having greater transportation distances).[1]

During cluster formation, a specific industry group typically takes a lead role, defining products and coordinating the relationship-building process (Colgan and Baker 2003). Without the presence of a large sawmill in central Arizona, this cluster leadership could be provided by a bioenergy producer (either pellet production or energy generation), several intermediate-sized sawmills, or perhaps a new wood products enterprise.

A successful cluster would likely include diverse members, serving niche markets while also providing synergy in terms of raw material flows and shared resources (table 3). Cluster environments often lead to greater innovation and a greater flow of ideas (Ketels 2009). Further, cluster development can be greatly influenced by government policy. This is important for potential wood products clusters in Arizona owing to the diversity of products possible from restoration thinning, much of which would take place on Forest Service land. Improvements in cluster productivity often occur only when multiple parts of the supply chain improve simultaneously (e.g., logging operations and sawmilling) (Porter 1998). In northern Arizona, a sudden influx of woody biomass could necessitate similar improvements in different parts of the cluster, including harvesting, primary and secondary processing, biomass utilization, and processing of small-diameter stems into lumber.

Lowell and Green (2001) found that small-diameter ponderosa pine could have enough value for lumber and potentially moulding and millwork production. However, wood product and processing options should be chosen carefully by startup

Table 3—Flow of wood from specific harvesting contractors, Apache-Sitgreaves National Forest, Arizona (2006)

Number of contractors	Green tons	Product
2	95,900	Pellets
2	23,800	Lumber
3	20,900	Biomass
2	6,200	Posts and poles
2	7,400	Lumber
11	154,200	

Source: Hampton et al. 2008.

[1] Rappold, P. 2013. Personal communication. Wood utilization and marketing specialist, Arizona State Forestry Division, 3650 Lake Mary Road, Flagstaff, AZ 86001.

firms. Fight et al. (2004) evaluated small-diameter processing options in the eastern White Mountains region of Arizona, finding that machine-processed utility poles were not a viable product option because of high equipment costs, while hand-peeled poles were more economically attractive. Despite this research finding, at least one regional firm does have a pole-peeling operation, taking advantage of the generally favorable tree forms found in the eastern White Mountains (see footnote 1).

As of 2002, there were 23 primary processing facilities in Arizona (Morgan et al 2006); by 2007 this had dropped to 17 (Hayes et al. 2012) (table 4). Lumber production from sawmills could play an important role in the success of future restoration initiatives such as the 4FRI collaborative. Simulation studies near Flagstaff, Arizona, found that when some 16- to 21-in stems were harvested, the effect was lower operating costs, higher financial net returns, and increases in harvested fiber (versus harvesting only smaller stems) (Larson and Mirth 2001). Similarly, Lowell and Green (2001) found that project economics could be improved when some larger stems were included, especially for appearance lumber grades.

Other research on Western forests studies found that removal of some larger stems can improve stand structure and fire resilience (Hollenstein et al. 2001). Diameter caps could also have negative impacts on ecosystem factors, including forest canopy openings, understory functioning, streamflow, and fire behavior (Abella et al. 2006). The issue of removing larger stems (greater than 16 inches in diameter) that could support a viable sawmill industry is potentially a very controversial issue that, despite likely economic benefits, could reduce the level of broad-based consensus needed for large-scale restoration projects.

Table 4—Primary wood products facilities in Arizona, by product (2007)

Year	Lumber	Log homes and house logs	Other products[a]	Pulp and paper	Total
2007	8	5	4	0	17
2002	11	5	7	0	23
1998	6	4	2	1	13
1990	14	3	1	1	19
1984	20	0	2	1	23

[a] Other products include posts, poles, vigas, latillas, fuel pellets, log furniture, and biomass energy.
Sources: Hayes et al. 2012, Keegan et al. 2001, McLain 1988, Morgan et al. 2006.

Bioenergy Applications for Whole-Tree Chips

A successful market for WMSP biomass over the past 5 years has been clean, bark-free chips for pellet production. The pellet mill in Show Low, Arizona, is currently producing about 60,000 tons of wood pellets per year, mostly for the residential heating market. "Green" pellets (containing wood, bark, and foliage) could be produced to supplement the clean (debarked) pellets currently used at the Show Low plant. Whole tree chipping could also result in greater in-woods production, because bark, limbs, and needles would be utilized (vs. left on site). A good example of this market has been the Snowflake Power facility. This biomass plant, which began operations in 2008 and closed in March 2013, had been scheduled to reopen in late 2013, once again enhancing markets for WMSP biomass (Worth 2013).

However, questions remain regarding use of whole trees for pellets. For example, how would needles, bark, and dirt content influence fuel quality for the different intended uses? Could an industrial grade pellet be produced from whole-tree chips that could find widespread utility in central Arizona markets?

Forest Land Ownership

Land ownership on public and private lands within a 30-mi radius from a potential cluster site was evaluated using customized USDA Forest Service Forest Inventory and Analysis (FIA) data retrievals (USDA FS 2011). Forest Service ownership, other federal ownership, state and local government, and private landowners were considered. Land ownership patterns vary greatly between the three potential cluster sites. Private ownership predominates near Show Low, whereas Flagstaff is closer to large areas of Forest Service land (fig. 2). Despite this trend, high land prices have had a limiting effect of development of the sawmill industry in certain Arizona markets (including the Flagstaff/Williams, Arizona area) (see footnote 1).

Forest restoration treatments on federal lands are subject to environmental reviews and legal appeals, leading to potentially expensive and time-consuming delays. In other areas, federal lands are intermixed with private properties in a mosaic pattern, for example near Lakeside, Arizona. Here, stewardship activities on federal lands can have a direct impact on private lands (and vice versa).

Near Show Low, Arizona, land ownership is also characterized by multiple owners. For example, in much of the White Mountains region of Arizona, the Apache-Sitgreaves National Forest, a thin strip of land (typically less than 10 mi wide) is bordered on the south by the White Mountain Apache Reservation and on the north by private or nonforested land. Any wood users in this region would likely draw upon multiple land ownerships for their raw material supply. It should

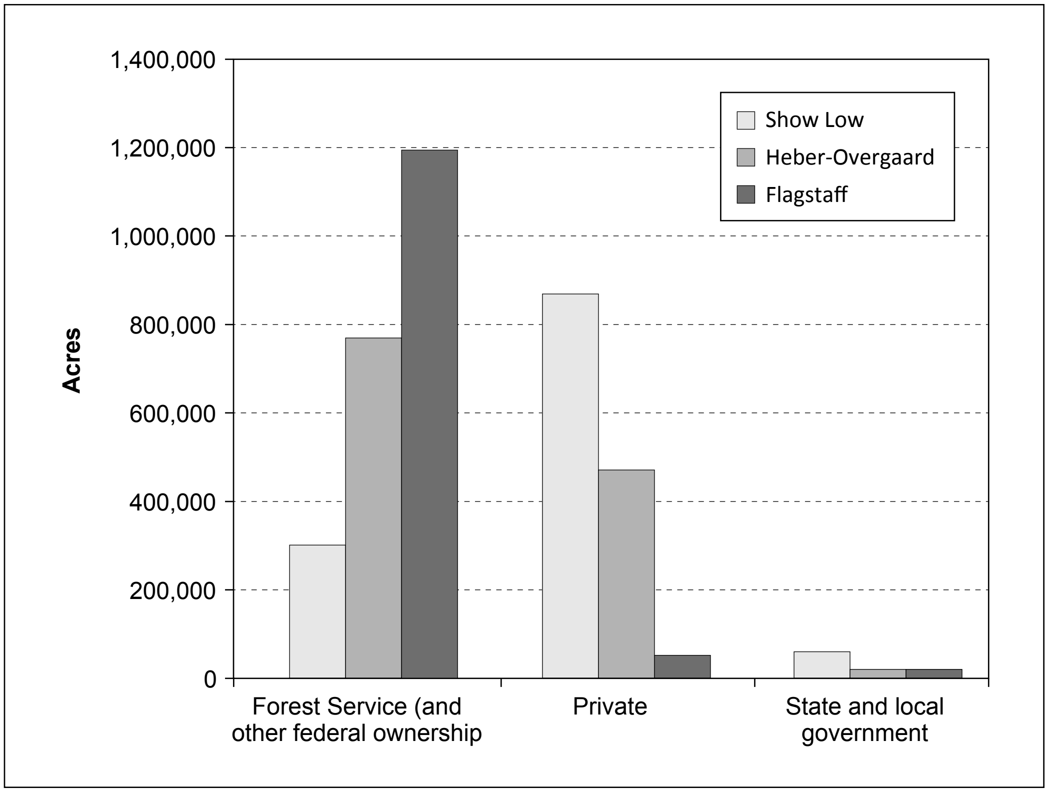

Figure 2—Land ownership near three potential wood products cluster sites in Arizona (number of acres within 30-m radius from community center).

be noted that the communitites of Eagar, Springerville, and Nutrioso, on the eastern edge of Arizona's White Mountains, were severely affected by the Wallow Fire (in June 2011), and could potentially yield large volumes of fire-salvaged timber.

Local Employment

An estimated, 319 jobs have stemmed directly from WMSP work, and more than $13 million annually is spent by businesses purchasing wood fiber and by related contractor operations (Sitko and Hurteau 2010). It is estimated that additional mechanical thinning activities on 30,000 ac per year as part of the 4FRI initiative could support up to 600 private sector jobs in Arizona (Hjerpe and Gunderson 2007). On a broader scale, Hjerpe and Kim (2008) attributed the creation of 500 jobs to fuel reduction programs in five national forests in the Southwest Region of the Forest Service (fiscal year 2005).

The presence of one or more large producers could have an important influence on the dynamics of biomass supply, cluster formation, employment, and other economic factors. Larger wood products facilities have the potential to pay a premium for smaller diameter material, reducing the financial burden on national forests to pay for restoration treatments (Abrams and Burns 2007).

Biomass Transportation Distances and Harvesting Costs

For the Southwestern United States, Hjerpe et al. (2009) estimated restoration costs to range from $300 to $700 per acre. This is in line with harvesting costs in northern Arizona, estimated to range from $557 to $836 per acre, excluding transportation costs (Selig et al. 2010). However, in the White Mountains of the Apache-Sitgreaves National Forest, harvest costs from restoration treatments have been higher, generally ranging between $1,100 and $1,300 per acre (Selig et al. 2010).

Factors such as slope, transportation distance, trees per acre, and stem diameter can have a bearing on total costs. For example, mechanized sawlog-only harvesting options in Western states have been shown to be cost effective for hauling distances up to 53 mi (Han et al. 2004). Yet, for smaller stems less than 5 inches in diameter, harvesting and transportation in Arizona averaged about $55 per bone-dry ton for short transportation distances of 36 mi or less (Pan et al. 2008). Here, transportation costs represented more than 47 percent of total costs. Because harvest costs are often borne by larger diameter sawlogs, the smaller diameter stems can be considered "free" except for the costs of transporting them from the forest landing to a final destination. However, because many of the utilization sites are located "on the edge of the desert" they could require transportation distances greater than 36 mi, increasing the likelihood that delivered wood fuel prices would exceed current market values.

Biomass transportation costs could vary considerably between the three cluster locations that were evaluated. Becker et al. (2009), using financial harvesting cost models, found that co-locating processing facilities to minimize transportation distances was the single most important cost-reduction strategy. When considering Arizona wood products clusters, there were considerable differences in biomass availability between sites.

Valuing Ecosystem Services

Numerous ecosystem service benefits have also been realized from restoration treatments, including forest health improvements and landscape level increases in vegetation structural diversity (Sitko and Hurteau 2010). Carbon benefits have also been recognized by Hurteau et al. (2008), who found that, when considering stand-replacing fires, prior thinning treatments could reduce carbon dioxide (CO_2) release by as much as 98 percent (versus a scenario of catastrophic fires). Forest thinning can also influence the connectivity of forest "patches" needed to ensure suitable wildlife habitat (Sitko and Hurteau 2010). The northern goshawk (*Accipiter gentilis*), Merriam's wild turkey (*Meleagris gallopavo merriami*), and red-faced warbler (*Cardellina rubrifrons*) all depend on habitat connectivity.

Benefits for forest health, biodiversity, wildlife habitat, carbon sequestration, and water quality are possible, yet their economic benefits are difficult to quantify. For example, North and Hurteau (2011) found that significant carbon benefits can be attained when fuels treatments are used to reduce carbon stock losses in the event of a high-severity wildfire. In Southwestern ponderosa pine forests, ecosystem health can be improved by reducing ladder fuels, protecting large trees, and increasing overall biodiversity levels (Allen et al. 2002).

Thus, management activities designed to benefit one or more ecosystem services can result in tradeoffs among other ecosystem services, including wood production. Of particular interest moving forward with the WMSP will be the desire to reduce fire risk while also providing ecosystem services and economic benefits for area residents and visitors. For example, Snider et al. (2003) found that it would be cost effective to spend up to $505 per acre for restoration to prevent catastrophic fires in Southwestern forests. However, this estimate did not include ecosystem service benefits associated with water, recreation, wildlife, and scenic values—benefits that would be impaired after a catastrophic fire. Several Southwestern U.S. municipalities have taken a proactive approach toward minimizing the loss of wildfire-related ecosystem services (namely water quality). The City of Flagstaff, Arizona, has passed a $10 million referendum to treat forests within its watershed. Likewise, Santa Fe, New Mexico, has adopted a “watershed tax” to offset the cost of thinning operations in its watershed (see footnote 1).

The formation of a successful wood products cluster in central Arizona, and its resulting economic benefits, will be inextricably linked to the suite of ecosystem services needed for long-term forest management objectives. A sustainable wood products cluster is one that could work in equilibrium with a sustainable ecosystem services regime to arrive at the tradeoffs that would best serve the interests of both.

The Four Forest Restoration Initiative

The Four Forest Restoration Initiative is a collaborative effort to treat portions of four of Arizona’s national forests (the Apache-Sitgreaves, Coconino, Kaibab, and Tonto National Forests) under one initiative. This effort, started in 2010, has included more than a dozen public meetings at various Mogollon Rim locations. A memorandum of understanding between the Forest Service and 24 stakeholder representatives was signed in February 2011. Plans to treat up to 2.4 million ac of forest using stewardship contracts on these four national forests would likely include a wide range of forest types over a large geographic area. The 4FRI has an objective of reducing the agency costs to close to zero (Wilent 2010).

Under the 4FRI, integrated landscape-level treatments are planned across the Mogollon Rim to reduce fire risk while also providing for sustainable forest industries and delivering other ecosystem service benefits. The 4FRI hopes to mechanically thin up to 50,000 ac of forest land per year over a 20-year period (for a total of up to 1 million ac). Up to 850 million ft^3 of stem volume and 8 million green tons of tree crown biomass could potentially be generated from this initiative (Hampton et al. 2011). Much of this material (43 percent of the total) is in the 5- to 16-in diameter class. Central to the 4FRI planning are the implementation costs, and the desire that treatments require only minimal federal subsidies. Total administrative costs have been estimated to be close to $360 per acre, including planning, preparation, and harvest administration costs (Selig et al. 2010). Although these costs are in line with comparable costs for the WMSP, estimated to be about $300 per acre (Sitko and Hurteau 2010), others (Bright 2008) have identified methods to reduce these costs to about $175 per acre. Beyond these administrative costs, site-specific factors such as harvest methods, topography, and hauling distances can have a strong bearing on costs.

Community support for forest restoration initiatives has proven to be a key to success. For example, there has been broad-based community support for the WMSP project, as indicated by a survey of more than 700 households, which found that 94 percent supported mechanical treatment of forests to reduce fire risk (Sitko and Hurteau 2010). The Prescott Area Wildland/Urban Interface Commission and the Greater Flagstaff Forest Partnership are two examples of collaborative community organizations with a focus on forest ecosystem restoration. Among the roles that community groups can play include assisting hazard fuel removals, promoting local markets for wood products, and providing community fire safety education (Iversen and Van Demark 2006). A total of six community wildfire protection plans have been developed by local governments within the 4FRI treatment area in Arizona (Anon. 2010), a further indication of community support. To date, there have been more than 14 public planning meetings as part of the 4FRI initiative (4FRI 2011). A unique feature of the 4FRI effort has been the high level of collaboration between environmental and conservation groups, the Forest Service, and industrial partners.

Conclusions

Forest restoration harvests in central Arizona have yielded important economic and ecological benefits thus far during the WMSP, and are likely to continue as larger scale efforts are planned. The formation of one or more wood products clusters in the Mogollon Rim region could create tangible benefits for communities in central

Arizona as new businesses use increasing volumes of wood fiber. However, cluster development will not occur overnight. A sudden influx of wood from planned large-scale restorations could create growing pains for wood products businesses; the best use for material of diverse harvest locations, species, diameter classes, and wood quality would likely be determined during an adaptive, market-driven process. Key issues include timber availability, commercial land availability, and support from government in the form of incentive programs and renewable energy standards, among other policy measures.

Moreover, careful establishment of the most viable wood-based industries through market-driven processes will be important, because subtle differences in products and processing options can result in large differences in economic feasibility. Successful cluster development is often aided by leadership from one or more established firms, and there are several businesses in central Arizona that could serve this role. However, just as important is broad-based community support and collaboration in all phases of planning. Because the need to improve forest health will drive restoration activities and ultimately wood utilization opportunities, it will be important that any new industry be appropriately scaled and that stakeholders reach consensus across large areas (Hampton et al. 2011). Finally, land ownership patterns, which varied considerably between the three potential locations, will influence wood availability, treatment procedures, and the regulatory environment in which cluster formation can occur.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	2.540	Centimeters (cm)
Miles (mi)	1.609	Kilometers
Acres (ac)	0.4047	Hectares (ha)
Cubic feet (ft^3)	0.0283	Cubic meters (m^3)
Tons	.454	Kilograms

Literature Cited

Anon. 2010. The Four Forest Restoration Initiative: promoting ecological restoration, wildfire risk reduction, and sustainable wood products industries-a proposal for funding under the collaborative forest landscape restoration program. 28 p. http://www.4fri.org/pdfs/documents/CFLRP/4fri_funding_proposal.pdf. (22 August 2011).

Abella, S.R.; Covington, W.W.; Fule, P.Z. 2006. Diameter caps for thinning southwestern ponderosa pine forests: viewpoints, effects, and tradeoffs. Journal of Forestry. 104(8): 407–414.

Abrams, J.B.; Burns, S. 2007. Case study of a community stewardship success: the White Mountain Stewardship Contract. Flagstaff, AZ: Northern Arizona University, Ecological Restoration Institute. 20 p. http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASHb445.dir/doc.pdf. (4 March 2014).

Aguilar, F.X.; Vlosky, R.P. 2006. Spatial analysis of forests products manufacturer clusters in Louisiana. Wood and Fiber Science. 38(1): 121–131.

Allen, C.D.; Savage, M.; Falk, D.A.; Suckling, K.F.; Swetnam, T.W.; Schulke, T.; Stacey, P.B.; Morgan, P.; Hoffman, M.; Klingel, J.T. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: a broad perspective. Ecological Applications. 12(5): 1418–1433.

Becker, D.R.; Larson, D.; Lowell, E.C. 2009. Financial considerations of policy options to enhance biomass utilization for reducing wildfire hazards. Forest Policy and Economics. 11(8): 628–635.

Bright, D. 2008. Northern Arizona forests project cost centers—2008. Presentation to the Southwestern Region Restoration Task Group. September 4, 2008, Coconino National Forest, Flagstaff, Arizona.

Bumgardner, M.; Romig, R.; Luppold, W. 2008. The Amish furniture cluster in Ohio: competitive factors and wood use estimates. In: Jacobs, D.F.; Michler, C.H., eds. Proceedings of the 16th central hardwoods forest conference. Gen. Tech. Rep. NRS-P-24. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 130–138.

Colgan, C.S.; Baker, C. 2003. A framework for assessing cluster development. Economic Development Quarterly. 17(4): 352–366.

Fight, R.D.; Pinjuv, G.L.; Daugherty, P.J. 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.

Gibbs, R.M.; Bernat, G.A., Jr. 1997. Rural industry clusters raise local earnings. Rural Development Perspectives. 12(3): 18–25.

Hagadone, T.A.; Grala, R.K. 2012. Business clusters in Mississippi's forest products industry. Forest Policy and Economics. 20: 16–24.

Hampton, H.M.; Sesnie, S.E.; Bailey, J.D.; Snider, G.B. 2011. Estimating regional wood supply based on stakeholder consensus for forest restoration in northern Arizona. Journal of Forestry. 109(1): 15–26.

Hampton, H.M.; Sesnie, S.E.; Dickson, B.G.; Rundall, J.M.; Sisk, T.D.; Snider, G.B.; Bailey, J.D. 2008. Analysis of small-diameter wood supply in northern Arizona. Forest Ecosystem Restoration Analysis Project. 210 p.

Han, H.S.; Lee, H.W.; Johnson, L.R. 2004. Economic feasibility of an integrated harvesting system for small-diameter trees in southwest Idaho. Forest Products Journal. 54(2): 21–27.

Hayes, S.W.; Morgan, T.A.; Berg, E.C.; Daniels, J.M.; Thompson, M.T. 2012. The Four Corners timber harvest and forest products industry, 2007. Resour. Bull. RMRS-RB-13. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 61 p.

Hjerpe, E.; Abrams, J.; Becker, D.R. 2009. Socioeconomic barriers and the role of biomass utilization in Southwestern ponderosa pine restoration. Ecological Restoration 27(2): 169–177.

Hjerpe, E.; Gunderson, R.J. 2007. Impact analysis of Arizona Forest Restoration Products' oriented strand board facility. Flagstaff, AZ: Northern Arizona University, W.A. Franke College of Business. 36 p.

Hjerpe, E.E.; Kim, Y.-S. 2008. Economic impacts of southwestern national forest fuels reductions. Journal of Forestry. 106(6): 311–316.

Hollenstein, K.; Graham, R.L.; Shepperd, W.D. 2001. Biomass flow in western forests: simulating the effects of fuel reduction and presettlement restoration treatments. Journal of Forestry. 99(10): 12–19.

Hurteau, M.D.; Koch, G.W.; Hungate, B.A. 2008. Carbon protection and fire risk reduction: toward a full accounting of forest carbon offsets. Frontiers in Ecology and the Environment. 6(9): 493–498.

Iversen, K.; Van Demark, R. 2006. Integrating fuel reduction management with local bioenergy operations and businesses—a community responsibility. Biomass and Bioenergy. 30(4): 304–307.

Keegan, C.E.; Chase, A.L.; Morgan, T.A.; Bodmer, S.E.; Van Hooser, D.D.; Mortimer, M. 2001. Arizona's forest products industry: a descriptive analysis, 1998. Missoula, MT: University of Montana, School of Business Administration, Bureau of Business and Economic Research. 20 p.

Ketels, C. 2009. Clusters, cluster policy, and Swedish competitiveness in the global economy. Expert report no. 30 to Sweden's Globalisation Council. 66 p.

Larson, D.; Mirth, R. 2001. Projected economic impacts of a 16-inch tree cutting cap for ponderosa pine forests within the greater Flagstaff urban-wildlands. In: Vance, R.K.; Edminster, C.B.; Covington, W.W.; Blake, J,A., comps. 2001. Ponderosa pine ecosystems restoration and conservation: steps toward stewardship. Proceedings RMRS-P-22. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 154–160.

Lowell, E.C.; Green, D.W. 2001. Lumber recovery from small-diameter ponderosa pine from Flagstaff, Arizona. In: Vance, R.K.; Edminster, C.B.; Covington, W.W.; Blake, J.A., comps. Ponderosa pine ecosystems restoration and conservation: steps toward stewardship. Proceedings RMRS-P-22. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 161–165.

McLain, W.H. 1988. Arizona's timber production and mill residue, 1984. Resour. Bull. INT-55. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 16 p.

Morgan, T.A.; Dillon, T.; Keegan, C.E.,III; Chase, A.L.; Thompson, M.T. 2006. The Four Corners timber harvest and forest products industry, 2002. Resour. Bull. RMRS-RB-7. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 64 p.

Neary, D.G.; Zieroth, E.J. 2007. Forest bioenergy system to reduce the hazard of wildfires: White Mountains, Arizona. Biomass and Bioenergy. 31(9): 638–645.

North, M.P.; Hurteau, M.D. 2011. High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest. Forest Ecology and Management. 261: 1115–1120.

Pan, F.; Han, H-S.; Johnson, L.R.; Elliot, W.J. 2008. Production and cost of harvesting, processing, and transporting small-diameter (≤ 5 inches) trees for energy. Forest Products Journal. 58(5): 47–53.

Porter, M.E. 1998. Clusters and the new economics of competition. Reprint 98069. Harvard Business Review: 77–90.

Porter, M.E. 2000. Location, competition, and economic development: local clusters in a global economy. Economic Development Quarterly. 14(1): 15–34.

Rojas, T.D. 2007. National forest economic clusters: a new model for assessing national-forest-based natural resources products and services. Gen. Tech. Rep. PNW-GTR-703. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 33 p.

Selig, M.; Vosick, D.; Seidenberg, J. 2010. Four forest restoration initiative landscape strategy—economics and utilization analysis—report from the Four Forest Restoration Initiative Stakeholder Group to the USFS 4FRI Planning Team. 28 p. http://www.4fri.org/pdfs/documents/CFLRP/econ_and_utilization_final_draft.pdf. (7 July 2011).

Sitko, S.; Hurteau, S. 2010. Evaluating the impacts of forest treatments: the first five years of the White Mountain Stewardship Project. Phoenix, AZ: The Nature Conservancy. http://azconservation.org/dl/TNCAZ_White_Mountain_Stewardship_Project_5years.pdf. (30 June 2011).

Snider, G.B.; Wood, D.B.; Daugherty, P.J. 2003. Analysis of costs and benefits of restoration-based hazardous fuel reduction treatments vs. no treatment. Progress report #1. Flagstaff, AZ: Northern Arizona University, Ecological Restoration Institute. 16 p. http://library.eri.nau.edu/gsdl/collect/erilibra/import/SniderEtal.2003.AnalysisOfCostsAndBenefits.pdf. (4 March 2014).

U.S. Department of Agriculture, Forest Service [USDA FS]. 2011. Forest Inventory and Analysis National Program. Data and tools. http://www.fia.fs.fed.us/tools-data/default.asp. (4 March 2014).

White Mountain Apache Tribe [WMAT]. 2011. Fort Apache Timber Company. http://www.wmat.us/fatco.html. (22 August 2011).

Wilent, S. 2010. Contract brings jobs, energy, and healthier forests—five year progress report on the White Mountain Stewardship Project. The Forestry Source. 15(12). http://www.forestsforall.com/wp-content/uploads/2010/11/Forestry-Source-December-2010_72.pdf. (30 June 2014).

Worth, N. 2013. Snowflake power plant to restart. http://www.azjournal.com/2013/08/02/snowflake-power-plant-to-restart/. (16 December 2013).

U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW 3rd Ave.
P.O. Box 3890
Portland, OR 97208–3890