Regional Economic Contributions of the Four Forest Restoration Initiative

by

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Executive Summary

A leading wildfire management strategy is restoring forests by thinning trees and conducting prescribed burns, especially in wildland urban interfaces (WUI), to allow fire to play its more natural role and to lessen wildfire severity. The Four Forest Restoration Initiative (4FRI) in Arizona is an example of a large USFS forest restoration approach in its early stages. Nationally, 4FRI is part of the Collaborative Forest Landscape Regional Program (CFLRP) and is the largest collaborative restoration project in USFS history. With such a large landscape approach, 4FRI has the potential to positively affect rural economies by facilitating employment and income generation with logging, wood utilization, and other restoration activities. To understand the extent of regional employment, income, and output, and to establish a monitoring baseline, we conducted a regional economic contribution analysis of 4FRI activities for Fiscal Year 2017.

The regional economic contribution zone was confined to five northern Arizona counties: Apache, Coconino, Gila, Greenlee, and Navajo. To determine regional economic contributions of 4FRI-related activities, we collected data on expenditures and employment in Fiscal Year 2017 (October 2016—September 2017) in three areas: thinning and wood utilization, other restoration activities such as watershed restoration and road decommissioning, and regional USFS activities that include National Environmental Policy Act (NEPA) planning, site preparation, and prescribed fire. A survey of all primary thinning contractors was conducted, and contract and employment data were collected from the USFS for other restoration activities.

We found that logging and wood utilization associated with 4FRI spur numerous good-paying jobs in the region. With over 12,000 acres mechanically thinned, operators removed about 400,000 green tons of sawlogs and biomass for processing. Combined with the important year-round USFS jobs and the other restoration contractors, the 4FRI has a large economic footprint to accompany its ecological footprint. Table ES1 illustrates the direct full-time equivalent (FTE) employment in the region associated with 4FRI activities:

Table ES1: Direct Regional Employment from 4FRI Activities (FY 2017)

4FRI Restoration Activity	FTE Annual Employment
Thinning and Wood Utilization	222
Other Contracted Restoration	30
USFS In-House Restoration	258
Total	**510**

In total, including multiplier effects, we found that FY 2017 4FRI activities generated:

- almost 1,000 full and part-time jobs and more than 900 FTE jobs in the region;
- approximately $150 million in regional output;
- $50 million in regional labor income; and
- impacted over 140 different industry sectors in the region.

Increasing overall restoration accomplishments and increasing regional wood utilization infrastructure are two methods for generating greater regional economic contributions. Despite the impressive regional economic contributions, restoration accomplishments have seen limited growth since the inception of the 4FRI and remain well below original project objectives and forecasts. With both the social license and agency support generally in place, the main barrier to ramping up 4FRI mechanical thinning accomplishments is the lack of profitability in thinning and processing small diameter ponderosa pine.

In order to achieve the ambitious goals of 4FRI, all stakeholders and the USFS must acknowledge the need for supplemental funding for southwestern forest restoration. Ponderosa pine forest restoration provides numerous ecosystem services and benefits to the state, counties, municipalities and to the public, and is vastly different than the traditional economic model of timber production. Because of this, a collaborative restoration effort requires an innovative collaborative funding effort, where the beneficiaries of the services help fund the restoration efforts and work with the USFS to collaboratively develop a productive local wood products industry.

Credit: Anne Mottek-Lucas

1. Introduction

Large-scale forest restoration in ponderosa pine forests in the Southwest is being conducted to help communities and landscapes adapt to more natural wildfire regimes. Mechanical thinning, prescribed fire, and watershed restoration are the primary techniques being used to help restore ponderosa pine forests (Covington et al. 1997), though comprehensive ecological restoration includes many other on-the-ground labor activities including hand thinning, culvert placements, road decommissioning, re-introducing native plants, and removing exotics (Ellison et al. 2010). With millions of acres potentially in need of restoration, thinning and restoration activities require large investments in workforce and wood utilization to realize major accomplishments. Restoration activities have tremendous effects on community socio-economics by generating regional employment, income, and other economic impacts, often in places that have experienced widespread reductions in logging and milling infrastructure over the last three decades (Hibbard and Karle 2002). Restoration also yields community benefits in terms of reducing catastrophic wildfire risk, protecting local water supplies, and enhancing a broad set of ecosystem services (Dubay et al. 2013).

Despite the importance of forest restoration for rural economies, there is little monitoring of detailed economic impacts experienced by at-risk forested communities (Daniels et al. 2018). To provide for greater socio-economic monitoring of forest restoration, we investigated the economic contributions from a large-scale restoration program in northern Arizona, the Four Forest Restoration Initiative. The Four Forest Restoration Initiative, or 4FRI for short, is the largest forest restoration effort in the U.S. The vision of 4FRI is articulated in the 4FRI Charter:[1] "…restored forest ecosystems that support natural fire regimes, functioning populations of native plants and animals, forests that pose little threat of destructive wildfire to thriving forest communities and support sustainable forest industries that strengthen local economies while conserving natural resources and aesthetic values."

In this report we present background information on forest restoration economics and details of the U.S. Forest Service's (USFS) Collaborative Forest Landscape Restoration Program (CFLRP). We describe our survey-based data collection efforts and how we traced restoration economic contributions throughout the regional economy of five northern Arizona counties. Finally, we present the results of the 4FRI contribution analysis, or measures of employment and income related to 4FRI restoration and discuss the findings.

1.2. Background

At the beginning of the 21st century, the USFS began to transition to ecosystem management, forest restoration, and wildfire fuels reduction after decades of sustained-yield timber production and fire suppression (e.g., Shultz et al. 2012, Davis et al. 2018). The evolution of public forest management towards forest stewardship and restoration has changed the type of economic values and impacts that come from the forest; these range from commodity timber production to numerous

non-market economic services that invoke both direct use and passive use values (Robbins and Daniels 2012). Despite the change in commodity focus, ecological restoration has become a significant industry generating $10 billion annually in U.S. output and 126,000 jobs (BenDor et al. 2015). Case studies in the Northwest have shown that forest and watershed restoration support approximately 16 jobs per million dollars of investment (Nielsen-Pincus and Moseley 2013).

Stewardship contracting, where goods such as woody biomass are offered for services such as restoration thinning, is playing a greater role in public lands forest restoration. As opposed to traditional timber sales, stewardship contracts allow for a greater retention of receipts locally, where the sale of woody byproducts are used for other local restoration projects instead of being retained by the U.S. treasury. Stewardship contracts are increasingly being incorporated as funding mechanisms for other restoration activities that may not produce salable products such as watershed restoration, road decommissioning, and the eradication of invasive species. Previous research has been conducted on the economic impacts of forest stewardship contracts involving holistic restoration approaches. Kerkvliet (2010) estimated the regional economic impacts of the Clearwater Stewardship Project in Montana and found an increase of $23 million in regional expenditures on restoration activities. More specifically, 85 percent of the project's economic impact resulted from the harvesting and processing of wood, but Kerkvliet noted that the incorporation of other restoration activities resulted in spreading imp-

Credit: Anne Mottek-Lucas

acts across a greater number of regional sectors due to the inclusion of watershed restoration activities, monitoring, and administration. Daniels et al. (2018) examined the regional economic contribution of two stewardship projects in Oregon that included forest and watershed restoration activities, combined with traditional timber commercial and pre-commercial thinning activities. They also found impacts spread across a greater number of regional industries as compared to traditional timber sale contracts with output and employment multipliers of 1.42 and 1.82 respectively. Economic multipliers are a measure of how many more indirect and induced jobs are locally generated from one restoration job, or how much output or income is indirectly generated from one dollar of output.

In Arizona, piecemeal forest restoration stewardship contracts have been ongoing since the early 2000s and, beginning in 2004, the White Mountain Stewardship Project in eastern Arizona has been the largest and longest stewardship contract to date. These earlier stewardship contracts, including the Ft. Valley pilot stewardship contract near Flagstaff, helped lay the groundwork for 4FRI. Hjerpe and Kim (2008) investigated the regional economic impact of forest restoration and fuels reduction in the Southwest (four Arizona and one New Mexico national forests) using stewardship contracting and found that some $40 million of output (total sales) and 500 regional jobs were generated across five national forests. Mottek-Lucas et al. (2017) reported on the socioeconomic contributions of the White Mountain Stewardship Project (WMSP) in Arizona for the ten-year duration of the contract. In terms of regional economics, the most important management implications focused on the need for wood business clusters and a vertically-integrated small diameter wood industry. Keys to the success of the WMSP were having both high-capacity sawmills and large utilizers of mill residues and thinning slash such as power and pellet plants (Mottek-Lucas et al. 2017).

Building on the success of previous stewardship contracts, the CFLRP was congressionally established in 2009 to provide long term funding for science-based ecosystem restoration programs jointly proposed by the USFS and local collaborators. The CFLRP was a competitive program, requiring review boards to allocate funds to the highest priority restoration landscapes and the proposals that illustrated the greatest amount of collaboration and social acceptability. There are currently 23 CFLRP projects across the country, all of which are in fire-adapted landscapes (Schultz et al. 2017). While the intent of the CFLRP is to broadly encourage ecological, economic, and social sustainability, three of the five national indicators of success for the program revolve around economic impacts, fire costs, and leveraged funds (Bixler and Kitler 2015). The economics of forest restoration play a central role in determining the value and the future of the CFLRP.

An innovative component of the CFLRP is its requirements for project-level multi-party monitoring, a component too often neglected in forest management projects (Shultz et al. 2014). Socio-economic monitoring may afford valuable insights on how to boost community impacts. In a recent investigation of the value of the CFLRP, Shultz et al. (2017) interviewed numerous USFS restoration managers and external restoration stakeholders to

understand their perspectives of the program. Overall, they found that managers and stakeholders perceive the greatest value in the CFRLP coming from the long-term funding commitment, allowing for greater leveraging in resources and funds and greater legitimacy in restoration collaborations and businesses. However, Shultz et al. (2017) found that while the program helps support existing wood industries, it has not been successful in catalyzing new wood markets and facilities nor has it significantly reduced treatment costs via the utilization of restoration byproducts.

The 4FRI is the most ambitious of the all the CFLRP projects, being conducted within a 2.4 million-acre ecosystem. It is also perhaps the most ambitious of all projects in terms of restoration costs and wood utilization potential. Large-scale ponderosa pine restoration in northern Arizona has the science-based backing and through past projects like the WMSP, has also gained the social license to move forward. But the economics of southwestern forest restoration, on the other hand, remain the primary obstacle to success (Hjerpe et al. 2009). Funded in 2010, the 4FRI was a result of years of collaborative processes from local forest restoration-based groups such as the Greater Flagstaff Forests Partnership (GFFP), the Natural Resources Working Group and the WMSP's multi-party monitoring board.

To monitor social and economic effects of the 4FRI, stakeholder group members developed an initial report, "Socioeconomic Monitoring for the Four Forest Restoration Initiative" (Mottek-Lucas 2012). The report was adapted and included as Appendix E in the 1st 4FRI Environmental Impact Statement (2013).[2] This plan included an economic monitoring framework with an extensive list of potential economic monitoring questions and associated metrics. Several monitoring questions presented in the framework were addressed in this study. Other economic-related studies and reports that have been conducted on behalf of 4FRI include "Economics and Utilization Analysis" (Selig et al. 2010) and "Workforce Needs of the Four Forest Restoration Initiative Project: An Analysis" (Combrink et al. 2012).

Planning documents produced by the USFS have examined the potential economic impacts and affected social environments related to 4FRI projects and can be used to inform and compare to our analysis (e.g., Jaworski 2014). Additionally, the USFS has conducted recent economic analyses for their annual CFLRP monitoring report,[3] using economic contribution analysis modeling software - Treatments for Restoration Economic Analysis Tool (TREAT). Our regional economic contribution analysis of FY 2017 4FRI activities helps fulfill mandatory monitoring, providing the first primary data collection effort from 4FRI forest restoration contractors and a detailed economic baseline and template for successive economic monitoring.

2. 4FRI Methods

Multiple methods were incorporated for our study of 4FRI economic contributions. We conducted a literature review and synthesis of existing information on 4FRI economics from the USFS and stakeholders. We collected primary economic data from regional operators and the USFS in order to analyze contributions of 4FRI-related projects. Primary data

were uploaded into IMpact analysis for PLANning (IMPLAN) economic modeling software. We conducted regional economic contribution analysis of contractor activities including: logging, road building, trucking, milling, and biomass utilization. In addition to mechanical thinning and wood utilization, other restoration activities conducted by the USFS and by private businesses such as prescribed fire, watershed restoration, and environmental planning were tracked and included in the overall analysis. Results were compared to contributions in the USFS's TREAT model and implications are discussed.

2.1 Study Site

Restoration activities associated with 4FRI are being conducted on four Arizona national forests: the Apache-Sitgreaves, the Coconino, the Kaibab, and the Tonto. These national forests stretch from central Arizona near the towns of Williams and Flagstaff across to eastern Arizona and the White Mountain towns of Snowflake, Heber-Overgaard, and Nutrioso (see Figure 1). Restoration efforts take place primarily in five Arizona counties: Apache, Coconino, Gila, Greenlee, and Navajo. These five counties contain the fire-adapted communities most impacted by ponderosa pine restoration. Because most of the restoration workforce for 4FRI are located in these counties, we use them as our IMPLAN regional economic impact zone for the contribution analysis.

One project not directly administered or funded as part of the 4FRI was included. The Flagstaff Watershed Protection Project (FWPP) is a partnership

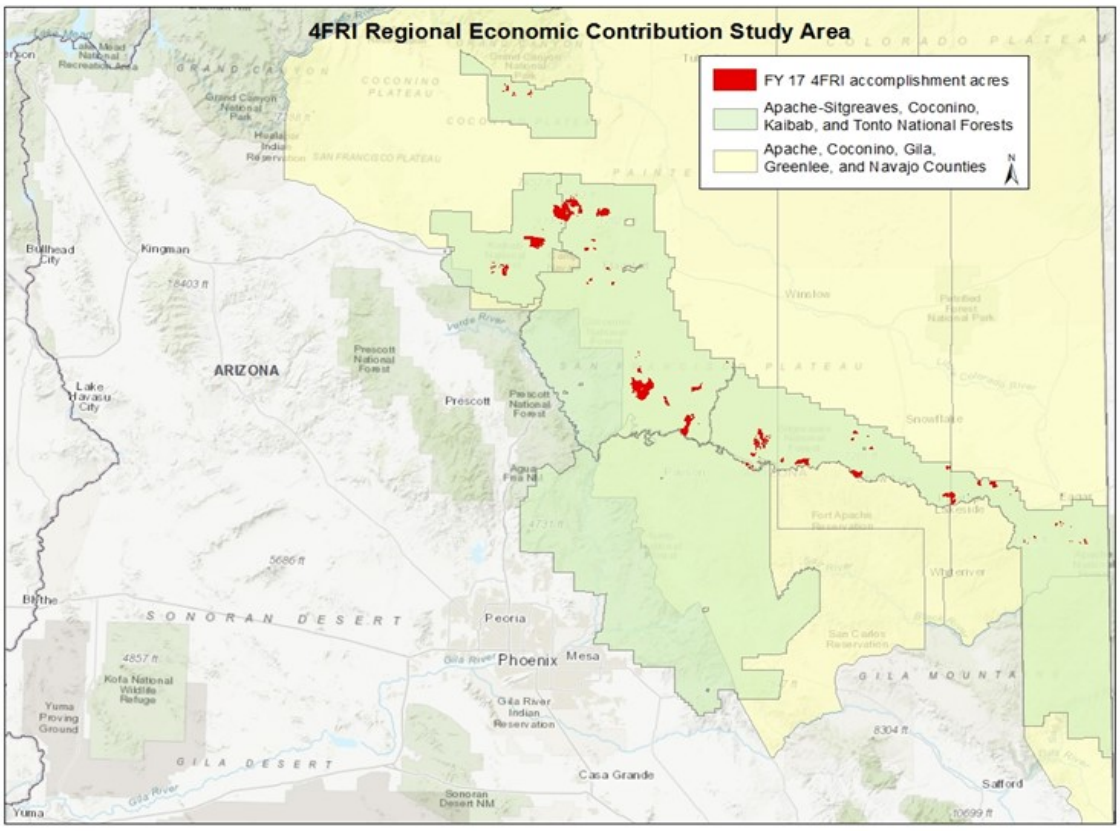


Figure 1: Regional Economic Contribution Zone

Figure 2: Cycle of Regional Final Expenditure Components for 4FRI Restoration

effort between the Arizona Department of Forestry & Fire Management, the City of Flagstaff, and the Coconino National Forest. In 2012, Flagstaff city voters approved a $10 million bond to restore forests on city, state, and national forest lands to reduce risk of severe wildfire and post-fire flooding and to preserve the water supply in two critical watersheds that the City of Flagstaff relies on.[4]

Though not all of the acres being treated for the FWPP are on national forest land, the connections to 4FRI and ponderosa pine restoration efforts in northern Arizona indicate that we should include FY 2017 FWPP thinning and wood utilization economic impacts in our overall contribution analysis.

2.2 Data Collection

To determine regional economic contributions of 4FRI -related activities, we collected data on expenditures and employment in Fiscal Year 2017 (October 2016—September 2017) in three areas: thinning and wood utilization, other restoration activities such as watershed restoration and road decommissioning, and regional USFS activities that include National Environmental Policy Act (NEPA) planning, site preparation, and prescribed fire (Figure 2). Due to differing contracting mechanisms and whether restoration activities were conducted in-house by the USFS, each set of regional contributions required separate data collection methods that are detailed below.

2.2.1 Thinning and Wood Utilization

Logging and milling companies bid on thinning contracts offered by the USFS. Stewardship contracts are awarded to businesses that achieve the highest rankings in several categories including cost, experience, and past performance. However, timber sales are awarded based on price and cost only. Because forestry businesses provide both a thinning

service and a subsequent wood utilization component, their regional economic activity impact multiple sectors of the economy and more industries as compared to other economic activities. Beyond harvesting and wood utilization sectors, forest restoration businesses also positively stimulate economic activity in temporary road construction/ decommissioning, culvert placements, and transportation of wood products.

Regional thinning operators were surveyed to understand their economic impacts. We developed, pre-tested, and implemented a survey of primary USFS thinning contractors for 4FRI activities in FY 2017. Contractors were identified from meetings with USFS managers and from publicly-available 4FRI Collaborative USFS monthly updates. In total, nine FY 2017 primary thinning contractors were identified.

Operators were contacted both by telephone and email and were asked to participate in our economic impact survey. When applicable, Dillman survey methods were employed including multiple follow-up requests for participation and assisting with survey completion. The survey was conducted over the fall and winter months of 2017 and 2018.

Survey questions centered on acres thinned, employment, and wood utilization. All survey questions were focused on outcomes from actual acres thinned in FY 2017. Primary contractors were asked to estimate 4FRI-related employment and wood utilization for their businesses and for any of their subcontractors who conducted thinning work and subsequent wood utilization. For all employment questions, contractors were asked to estimate the number of jobs that were conducted within the

Credit: Anne Mottek-Lucas

the regional economic impact zone and the percentage of employees that live within the region. Contractors were asked to estimate full-time equivalent (FTE) employment for the following activities:

- logging and in-woods chipping;
- road construction/decommissioning and culvert repair;
- technical assistance;
- administration and management of contracts;
- trucking of logs and biomass; and
- off-site wood milling and processing.

Survey data was ground-truthed to the greatest extent possible using known sources of logging and utilization jobs in northern Arizona. In some cases, contractors were called and asked to correct initial estimates that appeared to be outliers based on information from key informants who were familiar with the range of data. In these cases, survey participants misinterpreted the survey questions being asked. Table 1 illustrates the FTE employment for mechanical thinning and wood utilization from 4FRI.

2.2.2 Other Restoration Activities

Forest restoration involves a comprehensive landscape approach, centered on thinning trees, but is inclusive of watersheds, understory, archeology, and biodiversity. For the 4FRI, there are number of "other" restoration activities conducted, aside from the mechanical thinning of trees. These other restoration activities include stream channelization, invasive weed abatement, wetlands connectivity, road decommissioning, and hand thinning.

To estimate the regional contributions of non-thinning restoration activities, we acquired a list of all other restoration activities contracted out by the USFS for FY 2017 4FRI projects and identified expenditure amounts and business names. To isolate restoration contractors that are regionally based businesses, we conducted a web search of all business names to determine contractor addresses

Table 1: Regional 4FRI Mechanical Thinning and Wood Utilization Employment for FY 2017

IMPLAN Sector #	Description	FTE Annual Jobs
16	Commercial logging	57.7
19	Support activities for agriculture and forestry	13.6
47	Electric power generation - Biomass	25
64	Maintenance and repair construction of highways, streets, bridges, and tunnels	5.2
134	Sawmills	87.2
145	All other miscellaneous wood product manufacturing	8
411	Truck transportation	25.4
Total		**222.1**

and whether they had regional offices located within the five-county regional economic impact zone. Because northern Arizona is rural, it is impossible for the USFS to fill all restoration contract needs with local operators. However, because numerous "other" restoration contractors were determined to be local, it appeared that the USFS was trying to spur regional economic contributions when possible. All of the "other" restoration expenditures come from FY 2017 executed contracts.

Restoration contract expenditures were restricted to regional operators and were tallied among three broad categories:

- Equipment-intensive—includes excavation, construction, concrete and materials, and road building and decommissioning;
- Labor-intensive—includes hand thinning, invasive plant removal, and trail work;
- Technical—includes forestry consulting, archeology services, biological assessments, NEPA work, and research.

The other restoration expenditures were then bridged to the appropriate regional economic sector defined in IMPLAN. Table 2 shows the final list of regional expenditures by the USFS for other restoration work by IMPLAN sector. These expenditures were part of the final demand change, along with mechanical thinning, wood utilization, and USFS restoration jobs, used to initiate the contribution analysis. Expenditures were converted to FTE employment and IMPLAN full- and part-time jobs estimates in each category as detailed in the contribution analysis methods (see Table 3).

Credit: Andy Cuevas

2.2.3 USFS Prep and Prescribed Fire (Rx Fire)

The USFS is tasked with providing for restoration opportunities with regional businesses and with planning the activities. Additionally, the USFS, in concert with community and other agency fire departments, conducts prescribed burns as part of the re-introduction of surface fire to forests and to protect communities. Prescribed burns are a critical part of a holistic restoration approach for Southwest ponderosa pine by improving nutrient cycling, establishing native grasses and forbs, and reducing fuels and the risk of severe fire to communities.

Table 2: Regional 4FRI "Other" Restoration Contract Expenditures for FY 2017

IMPLAN Sector #	Description	Contracting Expenditures
16	Logging	$ 396,608
19	Support activities for agriculture and forestry	$ 136,032
56	Construction of new highways and streets	$ 825,459
64	Maintenance and repair construction of highways, streets, bridges, and tunnels	$ 150,163
455	Environmental and other technical consulting services	$ 634,887
456	Scientific research and development services	$ 31,872
469	Landscape and horticultural services	$ 256,872
531	Other state and local government enterprises	$ 12,012
Total		$ 2,443,903

Planning under the NEPA requires the USFS to undertake comprehensive biological and archeologic assessments on proposed treatment landscapes, assess multiple treatment alternatives and current socioeconomic conditions, and predict effects on communities and resources under various alternatives, all while incorporating public input.

To estimate the amount of regional, annual employment generated by the USFS for 4FRI activities conducted "in-house" (i.e., not contracted out), USFS managers provided a list of FTE jobs associated with 4FRI restoration work for the fiscal year of 2017. While numerous USFS staff work on 4FRI planning in both the Regional Office (Albuquerque, NM) and the national office (Washington D.C.), we limited USFS annual 4FRI employment to staff working in offices adjacent to the four national forests. Particularly in rural communities, such as those near the 4FRI landscape, year-round USFS jobs play an important role in regional economies.

In total, approximately 258 FTE USFS jobs focused on 4FRI planning and implementation were sustained in the regional economic contribution zone in FY 2017 (see Table 3). These jobs represent a diverse suite of restoration activities ranging from NEPA planning, to timber management, to conducting prescribed burns. However, for the regional economic contribution analysis they were entered under one IMPLAN sector (#535): employment and payroll of federal government, non-military.

2.3 Regional Economic Contribution Analysis

Forest restoration efforts on public lands in northern Arizona require initial expenditures from outside the region. The CFLRP funds and other USFS funds used for restoration trigger output and employment in several regional industry sectors including forestry, logging, and sawmills. The regional restoration expenditures spur initial, or direct effects, in the industry sectors such as contract sales for services.

Credit: Anne Mottek-Lucas

These direct effects, in turn, generate indirect effects on other industries that provide the supplies and basic services required for the final products and services. For example, logging companies performing restoration thinning purchase heavy equipment such as forwarders and feller-bunchers, fuel to run equipment, and electronic tablets for matching restoration prescriptions in the field. Finally, induced effects are spurred when logging sides spend their paychecks locally on goods and services like lunches and entertainment. The combination of direct, indirect, and induced effects creates the total effect that initial 4FRI restoration expenditures have on the regional economy.

Regional economic contribution analysis (ECA) is a method of tracking the backward linkages of indirect and induced effects spurred by restoration expenditures throughout a regional economy. Regional ECA is similar to economic impact analysis (EIA) in tracing initial changes in final demand throughout the regional economy but is more appropriate for activities that are re-occurring every year as opposed to the gain (or loss) of a new economic activity (Watson et al. 2007). A good delineation for determining whether economic impacts or contributions are the appropriate measure for a particular set of activities is the timing of the project. With projecting ex ante economic activities, generally employing economic impact analysis is best. On the other hand, in tracking ex post economic activities, economic contribution analysis is generally considered to be the preferred method (Watson et al. 2015).

Regional ECA is conducted within an Input-Output (I-O) model, where the production of all industries is presented in a matrix and all industries are both buyers and sellers of goods and services. The I-O model is predicated on the Leontief Inverse, or an equation allowing for the balancing of the social accounting matrix when inputs are applied to a

particular sector (Isard et al. 1998). IMPLAN originated as a Forest Service model and is well suited for regional analyses (Crihfield and Campbell 1991). However, a few of IMPLAN's limitations are important to acknowledge. First, IMPLAN and input-output models are just a partial view of overall economic values, focused on market impacts while neglecting societal costs and benefits. IMPLAN is a static I-O model, as opposed to some of the more expensive dynamic computable general equilibrium (CGE) models. Due to assumptions of fixed technology and no supply constraints, industry relationships tend to be more linear in the software and results generated in IMPLAN represent a snapshot in time.

Contribution analysis is conducted by entering initial changes in final demand transacted within the regional economy. In IMPLAN, changes in final demand can be entered as sales expenditures or as employment. IMPLAN regional economic data provides output, employment, labor income, and value-added equivalents by individual industry sectors based on the initial final demand changes entered. We use employment to initiate the contribution analysis. Because we had to conduct data collection in three different areas (see Figure 2), the primary data obtained were in different units ranging from job estimates to contract expenditures. To streamline the inputs for the contribution analysis, we converted all 4FRI contributions to employment estimates. "Other" restoration activity expenditures were converted to IMPLAN full and part-time jobs by dividing total contract expenditures in each sector by the average output per job for each sector presented in the IMPLAN study area data (i.e., the five-county regional economic impact zone). Survey data on thinning and wood utilization, along with USFS prep and prescribed fire, were collected as full-time equivalent (FTE) employment. Thus, we also converted these FTE data into IMPLAN full- and part-time jobs by applying IMPLAN conversion ratios specific to each industrial sector.[5]

Table 3: Final Demand Change for Regional 4FRI Activities in FY 2017

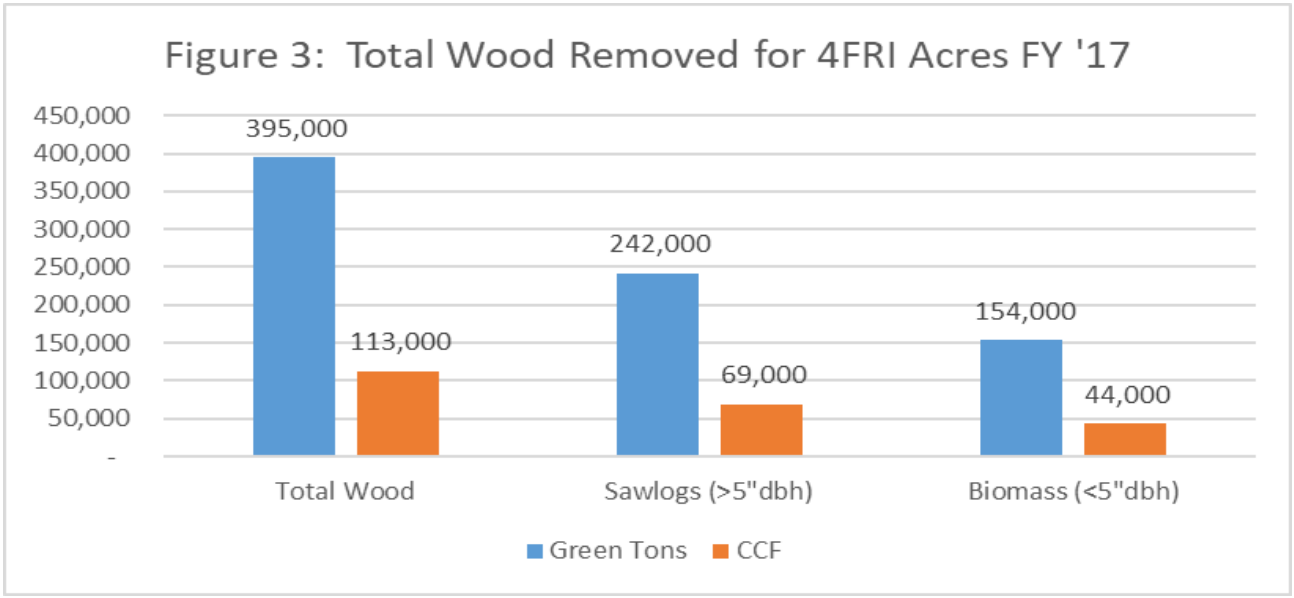
IMPLAN Sector #	Description	IMPLAN Full and Part-time Jobs	FTE Jobs
16	Logging	71.3	61.7
19	Support activities for agriculture and forestry	20.6	17.7
47	Electric power generation - Biomass	25.4	25.0
56	Construction of new highways and streets	5.4	5.2
64	Maintenance and repair construction of highways, streets, bridges...	6.5	6.2
134	Sawmills	90.0	87.2
145	All other miscellaneous wood product manufacturing	8.3	8.0
411	Truck transportation	26.8	25.4
455	Environmental and other technical consulting services	10.4	9.8
456	Scientific research and development services	0.1	0.1
469	Landscape and horticultural services	5.8	5.4
531	Other state and local government enterprises	0.2	0.1
535	Employment and payroll of federal govt, non-military	265.2	258.0
Total		**536.0**	**510.0**

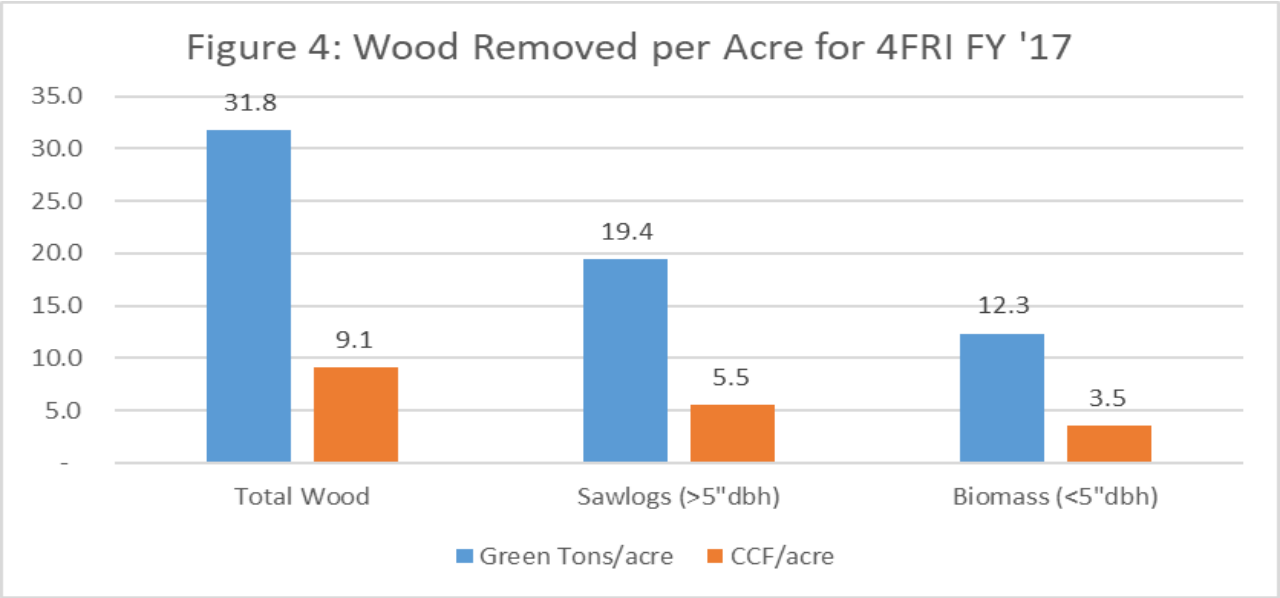
To estimate a regional ECA for 4FRI activities, total employment from the three regional final demand components were entered into IMPLAN's impact analysis under the appropriate industry sector. Table 3 illustrates final demand change by sector.

Including economic output generated from subsequent wood utilization from forest restoration projects should be done with caution. In some situations, such as restoration projects in areas with plenty of traditional timber production, subsequent milling and wood processing employment and output may be incorrectly attributed to the forest restoration project being analyzed and would result in over counting of economic inputs (see Daniels et al. 2018 for discussion). In the case of 4FRI economic contributions, subsequent regional wood utilization should be included in economic contributions as these sawmills, biomass plants, and other regional processors are almost entirely dependent upon USFS restoration wood supply. That is, without 4FRI projects, most regional wood processors would not exist, making 4FRI wood utilization an integral component of total regional economic contributions.

3. Results

Restoration activities associated with 4FRI are dispersed across four Arizona national forests and five Arizona counties. With the dramatic decrease in logging and timber production in the 1990s, Arizona wood products industries experienced sharp declines in economic importance that was particularly pronounced in rural forested communities. While the quality of timber and associated wood products has changed, landscape forest restoration efforts in Arizona associated with the 4FRI are helping to maintain and re-develop wood products industries. Likewise, the 4FRI is also catalyzing new, non-timber restoration industries that are facilitating the comprehensive restoration of ponderosa pine forests and reducing catastrophic wildfire risk.





3.1 Wood Utilization

In Fiscal Year 2017, approximately 12,450 acres of ponderosa pine were mechanically thinned across northern Arizona.[6] Survey results indicate that operators removed almost 400,000 green tons, or 115,000 ccf, of sawlogs and biomass from these treated acres.

Figures 3 and 4 illustrate wood removal and utilization rates as documented from our survey of primary 4FRI contractors. On a per acre basis, approximately 32 green tons were removed, or a little more than nine ccf per acre. About 20 tons were in the form of sawlogs and about 12 tons were biomass.

Wood utilization from 4FRI projects helps to generate jobs and income within the region. Typical mechanical thinning projects start with thinning and sorting of sawlogs and slash. Most operators grind and chip slash at the restoration site and then transport material to mills. Trucking of material is a large cost for wood utilizers, particularly when dealing with low-quality wood and when traveling long distances to mills. Finding market outlets for small diameter ponderosa pine can be difficult. On the East side of 4FRI (White Mountains region), wood processing from restoration projects is largely conducted within the White Mountains due to the existence of a small, but vertically-integrated and clustered wood products industry. The West side of 4FRI activities (greater Flagstaff region) has much less milling and wood products infrastructure, which in turn limits marketing and utilization options. Many of the sawlogs from 4FRI West side leave the region with limited or no processing. Figure 5 illustrates the primary wood products coming from 4FRI thinning, showing both regional and out-of-region pathways for restoration woody byproducts.

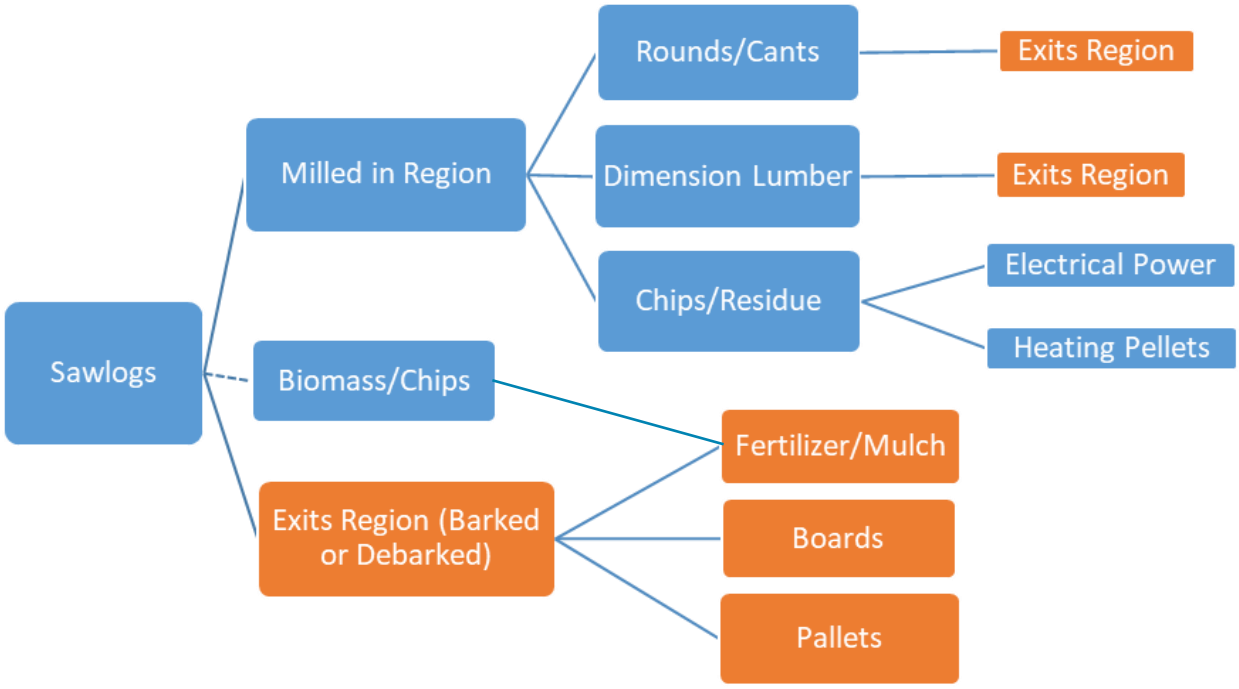


Figure 5: Typical Flow of 4FRI Wood Utilization (Blue Boxes Indicate Regional Economic Contributions)

In FY 2017, thinning for 4FRI led to the regional production of 18 million board feet (mmbf) of rounds or cants and 10 mmbf of dimension lumber. Biomass from 4FRI projects collectively provided over 100,000 tons of chips and residue for electricity generation, approximately 18,000 tons of material for heating pellets, and some 20,000 tons for conversion into fertilizer and landscaping mulch.[7]

3.2 Regional Economic Contributions

Including indirect and induced effects, 4FRI activities provided for almost 1,000 full and part-time jobs in FY 2017. For every job generated, another .8 jobs were supported, with a regional employment multiplier of 1.79. About $100 million of direct regional output was spurred by all 4FRI activities in FY 2017. This regional output in turn generated another $46 million in output when including total effects for a regional output multiplier of 1.46. In total, 4FRI activities contributed $50 million in annual, regional labor income. Table 4 illustrates total effects and multiplier effects for employment, labor income, total value added, and output.

In terms of regional employment, the federal USFS land managers that plan and implement restoration activities account for over 250 FTE annual jobs to prepare the largest forest landscape restoration program in the U.S. (see Table 5). In terms on non-federal job creation, 4FRI activities are most impactful on the logging and wood utilization sectors. When

Table 4: Total 4FRI Regional Economic Contributions for FY 2017 ($2017)

ImpactType	Employment*	Labor Income	Total Value Added**	Output
Direct Effect	536	$ 35,886,339	$ 55,791,608	$ 98,460,186
Indirect Effect	238	$ 8,130,931	$ 11,056,039	$ 22,794,086
Induced Effect	184	$ 6,356,022	$ 12,473,210	$ 22,839,887
Total Effect	**958**	**$ 50,373,292**	**$ 79,320,857**	**$ 144,094,159**
Multiplier Effect	**1.79**	**1.40**	**1.42**	**1.46**

Source: IMPLAN3, Northern Arizona Region 2016, Type SAM Multipliers
*Includes full and part-time jobs.
**Value added is the difference between an industry's total output and its intermediate inputs. It includes employee compensation, taxes, and surplus.

including indirect and induced effects, commercial logging generates over 150 full- and part-time jobs and sawmills spur almost 100 full- and part-time jobs. Support activities for 4FRI forest restoration, trucking of woody byproducts, and the biomass power plant contribute another 100 full- and part-time jobs to the regional economy. Employment from 4FRI activities are dispersed across northern Arizona and impact 143 different industrial sectors.

In terms of total regional output, federal 4FRI staff lead the way with $31.5 million, but electric power generation is almost as impactful with some $30 million of output contributed. Additionally, sawmills contribute almost $22 million of regional output while logging contributes over $13 million. Table 6 presents regional output of the ten industry sectors most affected by 4FRI activities.

Table 5: Top Ten Regional Employment for 4FRI FY 2017 ($2017)

Description	Total Employment*	Total Labor Income	Total Value Added	Total Output
Employment and payroll of federal govt....	265.2	$ 24,321,200	$ 31,501,009	$ 31,501,007
Commercial logging	156.2	$ 6,825,055	$ 7,340,017	$ 13,547,127
Sawmills	92.1	$ 2,483,640	$ 2,684,270	$ 21,812,472
Support activities for agriculture and forestry	38.9	$ 571,022	$ 634,655	$ 1,112,463
Truck transportation	31.7	$ 2,207,149	$ 2,758,931	$ 5,660,667
Electric power generation - Biomass	25.4	$ 2,611,361	$ 14,208,380	$ 30,201,791
All other crop farming	22.6	$ 8,564	$ 16,200	$ 44,302
Full-service restaurants	18.3	$ 462,714	$ 514,828	$ 947,564
Wholesale trade	15.7	$ 538,430	$ 1,276,722	$ 2,546,097
Limited-service restaurants	14.6	$ 299,683	$ 693,013	$ 1,224,368

Source: IMPLAN3, Northern Arizona Region 2016, Type SAM Multipliers, Total Effects include Indirect and Induced
*Includes full and part-time jobs.

Table 6: Top Ten Regional Output for 4FRI FY 2017 ($2017)

Description	Total Employment*	Total Labor Income	Total Value Added	Total Output
Employment and payroll of federal govt...	265.2	$ 24,321,200	$ 31,501,009	$ 31,501,007
Electric power generation - Biomass	25.4	$ 2,611,361	$ 14,208,380	$ 30,201,791
Sawmills	92.1	$ 2,483,640	$ 2,684,270	$ 21,812,472
Commercial logging	156.2	$ 6,825,055	$ 7,340,017	$ 13,547,127
Truck transportation	31.7	$ 2,207,149	$ 2,758,931	$ 5,660,667
Owner-occupied dwellings	0.0	$ -	$ 2,681,233	$ 4,132,484
Wholesale trade	15.7	$ 538,430	$ 1,276,722	$ 2,546,097
Hospitals	14.3	$ 1,160,452	$ 1,340,404	$ 2,294,832
Real estate	14.1	$ 249,916	$ 1,281,357	$ 2,103,826
Other local government enterprises	6.0	$ 427,288	$ 778,111	$ 1,887,298

Source: IMPLAN3, Northern Arizona Region 2016, Type SAM Multipliers, Total Effects include Indirect and Induced
*Includes full and part-time jobs.

4. Discussion

This is the first recording of regional economic contributions of 4FRI activities using primary data collected from logging contractors and wood processors. Previous estimates of regional economic contributions of 4FRI have been presented in required annual CFLRP reports (FY 2012-2017).[8] Annual estimates of regional CFLRP contributions are prepared by local USFS staff and then analyzed by USFS economists using TREAT modeling software. TREAT incorporates pre-packaged regional input-output tables from IMPLAN but includes modifications germane to logging and wood production industries that allow for greater accuracy when compared to just using IMPLAN coefficients and multipliers. Specifically, the latest version of TREAT utilizes restoration employment coefficients as detailed from a national survey conducted by the University of Oregon's Ecosystem Workforce Program (Nielson-Pincus and Moseley 2013). The TREAT model also now incorporates employment and income direct response coefficients for logging and wood utilization based on regional surveys of forest and mill operators (Sorenson et al. 2015). These two recent modifications to the TREAT model allow for greater modelling precision, as compared to original TREAT versions.

The FY 2017 CFLRP annual report for 4FRI has TREAT estimates of regional economic contributions. The overall project estimates include activity funded directly from CFLRP budget line items and matching funds. The FY 2017 4FRI annual report includes 13,108 acres of mechanical harvest. When including other hand thinning acres, 327 full and part time jobs were reported for the timber harvesting component and 185 full and part time jobs for the mill processing component. "Other" forest and watershed restoration were reported to contribute about 50 full- and part-time annual jobs, while another 331 full- and

part-time jobs were contributed for implementation and monitoring of 4FRI activities by USFS staff. In total, the almost 900 full- and part-time jobs were estimated in TREAT to provide for over 1,700 jobs and over $52 million in labor income when including indirect and induced effects.

When utilizing primary employment data collected from 4FRI wood contractors, our results are a bit more conservative than the 4FRI annual report estimates analyzed in the TREAT model. The differences are accounted for in the different methods used in our contribution analysis. Surveying local operators, as done in this study, provides higher resolution data on wood harvested and employment associated with 4FRI thinning. The TREAT model utilizes estimates of wood harvests based on cut and sold agency reports, as opposed to tracking actual harvest amounts for the fiscal year. The TREAT model incorporates regional response coefficients to determine logging and sawmill employment per unit of harvested wood. These response coefficients originate from regional, multi-state surveys of logging and wood processing companies. Multi-state surveys would likely inflate the estimates of logging and wood utilization employment, when compared to tracking down employment numbers within just five counties. While the CFLRP annual report creators are required to list the percentage of leakage from assumed wood utilization, such as wood processing that occurs outside of the defined region, it is difficult to estimate with high accuracy. Also, multi-state surveys produce average employment response coefficients for an entire region. For example, northern Arizona wood utilization employment rates are likely quite different than employment rates in northern New Mexico.

Credit: Steve Horner

4.1. Conclusion

Logging and wood utilization spur numerous good-paying jobs in the region. Combined with the important year-round USFS jobs and the other restoration contractors, the 4FRI has a large economic footprint to accompany its ecological footprint. 4FRI restoration activities provide for important economic contributions across northern Arizona, leading to almost 1,000 full and part-time jobs and $150 million in regional output when including multiplier effects in FY 2017. Over 140 separate industry sectors were impacted by 4FRI activities in this fiscal year. It is important to note that our study is a snapshot of 4FRI activities and is not a complete picture of all Arizona logging and wood utilization, nor a complete picture of all forest restoration contributions in Arizona. For example, 4FRI activities are not inclusive of pinyon/juniper restoration efforts that also contribute to thinning employment and biomass processing facilities.

An important concept for understanding regional economic contributions is evaluating the amount of leakage of expenditures from the region, or alternatively, the local capture rate of 4FRI expenditures. There are two primary methods for boosting regional economic contributions of forest restoration. The first is to increase the scale of acres treated, which would result in greater thinning and wood utilization employment. The second method for increasing regional economic contributions is to decrease the amount of contributions leaked from the region or, vice versa, increase the local capture rate of contributions. In rural areas, such as northern Arizona, a portion of restoration expenditures will immediately leak out of the region due to a lack of manufacturing of equipment, technical services, and fuel production in the region. That is, rural counties cannot be expected to produce all the equipment, services, fuel, etc., necessary to complete 4FRI activities. Likewise, when dealing with large-scale land treatments on public lands, a good portion of federal funds will necessarily be expended outside of the region. But, increasing regional wood processing options can be a focal point for decreasing leakage of restoration contributions. Currently, the majority of sawlogs and biomass on the West-side of 4FRI are processed outside of the regional economic contribution zone due to a lack of wood utilization infrastructure. Our research focused strictly on in-region restoration expenditures. As such, we do not know the total amount of funds expended nationwide on 4FRI activities and therefore do not know the exact amount of leakage. But addressing local wood utilization infrastructure would assuredly decrease overall leakage of 4FRI regional expenditures.

Despite impressive regional economic contributions, overall restoration accomplishments have seen limited growth since the inception of the 4FRI and remain well below original project objectives and forecasts. 4FRI foundational documents called for thinning up to one million acres over 20 years, ramping up to 50,000 acres per year. If treated acres were closer to original projections, regional economic contributions would be much greater. With both the social license and agency support generally in place, wood supply is no longer an issue. The clear barrier to ramping up 4FRI mechanical thinning accomplishments is the lack of profitability in thinning and processing small diameter ponderosa pine.

In order to achieve the ambitious goals of 4FRI, all stakeholders and the USFS must acknowledge the need for supplemental funding for southwestern forest restoration. Ponderosa pine forest restoration provides numerous ecosystem services and benefits to the state, counties, municipalities and to the public, and is vastly different than the traditional economic model of timber production. Because of this, a collaborative restoration effort requires an innovative collaborative funding effort, where the beneficiaries of the services help fund the restoration efforts and work with the USFS to collaboratively develop a productive local wood products industry.

Though it is difficult to make sweeping conclusions based on initial baseline economic monitoring, there are some notable findings in the data and the literature. One clear implication is that there needs to be a significant utilizer of small trees, chips, slash, and residue within a reasonable transportation distance on the West side of 4FRI. Logging operators and mills on the East side of the 4FRI footprint have consistently processed much more wood per acre within the region than their counterparts on the West side, leading to greater capture rates and less leakage of regional economic contributions. This is because there is greater wood infrastructure in the White Mountains region than in the Flagstaff region. In particular, the Apache-Sitgreaves National Forest region contains a greater number of family-owned businesses (Mottek-Lucas et al. 2017), tribal timber processors that allow for market outlets for larger diameter trees, and most importantly for 4FRI, the region has a 27-megawatt biomass power plant.

While the importance of a keystone bio-energy plant for rural economic wood utilization is recognized, it cannot be overstated how vital it is to develop a profitable, vertically integrated wood industry cluster. So important, rural communities with high forest restoration needs and low levels of wood utilization infrastructure should prioritize the development of a collaboratively-funded processing facility, such as a biomass plant, at the beginning of large-scale restoration programs. High production, small diameter sawmills are also critical to success, but mills and other processing options are likely to follow a large biomass processing facility. While any large processor of small-diameter pine would be a welcome addition, a biomass power plant has advantages of uploading product directly to existing power grids. Haul distances are not only a concern for getting logs to the mill, they are also important in the marketing of final wood products. Northern Arizona rural towns are generally far from large markets, making composite products such as oriented strand board (OSB) a bit more cost prohibitive for market options for small diameter ponderosa.

For northern Arizona, forest restoration has been shown to reduce wildfire suppression costs (Fitch et al. 2018) and lead to substantial avoided costs from wildfire risk reduction (Combrink et al. 2013, Combrink and Rousse 2018). Homeowners and businesses are willing to pay for the watershed and fire risk reduction services provided by forest restoration (Mueller 2013, Mueller et al. 2013, Mueller et al. 2018) and 74% of the voters approved the FWPP $10 million bond. Additionally, woody

biomass electricity generation in northern Arizona has been shown to result in avoided environmental and health damage costs when compared to current coal use (Huang and Bagdon 2018). If restoration is to ramp up in the 4FRI footprint, and if regional economic contributions are to increase, the key will be in designing new collaborative wood industry models that interlink communities and their governing municipalities, counties, and the state with the USFS and 4FRI stakeholders to collectively enact funding and loan mechanisms, purchasing agreements, and supply offerings.

Credit: Jay Smith

5. Endnotes

1. 4FRI Charter (Amended Feb. 2013): http://4fri.org/wpcontent/uploads/2018/04/4FRI_charter_amended_022713.pdf

2. Available at: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3836490.pdf.

3. Available at: https://www.fs.usda.gov/detailfull/4fri/home/?cid=stelprdb5346432.

4. For more information see: http://flagstaffwatershedprotection.org/.

5. IMPLAN sector conversions from full and part-time jobs to FTE jobs, or vice versa, are available here: https://implanhelp.zendesk.com/hc/en-us/articles/115002997573-536-Sector-Bridges-and-Conversions.

6. This total includes 1,460 acres of non-USFS lands that were part of the Flagstaff Watershed Protection Project.

7. Most of the fertilizer/mulch is processed outside the region and is not included in our regional contribution analysis.

8. Available at: https://www.fs.usda.gov/detailfull/4fri/home/?cid=stelprdb5346432.

6. References

BenDor, T., Lester, T.W., Livengood, A., Davis, A. and Yonavjak, L. (2015). Estimating the size and impact of the ecological restoration economy. PloS one, 10(6), p.e0128339.

Bixler, R. P., & Kittler, B. (2015). Collaborative Forest Landscape Restoration: A meta-analysis of existing research on the CFLR Program. Pinchot Institute for Conservation. Available online at www. xalioxs. pinchot. org/pubs/548.

Combrink, T., Fox, W., Peterson, J. (2012). Workforce needs of the Four Forest Restoration Initiative Project: an analysis. Ecological Restoration Institute. 19p.

Combrink, T., Cothran, C., Fox, W., Peterson, J., and G. Snider. (2013). A full-cost accounting of 2010's Schultz Fire. Northern Arizona University, Arizona Rural Policy Institute and the Arizona Hospitality Research and Resource Center. 58 p

Combrink, T. and W. Rousse. (2018). The economic impact of post fire flooding: Bill Williams Mountain. The Alliance Bank Economic Policy Institute and the W.A. Franke College of Business, Northern Arizona University. 24p.

Covington, W. W., Fule, P. Z., Moore, M. M., Hart, S. C., Kolb, T. E., Mast, J. N., ... & Wagner, M. R. (1997). Restoring ecosystem health in ponderosa pine forests of the Southwest. Journal of forestry, 95(4), 23.

Crihfield, J. B., & Campbell Jr, H. S. (1991). Evaluating alternative regional planning models. Growth and Change, 22 (2), 1-16.

Daniels, J. M., Nielsen-Pincus, M., Paruszkiewicz, M., & Poage, N. (2018). The Economic Contribution of Stewardship Contracting: Two Case Studies from the Mount Hood National Forest. Journal of Forestry, 116(3), 245-256.

Davis, E. J., Abrams, J., White, E. M., & Moseley, C. (2018). Current challenges and realities for forest-based businesses adjacent to public lands in the United States. Journal of Rural and Community Development. 13 (1): 125 –142., 13(1), 125-142.

Dubay, T., Egan, D., Hjerpe, E. E., Selig, W., Brewer, D., Coelho, D., ... & Waltz, A. E. (2013). Breaking barriers, building bridges: collaborative forest landscape restoration handbook. Ecological Restoration Institute.

Ellison, A., Moseley, C., Nielsen-Pincus, M. and MacDonald, F. (2010). The business of restoration: a profile of restoration contractors in Oregon. University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program, Working Paper Number 23, 20 pp.

Hibbard, M. and Karle, K., (2002). Ecosystem restoration as community economic development? An assessment of the possibilities. Community Development, 33(2), pp.39-60.

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

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.

Huang, C. H., & Bagdon, B. A. (2018). Quantifying environmental and health benefits of using woody biomass for electricity generation in the Southwestern United States. Journal of Forest Economics, 32, 123-134.

Isard, W., I. J. Azis, M. P. Drennan, R. E. Miller, S. Saltzman, and E. Thorbecke. (1998). Methods of interregional and regional analysis, vol. 490. Aldershot, UK: Ashgate.

Jaworkski, D. (2014). Four Forest Restoration Initiative Socioeconomic Resource Report. Specialist Report for FEIS.

Kerkvliet, J. (2010). The practice and economics of stewardship contracting: A case study of the Clearwater Stewardship Project. Forest Products Journal, 60(3), 213-220.

Mottek Lucas, A.L. (2012). Socioeconomic Monitoring for the Four Forest Restoration Initiative. Prepared and Submitted by the Science and Monitoring Working Group. 14 p.

Mottek Lucas, A., Kim, Y. S., Greco, B., Becker, D. R., Hjerpe, E. E., & Abrams, J. (2017). Social and Economic Contributions of the White Mountain Stewardship Project: Final 10-Year Assessment—Lessons Learned and Implications for Future Forest Management Initiatives. Journal of Forestry, 115(6), 548-558.

Mueller, J. M. (2013). Estimating willingness to pay for watershed restoration in Flagstaff, Arizona using dichotomous-choice contingent valuation. Forestry, 87(2), 327-333.

Mueller, J. M., Swaffar, W., Nielsen, E. A., Springer, A. E., & Lopez, S. M. (2013). Estimating the value of watershed services following forest restoration. Water Resources Research, 49(4), 1773-1781.

Mueller, J. M., Springer, A. E., & Lima, R. E. (2018). Willingness to pay for forest restoration as a function of proximity and viewshed. Landscape and Urban Planning, 175, 23-33.

Nielsen-Pincus, M. and Moseley, C. (2013). The economic and employment impacts of forest and watershed restoration. Restoration ecology, 21(2), pp.207-214.

Robbins, A. S., & Daniels, J. M. (2012). Restoration and economics: a union waiting to happen? Restoration Ecology, 20(1), 10-17.

Schultz, C.A., Jedd, T. and Beam, R.D. (2012). The Collaborative Forest Landscape Restoration Program: a history and overview of the first projects. Journal of Forestry, 110(7), pp.381-391.

Schultz, C. A., McIntyre, K. B., Cyphers, L., Ellison, A., Kooistra, C., & Moseley, C. (2017). Strategies for success under Forest Service restoration initiatives. Ecosystem Workforce Program Working Paper Number 81.

Selig, M., Vosick, D., Seidenberg, J. (2010). Economics and Utilization Analysis. Report from the Four Forest Restoration Initiative. 28p.

Sorenson, C. B., Keegan III, C. E., Morgan, T. A., McIver, C. P., & Niccolucci, M. J. (2015). Employment and wage impacts of timber harvesting and processing in the United States. Journal of Forestry, 114(4), 474-482.

Watson, P., Wilson, J., Thilmany, D. and Winter, S. (2007). Determining economic contributions and impacts: What is the difference and why do we care. Journal of Regional Analysis and Policy, 37(2), pp.140-146.

Watson, P., Cooke, S., Kay, D., & Alward, G. (2015). A method for improving economic contribution studies for regional analysis. Journal of Regional Analysis & Policy, 45(1), 1.