A Case Study on the Economics of Thinning in the Wildland Urban Interface

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ABSTRACT: *This is a case study, supplemented by an economic model, of one 85 ac ponderosa pine* (Pinus ponderosa) *dominated stand, called Unit 16, that was treated during the summer of 2001. Unit 16 is located in the Greater Flagstaff Forests Partnership's Fort Valley project area of the Coconino National Forest and is part of the Flagstaff, AZ wildland urban interface. The silvicultural prescription was a full restoration prescription anchored to the presettlement condition and was limited by a 16 in. dbh cutting cap. The operational strategy for the merchantable material was hand felling, limbing, topping, bucking in the forest, and forwarding of logs to the landing for loading on waiting trucks. The nonmerchantable trees were cut and rough piled, along with limbs and tops. The economic model estimated the logging contractor's costs to total \$124,117. His total revenue stream during the summer of 2001 was detrimentally impacted by two unforeseen changes in his market. His normal purchaser of wood from small trees <8.0 in. dbh was unable to purchase this wood and his other market reduced its purchase price by 11%. As a result, his projected income went from providing a small profit of \$7,857 to a loss of \$3,284. Costs to the Forest Service to prepare the unit and to conduct postthinning activities were estimated to total \$31,9160. Net costs to the Greater Flagstaff Forests Partnership in the form of a service contract with the logger totaled \$17,000. West. J. Appl. For. 19(1):60–65.*

Key Words: Arizona, ponderosa pine, harvesting, fuels removal.

The Greater Flagstaff Forests Partnership (GFFP), formerly known as the Grand Canyon Forests Partnership, is a joint effort between the Coconino National Forest, the City of Flagstaff, Northern Arizona University, and a number of other regional organizations located in northern Arizona. This effort is formally recognized via a cooperative agreement between the USDA Forest Service and the GFFP for the purpose of improving and restoring ecosystem health of ponderosa pine (*Pinus ponderosa*) forest ecosystems over 100,000 ac of Flagstaff wildland urban interface (WUI) (GFFP 1998). The agreement establishes the GFFP as a National Performance Review Reinvention Laboratory and permits the cutting of timber "in connection with land uses which are of substantial benefit to the National Forests" without payment. The effects of this agreement are: timber can be conveyed, at no cost, to the GFFP from the Forest Service; the GFFP can enter into contracts with private operators to thin Forest Service lands; the GFFP is responsible for all funds, except contract administration, necessary to complete thinning projects; generated funds can only be used for on-the-ground restoration work; and contract administration remains with the Forest Service (GFFP 2001a).

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The GFFP seeks to combine both ecosystem restoration and forest fuels reduction goals in the WUI using ecologically sound, economically viable, and socially acceptable practices (GFFP 2001b). These practices include: the reduction of excess trees by thinning; the removal of ground, ladder, and aerial fuels; the re-introduction of low-intensity fire; the restoration of meadows; and the obliteration of some non-Forest Service system trails and two-track roads.

Our work with the GFFP focuses on the economics of thinning and fuels removal. We strive to understand the relationships between current forest conditions, on-the-ground management decisions, the resulting primary operations, and market influences. This article, a case study of an actual GFFP project supplemented by an economic model, provides some interesting insights about these relationships within the WUI of Flagstaff, AZ. Specifically, it includes: (1) an examination of actual thinning costs by hand felling; (2) a comparison of these costs to the value of the harvested wood; (3) the incorporation of costs incurred by the local Forest Service in preparation for (e.g., NEPA) and after thinning (e.g., burning); and (4) a prediction of how a small wood, low value market could have changed the logger's net return.

Unit, Stand, and Treatment

The study focuses on the treatment of one 85 ac unit, Unit 16, which was thinned in the summer of 2001. Unit 16 is part of a 1,700 ac GFFP project called Fort Valley Ecosystem Restoration Project—Phase I. This project is located about 5 mi northwest of Flagstaff within an area of the Coconino National Forest that is adjacent to deeded, private, mostly developed inholdings (Peaks 1998). The project includes a mosaic of silvicultural prescriptions, ranging from no treatment in wildlife areas to full restoration in areas with five or more large, mature ponderosa pine trees/ac. All prescriptions, however, were constrained by a cutting cap that limited thinning to trees smaller than 16 in. in diameter measured at breast height (dbh). This cap was in response to concerns expressed by regional environmental organizations (SWFA 1996 and 1998, Suckling 2000). The GFFP attempted, via the cap, to prove that its focus is forest restoration and fuels reduction, and not commercial, large-tree, logging.

Unit 16 is one of four rectangular shaped treatment units of the Phase I project designed to test four different silvicultural prescriptions. Unit 16 includes a game corridor running in a north-south direction through the eastern side of the unit. Ground slope is approximately 6%. The existing stand and leave tree mark on Unit 16 were inventoried during the summer of 2000 using a systematic strip sampling technique with a 0.89 confidence interval and a 26% error over the unit. The existing tree count averaged 426 tpa. Average tree size was 7.0 in. dbh.

The silviculture prescription applied to Unit 16 is called full restoration thinning, also known as the presettlement 1.5–3 treatment (Peaks 1998). This prescription was designed by the staff from NAU's Ecological Restoration Institute (ERI) and is anchored to the presettlement condition, as presented via evidences such as stumps, snags, downed trees, and stump holes. See Covington and others (2001 and 1997) for additional information about this prescription. Each evidence is replaced by 1.5 trees whenever large (>16 in. dbh) vigorous trees are available within a specified search radius. If the only available replacement trees are smaller than 16 in. dbh, three trees are marked for retention. For this project, two different search strategies were used (H.B. Smith, Pers. Comm., Ecological Restoration Institute, Northern Arizona University, Flagstaff, AZ, June 22, 2000). Over the eastern half of the unit, a 60 ft search radius was used. Over the western half, the search radius was decreased to 30 ft. Within both search areas, a deliberate attempt was made to group the leave trees.

Figure 1 is a summary of the existing stand, cutting activity, and residual tree projections in six size classes averaged over the entire unit. A close examination of Figure 1 suggests that approximately two 16 in. dbh or greater trees/ac will be cut, regardless of the cutting cap. This is not really the case but is indicative of an error in marking or inventory measurements. What might be a 15.9 in. dbh tree to a marker was found to be a 16 in. dbh tree during the inventory.

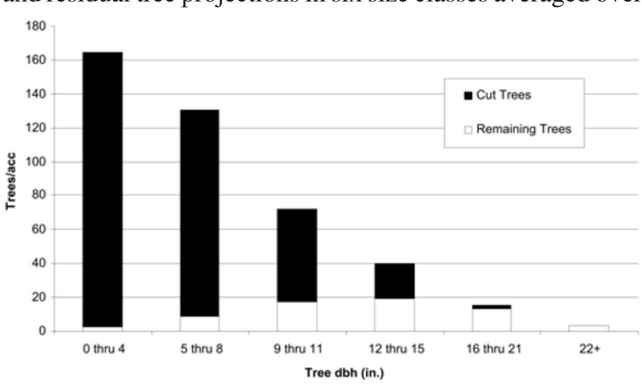

Figure 1. Unit 16 existing and residual tree inventory.

Cutting projections form the basis of the economic work presented in this article. These projections are summarized in Table 1 in terms of cut tree numbers and merchantable wood volume in 100 ft^3. Merchantable wood volume was estimated using equations derived by Hann and Bare (1978) that depend upon tree dbh, overall tree height, and inside bark diameter (dib) at top. Tree heights were estimated from a height-diameter curve (Larson et al. 2001) established from unpublished tree data collected by ERI (Fulé 2000) in units adjacent to Unit 16. Market conditions dictate top dib and, as such, volumes were estimated using a 4 in. dib for 5 to 7.9 in. dbh trees and a 6 in. dib for larger trees. Average size of the cut tree was estimated to be 8.7 in. dbh.

Cost to Restore Forests and Reduce Fuels

Contract and Operational Strategy

Since this was a GFFP project established in accordance with the cooperative agreement, the thinning contract over Unit 16, as well as two other units, was prepared and negotiated by the GFFP. It called for hand felling, limbing, topping, and bucking in the forest of all trees larger than 5 in. dbh and the forwarding of associated logs to the landing for loading onto waiting trucks. The nonmerchantable trees (<5 in. dbh) were cut and rough piled, along with limbs and tops. These piles were scattered throughout the forest. Eventually, the Forest Service will burn these piles plus conduct a broadcast burn. The contractor paid the GFFP a $50/ac stumpage for the saw logs harvested from the 9 to 15.9 in. dbh trees. The GFFP paid the contractor $250/ac to complete the thinning and rough piling work. These thinning funds were raised from private sources by the GFFP.

Cost Model Attributes

A previously developed model (Larson et al. 2000 and 2001), refined to capture the attributes of this unit and the operational strategy details, was used to estimate treatment costs. This model assigns only direct costs—equipment depreciation, opportunity costs, office overhead, and profit are not accounted for—to reflect the current realities of working in northern Arizona.

Table 1. Cutting and merchantable* wood volume projections on unit 16.

Dbh tree class (in.)	Number cut (tpa)	Merchantable volume (ccf/ac)
<4.9	162.00	0.00
5.0–8.9	122.00	3.78
9.0–11.9	54.67	4.93
12.0–15.9	20.67	4.10
16.0–16.9	2.00	.67
Total	361.33	13.48

* Merchantable wood volume is the volume of wood fiber having market value. These Table 1 volumes are based on a 4-in. dib top for 5.0 to 7.9 in. dbh trees and a 6 in. dib top for larger trees.

Northern Arizona is a region with few wood markets that can effectively utilize logs from trees <16 in. dbh. At the time of this project, the only available markets included: (1) A firewood producer located approximately 75 mi from Unit 16 desiring, at a minimum, an 8 ft log with a 4-in.-dib small end. It generally takes a 5 or 6-in.-dbh tree to produce this log. (2) A pallet mill located approximately 155 mi from Unit 16 desiring, at a minimum, a 12-ft-long log with a 6-in.-dib small end. It generally takes an 8-in.-dbh tree to produce this log. (3) A low volume viga, high quality poles that are used in southwestern-type roof and ceiling applications, market located approximately 135 mi from Unit 16 desiring, at a minimum, a 12-ft-long log with a 10-in.-dib small end. It generally takes a 14-in.-dbh tree to produce this log. (4) A sawmill located approximately 545 mi from Unit 16 desiring, at a minimum, a 16-ft 6-in.-long log with a 6-in.-dib small end. It generally takes a 9-in.-dbh tree to produce this log, and (5) A large log sawmill located approximately 155 mi from Unit 16 desiring, a 16-ft 6-in.- long log with a 9-in.-dib small end. It generally takes a 12-in.-dbh tree to produce this log.

These existing markets are less than suitable because they are of low value, too far away, or unable to utilize the wood taken from trees <9.0 in. dbh—the largest component of thinning. As the result, the local logging contractors stay in business because they have diversified their business (e.g., into trucking), or they rely on fully depreciated equipment and forego reinvestment in their logging business.

The model assumes that harvesting costs depend upon the processing speed of the three sawyers, with the forwarding and loading systems in balance with sawyer production. Assumed sawyer processing rates are given in Table 2. These rates were developed for relatively flat terrain and include walking time between trees and an efficiency factor of 0.7. These rates were field confirmed through observations made during the processing of 80 trees, ranging from 5 to 12 in. dbh. In those areas of the unit considered rough, due to the presence of large boulders and rock fields, processing rates were doubled to account for the more difficult working conditions. Over the range of merchantable trees, these assumptions yielded an average time of 5.12 min./tree to walk, fell, delimb, top, and buck.

The same sawyers that processed the merchantable trees also treated the precommercial stand component consisting of trees <5 in. dbh. The theoretical time to cut these trees was based on previous observations made of this contractor while working in another cutting area (Pinjuv 2000). These observations were made during the summer of 2000 in Unit 12 of the GFFP's Fort Valley Research and Demonstration Project located within the vicinity of this newer project. In addition to the observed cutting rate of 11 trees/min., the model incorporated additional time for walking between the clumps of small trees, rough piling, and downtime.

Table 2. Sawyer rates to process ponderosa pine trees on unit 16.

Dbh tree class (in.)	Processing rate[1] (trees/min.)
5.0–8.9	0.71
9.0–11.9	0.36
12.0–15.9	0.18
16.0–16.9	0.09

[1] Processing includes downtime, walking, felling, limbing, topping, and bucking.

The logging contractor paid his sawyers by the truckload that on analysis yielded an equivalent basic rate of $11/hr. The cost model included the additional employer related expenses of workman's and unemployment compensation, social security and Medicare taxes, and liability insurance.

Mobilization and roadwork costs were assigned according to ratios established in a previous project on the Fort Valley Experimental Forest (Larson and Mirth 1999) that had road, terrain, and stand characteristics similar to that of Unit 16.

The cost to truck was based upon a flat rate of $60/hr with time allocated for travel to and from market, loading, unloading, and delays. In this case, the contractor's markets—pallets and vigas, as described in more detail below—were located in the Phoenix area. Total miles per truckload, including empty back hauls, averaged 306 mi. The number of truckloads was calculated directly from the stand data estimates of merchantable wood applicable to the pallet and viga mix. These calculations yielded 1.76 loads/ac for a total of 149.6 loads. The operator's actual production records showed a total of 150 truckloads.

Model Results

The model estimated total contractor costs over Unit 16 as $124,117, equivalent to $1,460/ac. The relative contributions of the major costs for the direct-cost contractor are summarized in the pie chart of Figure 2. As shown, trucking the logs to market accounted for 48% of the costs, followed closely by harvesting (thinning and removal) of the trees 5 in. dbh and greater. Treatment of the precommercial trees accounted for only a small portion of the total project costs, reflecting a relatively small number, 162 tpa, of nonmerchantable trees/ac. The contract stumpage of $50/ac accounted for 3% of the contractor's costs.

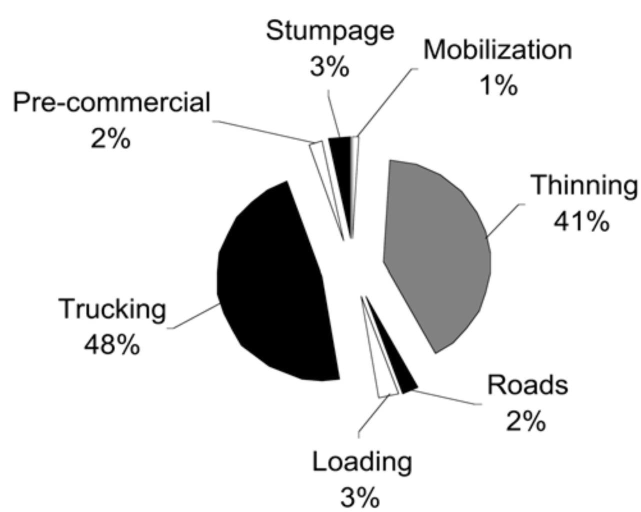

Figure 2. Logging contractor costs for Unit 16.

Other Costs

Although this project is a GFFP one, the Forest Service still incurred related costs. Their responsibilities to the NEPA process, as well as the need to monitor, burn piles, and conduct broadcast burns, is the same regardless of the project's relationship to GFFP. No analysis of treatment costs would be complete without the recognition of these costs, which are reported in Table 3.

These costs were estimated using data from a 5 yr planning document prepared by the Peaks/Morman Lake Ranger District of the Coconino National Forest (Waldrip 2002). Unit 16 lies within the Peaks Ranger District. Table 3 shows that the total estimated costs incurred for this one 85 ac unit is $31,960, equal to $376/ac. Missing from this table is the service fee that is typical of these types of projects. In this case, the GFFP incurred this cost of $250/ac for a total of $21,250.

Revenue from Forest Restoration and Fuel Reduction

Although costs are important, they must be contrasted against the revenue generated through the sale of harvested wood to gain a more complete understanding of economics. The influence of wood markets must be evaluated. In this section, we provide two different revenue analyses. The first analysis examines the actual market conditions during the summer of 2001 and the resulting logger income and net return on the unit. The second is a follow-on, what-if analysis examining income and net returns due to the availability of an additional small-wood, low-value market.

Summer of 2001: Markets, Income, and Net Return

Typically, the contractor of Unit 16 sold his wood into three markets. Small logs (4 in. dib, small end) were sold for conversion into packaged bundles of split firewood. Larger logs (6 in. dib, small end) were sold for conversion into pallets. Logs from the limited number of available trees (14 in. dbh and larger) were sold for conversion into high-value rough-hewn beams and vigas.

At the time of this project, however, the firewood manufacturer was unable to purchase logs due to a zoning dispute restricting log storage at the manufacturer's yard. As a consequence, the logger was limited to only the pallet and viga markets. The small tree component, generally consisting of merchantable trees <8 in. dbh, could not be brought to market and was wasted. The logger also suffered an additional market change during the thinning of Unit 16. The pallet mill reduced its offering price from the equivalent of $31.54/green ton to $28/green ton approximately two-thirds of the way through the unit. The actual pricing structure was different than this. An equivalent price is given here to provide a degree of confidentiality for the pallet mill and the logging contractor.

Table 3. An estimation of the costs incurred by the Peaks Ranger District, Coconino National Forests for the treatment of unit 16.

Work activities	Estimated cost ($US/ac)	Estimated unit 16 cost ($US)
Archeology survey	36.00	3,060.00
Other pre-NEPA surveys	9.00	765.00
Nepa documentation	18.00	1,530.00
Timber preparation	55.00	4,675.00
Monitoring	8.00	680.00
Pile burning	50.00	4,250.00
Broadcast burning	200.00	17,000.00
Total		31,960.00

In addition to markets, the logger received $250/ac to treat Unit 16. This was the service component of his contract—a cost to the GFFP as noted earlier.

The previously described cost model was modified to estimate the income received from selling the 149.6 truckloads of logs to the pallet and viga markets. This analysis suggested that the logger received a total of $99,583 for the wood plus an additional $21,250 for the service component of his contract. This is equivalent to $1,422/ac of income. Figure 3 shows the relative contributions that each income sector made to the total revenue estimate. Revenue from pallets dominated, accounting for 66% of the total.

A comparison of total revenue to incurred costs reveals a grim financial picture. This cost/revenue analysis indicates that the logger lost a total of $3,284 or $38.63/ac. The change in price by the pallet manufacturer was one factor contributing to this. If the pallet manufacturer had continued to pay $31.54/green ton throughout, the cost to revenue results would have been better with the net return moving from a loss to a small profit of $2,856 or $33.60/ac. The other market-related factor that contributed to the grim financial situation of Unit 16 was the unforeseen loss of the firewood market.

Impacts of the Missing Firewood Market

As noted above, the existing market of pallets and vigas, supplemented by the service contract, did not provide enough income to offset the logger's costs to treat Unit 16. The missing firewood market certainly contributed to this unfortunate financial situation, but by how much? This question is answered here by conducting a what-if analysis

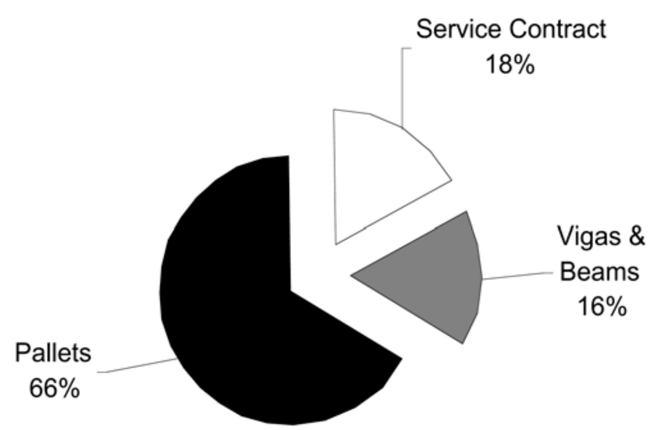

Figure 3. Logging contractor revenue on Unit 16 during the summer of 2001.

using the previous cost and revenue model modified to include a firewood market that: (1) was located about 75 miles from Unit 16; (2) could purchase all the logs harvested from the 5 to 7.9 in. dbh trees; and (3) was willing to pay $23/green ton for delivered logs.

The additional logs equated to approximately 34 truckloads of wood. Each load incurred new costs beyond that seen in the actual project due to loading and trucking. These additional costs were estimated to be $8,071. No other additional costs were incurred, as harvest costs had already been accounted for as part of the actual unit costs. In contrast, the sale of these smaller logs represented an increase to market-derived income by $13,072. The revenue stream, which included firewood, pallets, vigas, and the service contract, totaled $133,905. In this analysis, the pallet mill price structure was the same as in the original analysis of the actual market conditions; the price it would pay for the logs approximately two-thirds of the way through the treatment of Unit 16 was reduced. Figure 4 shows the relative contribution of each income sector. Firewood is estimated to contribute 10% to the total revenue stream.

A comparison between all incurred costs to total income provides a slightly better result than the actual summer of 2001 situation. Instead of losing money, the logger would realize a small profit of $1,718, equivalent to $20.20/ac.

Conclusions

Forest restoration and fuels reduction projects are often considered cost prohibitive. It is expensive to harvest small trees and there are few suitable markets located near the projects that can afford to pay for the true cost of this wood. This case study, enhanced by analyzing costs and income via an economic model, provides some insights into these cost prohibitive claims.

The work presented here focused on the costs and income opportunities for an 85 ac, GFFP unit located in the WUI of Flagstaff, AZ that was thinned during the summer of 2001. Unforeseen changes in the regional market for wood—the loss of the firewood market and a change in pricing for pallet logs—detrimentally affected the logger's net return. If these changes had not occurred, Unit 16 could have provided a small profit of $7,857 or $92.44/ac to the direct-cost logger Instead, the logger lost, as estimated via a cost and revenue model, $3,284 or $38.63/ac. The logger's actual costs were estimated to total $124,117 or $1,460.20/ac and his estimated income totaled $120,833 or $1,421.57/ac.

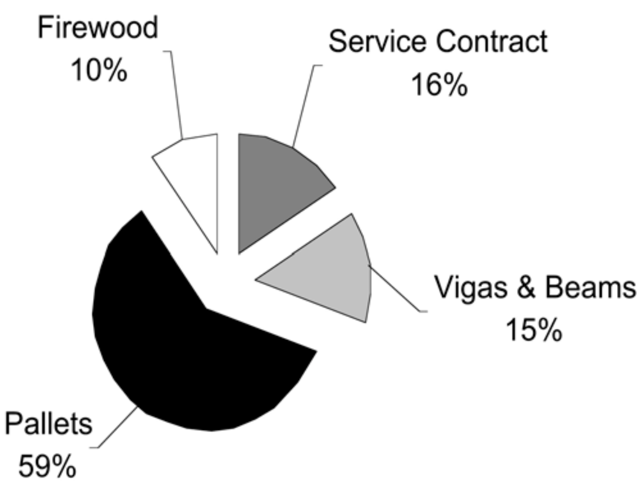

Figure 4. Logging contractor revenue if firewood market available.

Unit 16, through a cooperative agreement between the GFFP and the Forest Service, was a GFFP project where the Forest Service conveyed the timber to GFFP at no cost and the GFFP funded the thinning work. The GFFP's net costs, as a function of the service contract with an embedded timber fee, totaled $17,000 or $200/ac.

Also presented in this article was an estimate of the costs incurred by the Peaks Ranger District of the Coconino National Forest to prepare this unit for thinning and to conduct the post thinning activities. This estimate totaled $31,960 or $376/ac.

This work suggests that the net costs, incurred by the GFFP, the Ranger District, and the logger to complete the initial thinning and burning actions over this 85 ac unit of ponderosa pine forests, equaled a staggering $2,036/ac. Privately raised funds by the GFFP and income from the sale of the harvested logs offset these costs by 9.8 and 57.5%, respectively. The Forest Service and the logger assumed the remaining costs.

A better market for the merchantable wood—one that is located closer to the forests of northern Arizona, one that could pay more for the wood, or one that could utilize wood from trees <8 in. dbh, as well as the larger trees—would certainly enhance the current economic realities of these types of projects. Loggers could realize a profit, reinvest, and grow their businesses. The Forest Service, or in this case the GFFP, could recoup some of their costs vs. paying the logger to thin and remove trees.

Without these more suitable markets, it may become harder to complete on-the-ground projects. Logging contractors cannot stay in business under the conditions analyzed here, unless their service rates increase. Increased service rates without a comparable increase in Forest Service project dollars or without private donations from cooperators like the GFFP, will limit thinning, which is an important strategy for restoring forests and reducing fuels in the WUI.

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