A forest harvester cuts and stacks logs for the White Mountain Stewardship Project in Arizona. Photo by Tana Kappel/TNC

SOUTHWEST FIRE SCIENCE CONSORTIUM

Review of Economic Benefits from Fuel Reduction Treatments in the Fire Prone Forests of the Southwestern United States

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Oak Creek Canyon Prescribed Fire burns through a mechanically treated area. Photo by Coconino National Forest.

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Introduction

Wildfire suppression expenditures sharply increased from $528.5 million in 1985 (in 2015 dollars) to $2.1 billion in 2015 while the size of area burned has more than tripled (from 2.8 to 10.1 million acres) during the same time period (National Interagency Fire Center [NIFC] 2015, USDA Forest Service 2015). The proportion of the Forest Service's annual budget allocated to wildfire suppression has increased from 16% in 1995 to 52% in 2015 and is projected to increase to 67% of the budget by 2025 (USDA Forest Service 2015). Landscape-scale restoration and fuels-reduction treatments are now widely accepted management practices that are known to significantly decrease the risks and costs associated with wildland fire suppression (ERI 2013). However, the increased proportion of the Forest Service's budget going towards wildland fire expenditures has detracted from all non-fire programs and hindered the Forest Service's ability to implement more forest restoration and wildfire risk reduction treatments (Figure 1).

While acres restored by the Forest Service has improved in the southwest, the cost of treatment has been a major barrier to achieving a much broader area impacted. Included in the cost of treatment are the planning, preparation, administration, mechanical thinning and prescribed burning costs, which can total from $1,321 to $3,195 (in 2015 dollars) per acre (Selig et al. 2010, Huang et al. 2013). Without a forest products industry to utilize the large quantities of non-merchantable woody biomass planned to be removed from the mostly public lands (Nicholls 2014), policymakers and planners are unlikely to accomplish the targets set forth in their planning documents (i.e. Environmental Impact Statements). There is therefore a need to increase forest industry capacity in order to reduce fuel loads in concert with ecological restoration and to utilize wood products removed during restoration treatments. Yet, development of a more robust local forest products industry is hindered by the need for substantial upfront investments, depressed timber markets in the West (Keegan et al. 2006, Jones et al. 2010, Bagdon et al. 2016), and lack of a social license to harvest timber in the Southwest (Selig et al. 2010, 4FRI Stakeholders Group 2011, Nicholls 2014). This paper presents a review of the types of economic benefits that arise from fuels-reduction treatments in the southwestern U.S. to inform policy discussions about the economic impacts and benefits of the treatments.

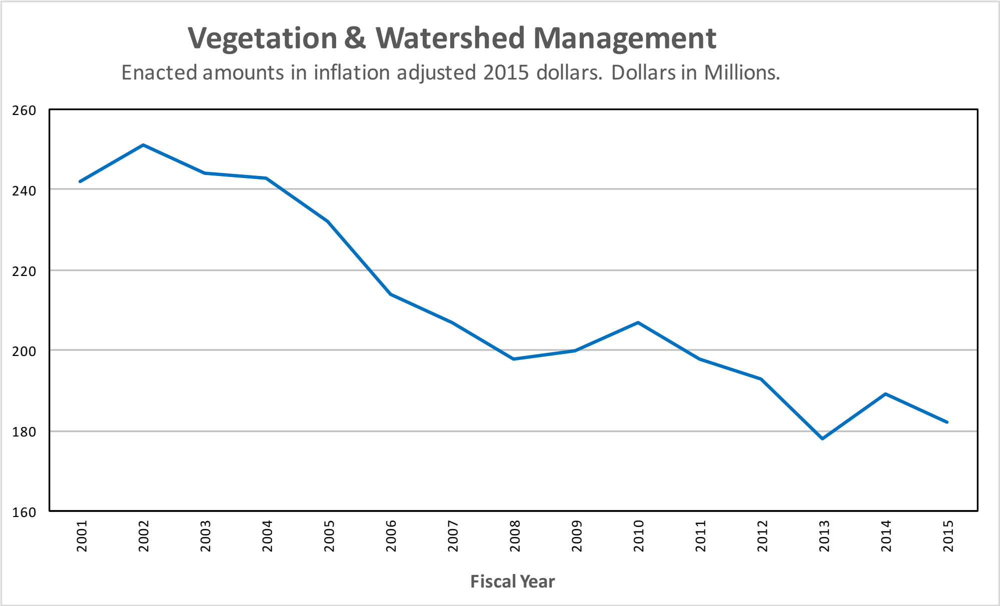

Figure 1. Dollars allocated to the US Forest Service Vegetation and Watershed Management Program (Vertical-axis), a primary source of funding for restoration and fuel reduction treatments. (Source: US Forest Service 2015).

National Forests in the Southwest

The majority of National Forests in the Southwest need fuels-reduction treatments that have not kept pace with tree growth and fuels accumulation, and landscape-scale forest restoration projects such as the White Mountain Stewardship Project (WMSP) and the Four Forest Restoration Initiative (4FRI) have been implemented in Arizona to address this issue. As the nation's first and largest ten-year stewardship contract, the WMSP, aiming at restoring forests in wildland-urban interface areas of the Apache-Sitgreaves National Forests, is an example of federal agencies paying a subsidy to a private entity for a large-scale restoration and fuel reduction project. Community capacity, utilization capacity and agency capacity have been credited as the major factors contributing to the success of this community stewardship project (Abrams and Burns 2007). The WMSP payment method is based on the difference between cost of noncommercial removals (< 12") and value of commercial removals (trees >= 12") averaging around $550 per acre (Abrams and Burns 2007). The WMSP received approximately $30 million of federal funding in its first five years to support local businesses but generated approximately $40 million in investments, expenditures, and tax revenue (Sitko and Hurteau 2010). The Four Forest Restoration Initiative (4FRI) is a collaborative effort supported through the Collaborative Forest Landscape Restoration Program to restore forest ecosystems on portions of four National Forests (Coconino, Kaibab, Apache-Sitgreaves and Tonto) along the Mogollon Rim (http://www.fs.fed.us/restoration/CFLRP/). The 4FRI aims to reduce fuels, enhance forest health and increase diversity of wildlife and plants through forest thinning and augmenting the use of prescribed fire with wildland fire use in order to achieve the restoration objectives. The 4FRI plans to implement restoration treatments across 2,400,000 acres of ponderosa pine forest and treat 50,000 acres annually over the next two decades. According to 4FRI Monthly Update, 2,252 acres have been mechanically thinned and 36,607 acres have been treated with prescribed fire in 4FRI Phase 1 Stewardship Contract as of March 2016 (http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd495901.pdf; last accessed 03/24/2016). Economic impacts of treating 4FRI NEPA-ready areas using prescribed fire, including pre-burn mechanical treatments, are projected to generate $144 million in output, $99 million in labor income, and create 1,675 jobs; the projected numbers for mechanical thinning alone are $129 million, $47 million and 1,456, respectively (Kim 2010).

Economic Benefits Defined

Economic benefits from fuel reduction treatments are commonly referred to as the monetary gains plus the expected avoided monetary expenditures that result from a specific schedule of treatment actions designed to reduce fire hazard at a particular site. Economists generally think of benefit as the 'utility,' or satisfaction derived from a particular activity and believe that consumers express utility through the imperfect mechanism of spending money in the marketplace. Because consumers have many choices in what they purchase, each dollar spent is like a vote cast for the good or service purchased (see Farber et al. 2002 for further discussion on economic utility and valuation in an ecological context). While these abstract concepts seemingly have little to do with fire management decisions, the practical application of these principles is paramount to accomplishing socially desired outcomes.

Economics is the science of allocating scarce resources among competing interests and is often concerned with achieving efficient outcomes, not just profit maximization. In a forestry context, many alternatives might exist for managing forests before, during, and/or after a wildfire, yet decision-makers are often constrained by time, money, and political will, while confronted by many uncertainties. A single treatment schedule is likely to result in multiple economic benefits in a given area, and the literature has attempted to parse out as many economic benefits as possible. Without a full accounting of the risks, costs, and benefits among alternative courses of action, inefficient outcomes are likely to result. It is worth noting here that benefits for fuel reduction treatments are much harder to quantify than the cost of implementing treatments, and studies have developed methods for evaluating alternatives when information about benefits is missing or incomplete (Omi et al. 1999, Rideout et al. 1999, Mason et al. 2006). For example, using *with and without analysis*, Omi et al. (1999) simulated four wildfires using the

FARSITE model and estimated that resulting from treatments, the reduced burned areas would range between 966 and 5,169 acres presenting approximately $8,000 to $62,000 cost reduction, the cost difference between wildfire costs without treatment and wildfire costs with treatments.

Market and Non-Market Economic Benefits

Economists note that monetary benefits can either be determined with or without a market, whereas monetary values that are not determined through the market mechanism of supply and demand are referred to as non-market values (Rideout et al. 1999, Millennium Ecosystem Assessment 2005, Venn and Calkin 2011). For example, the volume of timber harvested from a particular treatment may be sold to a mill for processing into merchantable products, usually pallets, small furniture, and pellets for wood stoves in the southwestern U.S. (Sitko and Hurteau 2010, Nicholls 2014). However, many of the goods and services that forests provide do not have monetary values as determined through a market interaction and, by default, are assigned zero value (Rideout et al. 1999, Daugherty and Snider 2003, Venn and Calkin 2011). The absence of a market does not imply that these goods and services do not have a monetary value or that they do not provide benefit to society. This paper discusses a few of indirect methods which have been used to reveal the monetary value society places on these non-market goods and services.

Market Benefits from Fuel Reduction Treatments

One example of a monetary benefit arising from fuel reduction treatments is the volume of merchantable timber removed during treatment and sold in the marketplace, also referred to as wood utilization (Selig et al. 2010, Combrink et al. 2012). However, mill capacity for large volumes of small-diameter, low-value timber is limited or non-existent in many parts of the southwestern U.S., and the value of this wood is unlikely to offset the cost of treatment (Selig et al. 2010, Keegan et al. 2011, Hayes et al. 2012, Nicholls 2014). Some studies have found that the small-diameter wood supplied from the large-scale treatments necessary to achieve adequate fuel reductions in the Southwest could support mills for certain types of forest products such as oriented-strand board (OSB), in addition to pellets, shipping pallets, and small furniture (Hampton et al. 2008, Combrink et al. 2012, Nicholls 2014); or that this wood could be used in biomass-to-energy facilities (TSS Consultants 2002, Neary and Zieroth 2007). Nicholls (2014) notes that a sudden influx of wood supplied to the limited existing infrastructure in northern Arizona could strain processing capacity and would require supply chain improvement including logging operations and sawmilling and new businesses utilizing small-diameter biomass.

Impacts to Regional and Local Economies

Restoration and fuels reduction projects have cascading economic impacts to regional and local economies that extend beyond the sale of value-added products. Economists regularly estimate the “multiplier” effect of money spent on treatments using Input-Output (I-O) analysis (Hjerpe and Kim 2008, Kim 2010, Sitko and Hurteau 2010). To clarify, economic impacts refer to the effects of a proposed or implemented action that accrue to a defined economy (e.g. local, regional, or national economy), quantified in terms of the change in business sales, jobs, value added, income, or tax revenue of the project area. Whereas economic benefits refer to the social welfare derived from a particular action and can be used to compare with costs to determine the net value and efficiency of a project or policy. A project may result in positive impacts to the local economy such as the added jobs or additional activity from supporting industries. However, positive economic impacts may result in negative net effects to social welfare when the costs of a project outweigh its benefits (i.e., building an expensive road to a stand with potential for a marginal reduction in fire risk). Positive economic impacts of restoration and fuels reduction projects are described below.

Fuel reduction projects create jobs that range from high-paying administrative positions to the indirect creation of positions that support local infrastructure such as restaurants and lodging. Combrink et al. (2012) estimated that the 4FRI project requires at least 422 full-time equivalent (FTE) employment positions in the private sector to conduct the treatments and 69 FTE positions in the public sector to administer and prepare the treatments. This study did not consider the indirect job creation resulting from the 4FRI project, and these indirect effects are often significant to rural economies (Sitko and Hurteau 2010). For instance, Kim and Hjerpe (2008) estimated that 98 FTE indirect positions were created from the implementation of

The Jack Fire, managed for multiple objectives, burns through the Blue Ridge Wildland Urban Interface treatment area. Photo by Coconino National Forest.

approximately 100,000 acres of fuel reduction treatments in FY2005 on a subset of the 4FRI area, out of an estimated 318 FTE total positions. Moreover, the indirect effects of implementing treatments extend beyond secondary job creation and include increased federal and state tax revenues, reduced unemployment insurance payments, and recycled wages throughout the local economy (Mason et al. 2006, Hjerpe and Kim 2008, Sitko and Hurteau 2010). Large-scale treatments often require the manufacture and purchase of heavy equipment to harvest the trees, build roads, and transport materials, which can have regional to global economic benefits (Mason et al. 2006, Combrink et al. 2012). These economic impacts tend to outweigh the temporary negative effects such as increased pollutant emissions from prescribed burning and traffic accidents (Kim 2010).

Avoided Costs as Economic Benefits from Fuel Reduction Treatments

Other monetary benefits from fuel reduction treatments are less direct than the tangible forest products sold in the marketplace. In fact, sometimes the majority of market value from fuel reduction treatments comes in the form of avoided damages from wildfire. Accounting for avoided cost is complicated by the fact that there are a large number of potential losses to consider. Lynch (2004) attempted to gather a full accounting of the "real cost" of a series of wildfires in Colorado and provided a detailed list of losses from the Hayman Fire of 2002, which were estimated at $1,508 per acre in direct expenditures and $160 per acre in post-fire expenditures and losses. Combrink et al. (2013) quantified the full cost of the 2010 Schultz Fire, which burned approximately 15,000 acres in Flagstaff, Arizona, and concluded that the total estimated impact of the Schultz Fire and Flood ranged from $133 to $147 million with the average per-acre cost between $8,873 and $9,793. Using the avoided cost analysis, Buckley et al. (2014) investigated the benefits of fuel reduction treatments in the Mokelumne Watershed including avoided damages associated with structures and transmission lines saved, fire suppression and cleanup, carbon sequestration, timber volume and woody biomass, road repairs and reconstruction, and water supply. They concluded that the treatments could reduce the size of wildfires by 41% and reduce the area of high-intensity wildfires by 75% with a benefit-cost ratio ranging from 1.9 to 3.3 and net benefit ranging from $158 to $422 per acre (Buckley et al. 2014).

Some avoided cost approaches use wildfire models to simulate how the same forest area would respond to a wildfire with and without fuel reduction treatments (Abt et al. 2007, Hugget et al. 2008, Sorenson et al. 2011, Huang et al. 2013, Bagdon 2015, Bagdon et al. 2016). Through fuels-reduction treatments, avoided wildfire damages and costs may include decreased property values after wildfire (Kim and Wells 2005, Donovan et al. 2007), decreased recreational demand and revenue to parks and local economies (Hesseln et al. 2003, Hesseln et al. 2004, Starbuck et al. 2006), reduced fire suppression costs, fatalities, facility and timber losses, regeneration and rehabilitation costs (Mason et al. 2006), and enhanced regional economic benefits and community value of fire risk reduction, forest health and water supply protection (Huang et al. 2013).

Non-market Valuation of Benefits from Fuel Reduction Treatments

Economists are able to measure the value of wildfire avoidance to the public through contingent valuation studies that survey participants' willingness-to-pay (WTP) for treatments and estimate the values of non-market goods and services. One study found that participants were willing to pay more as the area treated increased and that the total marginal benefit to one million households from prescribed fire treatments averaged $2,578 per acre (Loomis et al. 2009). However, it should be noted that the marginal benefit is dependent on the number of households affected by the treatments and that this marginal value would decrease as fewer homes are potentially benefitted by fuels-reduction treatments. The contingent valuation method was used to measure WTP for the Mexican spotted owl (MSO) and its 4.6 million-acre old growth habitat, and the mean annual WTP is $40.49 per household (Loomis and Ekstrand 1997). The contingent valuation method has also been used to determine that households were willing to pay an average of $56 per household for the protection of 2,570 acres of spotted owl habitat at risk of catastrophic wildfire in California and Oregon (Loomis and González-Cában 1998). It was estimated that 78% of four MSO protected activity centers (PACs) were within the 2010 Schultz Fire perimeter, and 88% of these PAC areas experienced moderate to high burn severity (Combrink et al. 2013). Using a wide range of estimated values of $100,000 and $3.54 million (in 2012 dollars) per PAC, Combrink et al. (2013) determined the habitat impact of the Schultz Fire on the four MSO PACs were between $400,000 and $14.2 million.

Values of fuels reduction treatments in the Wildland-Urban Interface

The wildland–urban interface (WUI) is the area where houses intermingle with fire-adapted vegetation and creates conflicts such as the destruction of homes by wildfires, fragmentation of habitat, introduction of non-native species, and declines in biodiversity (Radeloff et al. 2005). The WUI accounts for 9% (277,668 mile2) of land area and 39% (44.8 million) of housing units in the conterminous United States (Radeloff et al. 2005). Protection of the WUI accounts for the majority of the Forest Service's rising suppression expenditures, and 50 to 95% of large wildfire costs are directly related to protecting private property and homes in the WUI totaling approximately $547 million to $1 billion in 2003 and 2004 nationwide (USDA OIG 2006). Wildfire suppression costs are closely associated with the number and location of homes; for instance, a 1% increase in the number of homes within 6-mile distance of a wildfire is predicted to result in a 0.07% increase in fire suppression costs in the Sierra Nevada area of California (Gude et al. 2013). Using the contingent valuation method, Fried et al. (1999) surveyed WUI homeowners in Michigan. Based on homeowners' perception of the probability that a structure may be destroyed in a WUI fire, their median WTP for specific risk reduction actions that could be undertaken by a property owner was $200 to $500 compared to only $24 to $75 for a general program of risk reduction activities undertaken by the state (Fried et al. 1999). Kaval et al. (2007) found that Colorado residents who live in the WUI had a WTP for prescribed fire that ranged from $545 to $1,583 annually per household with a mean of $796 per year. These respondents' WTP values increased by $8 per year if they perceived fire frequency would increase in the vicinity of their homes, and their WTP increased by $284 per year if they foresaw their homes were in immediate wildfire danger. While these WTP studies are sometimes geographically localized, raising concerns about applicability across broader areas, Walker et al. (2007) showed that WTP values for thinning and prescribed burning treatments were similar between WUI and urban residents of Larimer and Boulder Counties in northern Colorado; WTP for thinning ranges from $289 to $443 per year, and WTP for burning ranges from $140 to $213 per year. While these findings are encouraging for the statewide application of WTP values, more work is needed to find out whether similar values hold across a regional population such as the southwestern U.S.

Challenges, Needs, and Shortcomings of Economic Benefits Estimation

Many of the economic benefits that result from fuel reduction treatments are difficult to account for explicitly, primarily because they are not realized immediately and are calculated under highly specific assumptions about the timing and conditions under which a wildfire will occur at the treatment site (Snider et al. 2006, Huang et al. 2013, Bagdon 2015, Taylor et al. 2015). The probabilistic nature of wildfire ignition and spread presents uncertainties in projecting if or when a wildfire will occur in a particular location, which is why so many studies have turned to modeling the economic benefits from fuel reductions. Another problem for calculating the benefits from fuel reduction treatments is that many non-market values, such as ecosystem services, are difficult to calculate. Non-market valuation typically requires time-intensive surveys to determine the local-to-statewide market value for a limited number of non-market benefits (Hesseln et al. 2003, Kaval et al. 2007, Loomis et al. 2009). This literature is also becoming outdated and may not reflect current household attitudes (Loomis and Ekstrand 1997, Loomis and González-Cában 1998). Finally, wildfires seldom burn according to the randomized experimental design (i.e. control sites verses treated sites), and statistical modeling would be required for forecasting large wildfire probabilities; therefore, generalized lessons from specific cases typically comprise the body of empirical research. Empirical studies are rare because they cannot be planned and have site-specific issues that may contribute to or mitigate benefits and costs. As a result, the body of literature examining empirical examples of economic benefits that occur with-and-without treatment and before-and-after a wildfire is limited (Ecological Restoration Institute 2013).

Conclusion

As the current trends of growing wildfire size, intensity, and suppression efforts continue in conjunction with shrinking budgets for restoration management, land managers will need to be more creative in their justifications for implementing precautionary measures such as fuel reduction treatments. The term 'economic benefits' is often synonymous with net financial gains and typically indicates a narrow interpretation that market prices can be calculated for the goods and services rendered. However, a broader interpretation of economic benefits should be used when considering fuels-reduction treatments in the southwestern U.S.. The lack of recent economic valuation studies evaluating the effects of wildfire on non-market values is a problem hindering a more accurate accounting of the full economic benefits that result from fuels-reduction treatments. While many localities in the southwestern U.S. may not have supporting literature for specific non-market economic benefits from fuel reduction treatments, the benefit transfer method may be used to extrapolate information from studies conducted in another location, to estimate economic values for non-market values and justify the economic benefit of the treatments. Additionally, other benefits such as avoided costs resulting from a landscape-scale treatment plan may inform net economic benefits that result from fuels-reduction treatments. The potential revenues from utilizing harvested wood also result in other induced direct and indirect economic activity, known as economic impacts. The lack of an industry presence has not helped the economics of implementing a more robust and widespread fuels-reduction program. As the frequency, extent, and severity of wildfires increases, land managers may need to partner with the types of industry that are socially acceptable and could be granted the social license to operate within the Southwest to mitigate wildland fire risks and to accomplish a better outcome in net social welfare.

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