Financial Results of Ponderosa Pine Forest Restoration in Southwestern Colorado

Dennis L. Lynch

Abstract—From 1996 to 1998, the Ponderosa Pine Partnership conducted an experimental forest restoration project on 493 acres of small diameter ponderosa pine in the San Juan National Forest, Montezuma County, Colorado. The ecological basis and the financial analysis for this project are discussed. Specific financial results of the project including products sold, revenues collected, harvesting costs incurred, and profits or losses realized are reported. Restoration costs are also compared with fire suppression costs experienced both in Colorado and nationwide. Using data collected since the conclusion of the project, the future potential for financing forest restoration in southwestern Colorado is explored.

Introduction

This paper presents specific financial results from a forest restoration project conducted by the Ponderosa Pine Partnership in southwestern Colorado. This Partnership was created by a group of organizations to explore potential benefits of forest restoration and includes Montezuma County, San Juan National Forest, Ft Lewis College, Colorado Timber Industry Association (CTIA), Colorado State Forest Service, College of Natural Resources, and Cooperative Extension at Colorado State University (CSU). The Partnership was formed because the County and the San Juan National Forest were concerned about several problems present in the 183,000 acre ponderosa pine forest northeast of Cortez, CO. These problems included:

- Potential for insect and disease outbreaks
- Risk of catastrophic forest fires
- Decline of small forest product businesses
- Recognition that ponderosa pine forests in this area are not within their range of natural variability and are probably not sustainable in their current condition (Romme 1999).

Dr. William Romme, professor in the Department of Biology at Ft Lewis College, Durango, CO, had principal responsibility for ecological data collection, development of an ecological prescription for this experimental forest restoration project, and subsequent monitoring. In his previous research in southwestern Colorado (Montezuma, La Plata, and Archuleta Counties) Romme (1999) reached generally similar conclusions as research from Arizona and New Mexico (Cooper 1960; Covington and others 1997; Dahms and Geils 1997; Fulé and others 1997). He found that in this forest area there were seven times more trees per acre today than in 1900. Specifically, there are 280 to 390 trees per acre today versus 40 to 50 trees per acre in 1900. Stands were characterized in 1900 by clumps of trees. These clumps were typically one-tenth to one-quarter acre in size, while today the clumped pattern of stands has largely been lost. Stump diameters of trees living in 1900 averaged 27 inches and ages were likely to reach 300 years. Today 95 percent of the trees are 16 inches in diameter at breast height or smaller and 110 years or less in age. Additionally, less than 20 percent of today's stands have pine regeneration. Mortality is also disproportionate, occurring in the very young and oldest trees.

He also discovered that fire frequencies have changed. For example, in the forest area, of which this study is a part, he found that during the period 1685–1872, the interval between fires ranged from 5 to 20 years, with a median of 12 years. In another part of the area he found that between 1729 to 1879 the range in fire frequency was 2 to 31 years with a median of 10 years. Since 1879, there has not been a fire that created a fire scar in most of the area.

On the basis of his research, Dr. Romme suggested that the current forest could be modified and restored to conditions similar to pre-1870 structure and processes. He designed an ecological prescription that retained large trees, developed the clumped nature of tree groups within the forest, developed glades and parks between tree clumps, reduced shrub understory while increasing the grass-forb component, and reintroduced low intensity fire as a process.

A dominant concern of this study was to ensure that the ecological prescription controlled implementation. It was also obvious that forest restoration could not proceed unless costs were paid. As previously stated, no government money was available to implement this study. Further it was highly unlikely that tax dollars would be appropriated to pay for forest restoration in any situation except, perhaps, those most severely threatening to life and property. Even then, the material to be removed would have to be disposed of in some way. Leaving thinning slash in the forest would only increase fuel loading and the probability of intense fires.

Sackett (2000) commented that prescribed burning alone has been unable to remove the volume of existing material in the Chimney Springs, AZ, area forest to a healthy state, let alone presettlement conditions. Recent catastrophic fires in the Southwest also attest to the danger associated with the use of prescribed fire alone. Therefore, this financial

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Dr. Dennis L. Lynch is Professor Emeritus, Department of Forest Sciences, College of Natural Resources, Colorado State University, Fort Collins, CO. At the time of this conference he was employed by State and Private Forestry, Region 2, Forest Service, USDA to complete research related to other forest restoration projects and the utilization of small diameter wood in Colorado. Dr. Lynch has completed three other similar cost studies on forest restoration in Colorado.

study was conducted to determine harvesting costs and potential revenues available from products removed in this experimental attempt at forest restoration.

It is also important to recognize that forest restoration projects are very different from typical timber sales. In forest restoration, the material removed is the least desirable from a product standpoint and may contain a predominance of small diameter trees that cost more to remove than they are worth. A large body of timber harvesting research, from the United States and internationally, clearly documents that manual or mechanical removal of small diameter trees is expensive. Thus the basic premise of forest restoration, which requires removing small trees and leaving the largest, presents a difficult financial problem. This problem is further complicated in Montezuma County because there are only a few local industries available to process small diameter material. Therefore, long haul distances are necessary to take small material to processing points. Forest Service procedures that required treating forest restoration activities as timber sales and an appraisal process that did not accurately estimate values of the material removed made the problem even more complex.

Carla Garrison Harper, representing Montezuma County, served as project coordinator for the Ponderosa Pine Partnership. The Partnership completed forest restoration on six representative sites in the Mancos-Dolores District of the San Juan National Forest. However, because financial data were incomplete and inconclusive on one unit, this report discusses financial results for five of the areas completed. These five study units totaled 492.6 acres. An overview of the ecological prescription, restoration work, costs, and subsequent monitoring is included in a paper by Lynch and others (2000). It does not, however, provide the cost detail presented here nor a comparison with wildfire costs.

Three key points should be emphasized:

- Dr. Romme's ecological prescription was formed on the basis of his previous research. The project objective was to restore the forest toward the ecological balance he envisioned.
- The Partnership did not have any Federally appropriated money to use to subsidize the removal of small diameter trees.
- After the largest trees had been retained in clumps, as specified by the ecological prescription, the excess material was removed and sold. The financial results presented here are for that undesirable and excess material. The project was not designed to make money, but to determine if forest restoration work based on good ecology could pay its way.

Description of Project Implementation

The five units selected for this study are representative of forest conditions in this area and are quite similar in regard to soil, slope, terrain, and access to haul roads. To implement forest restoration it was necessary, under existing Forest Service procedures, to transfer Dr. Romme's ecological guidelines to a timber sale format. Phil Kemp, forester with the Mancos-Dolores District, had primary responsibility for applying Dr. Romme's research and guidelines to develop and implement ecological restoration prescriptions. The retention of larger trees, and the clumped nature and spacing of tree groups were key considerations. Phil developed on-the-ground silvicutural prescriptions, and trained and supervised crews to mark the trees to be retained in the forest. He coordinated with Dr. Romme to develop a marking guide that would achieve the desired forest condition. Trees to be retained on the site were marked with blue paint. Following marking of each unit in this study, a cruise was conducted to determine the amount and character of the material to be removed. The Forest Service, using this information, prepared administrative timber sale contracts.

Montezuma County purchased each timber sale and arranged to pay for the wood removed and associated costs such as road rock replacement and slash disposal. Initially, costs to conduct the ecological and economic studies were also to be charged to the timber sale. However, research funds from other sources were secured to pay for the studies. Timber volumes and subsequent payments were initially based on cruise data that ultimately proved to be inaccurate. Cruise estimates tended to overestimate the amount of sawtimber available for removal and underestimate the volume of POL material to be removed. Such faulty estimates are of critical concern to both the Forest Service and small businesses. Cruise estimates of timber are not only costly to perform, but in forest restoration sales have the potential to be very erroneous because there is such great variation in the material to be removed. Therefore, weight samples were taken from logs and truckloads of logs were scaled after weighing to determine weight-volume relationships. Subsequent payments were based on weight, which proved to be more accurate and fair to both seller and purchaser.

CTIA coordinated with local industry and the San Juan National Forest to determine which industry firms were to be involved in the project. Ragland and Sons Logging of Dolores, CO, purchased the five timber sale units from Montezuma County and had primary responsibility for harvesting and marketing material removed from the forest. The material removed was used to produce a variety of wood products, some of which were experimental attempts to use small diameter trees. Every effort was made to market logs to processors in or near Montezuma County, but some small diameter material simply could not be processed locally. The bulk of this small material was taken as waferwood logs to the oriented strand board plant in Olathe, CO. At the plant, logs are debarked and processed through a waferizer, also known as a flaker, to create wafers or strands for oriented strand board production. Sawlogs from the sale were processed at the Ragland's Stonertop sawmill near Dolores into timbers and lumber. Material brought to the mill was appraised to all other possible mill sites and the value of the logs estimated on that basis.

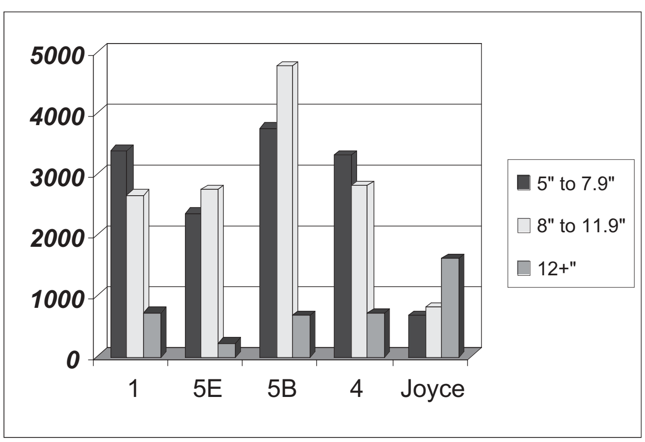
Ragland and Sons Logging utilized both manual (chainsaws) and mechanical (JD 743 Harvester) equipment for felling, limbing, and bucking (FLB) in this project. Slash was lopped and scattered in place for prescribed burning. Skidding was done with rubber-tired grapple skidders (CAT 518 and JD 540). Logs were loaded with a knuckle boom loader on conventional log trucks for transportation by product type to various mills. All trucks were weighed on scales to determine the amount of material removed.

We followed a program of adaptive management. As each unit was completed we reviewed the results to ensure that appropriate changes were made in the next unit to improve ecological accomplishment (Lynch and others 2000). Following logging, broadcast burning of slash by the Forest Service was used to reintroduce fire to the forest. Prescribed burning of these areas in later years will be done at intervals that are historically characteristic of these forests. This should result in low intensity fires in the future. Ecological monitoring of these areas is continuing.

Financial Studies and Results

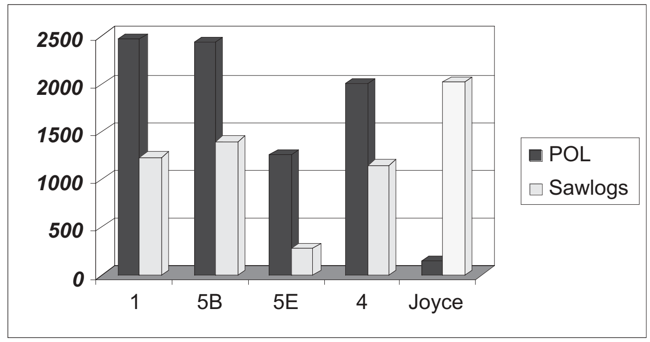
Study Methodology

In this financial study, we recorded every tree cut by diameter class. Distributions of trees removed by unit and diameter class are shown in figure 1. Every log skidded and every log loaded onto a truck were also counted. All trucks were weighed to determine the tons hauled by product type. The relationship of products other than logs (POL) to sawlog material by unit is shown in figure 2. Samples were taken from logs and sample truckloads were scaled by a Forest Service scaler to determine weight to volume relationships. Complete records of time and costs for all aspects of the operation were collected using established logging cost collection techniques. These included all costs associated with labor, equipment, oil, gas, diesel, supplies, field and office administration, and transportation involved in felling, limbing, bucking, skidding, loading, slash treatment (except prescribed burning), roads, and hauling logs. These costs are specific to the company participating in this study, so itemized cost information is not presented in order to respect the privacy of the firm. Revenues for each product were recorded



LEGEND
Left Axis — Number of Trees
Bottom Axis — Units
Bars- Diameter (DBH) Classes

Figure 1—Numbers of trees by unit and diameter class.



LEGEND
Left axis — Tons
Bottom axis — Units
Bars- POL or Sawlogs

Figure 2—Relationship of products by unit (tons of POL and tons of sawlogs per unit).

and profit or loss calculated. The efficiency of the logger was compared to USDA Forest Service regional average harvesting costs and harvesting cost studies in New Mexico, Arizona, Oregon, and Canada. Correlation analysis was used to compare the characteristics of units 1, 5B, 5E, and Joyce with unit profit. Initial analysis indicated that factors associated with the cold temperatures and deep snow in Unit 4 inflated costs and would bias results. Only correlations above 0.8 (+ or –) were considered strong enough to merit consideration.

Unit Results

Unit 1—Also known as the Smoothing Iron unit, Unit 1 is located on Haycamp Mesa and is 125 acres. A total of 6,754 trees were removed from the unit during August 25 to October 3, 1995. Figure 1 shows tree distribution by diameter class. In this unit, 1 cubic foot of ponderosa pine log at the landing weighed 71.78 lb with a standard deviation of 5.11 lb

The removal of trees resulted in the delivery of 1,232.76 tons of sawlogs to Stonertop sawmill in Dolores, 2,322.75 tons of waferwood logs to the Louisiana-Pacific oriented strand board mill in Olathe, and 145 tons of pine excelsior logs to Western Excelsior in Mancos. This was a relationship of 33.3 percent sawlogs to 66.7 percent products other than logs (POL) by weight. It amounted to a removal of 29.6 tons per acre. Any tree 8 inches d.b.h. or larger that would make a sawlog was taken to the sawmill. Other trees were taken for waferwood logs or pine excelsior logs. Table 1 lists unit revenue, and cost to the logger as well as profit or loss data per ton.

There was a total profit (total revenue minus actual costs) for the unit of $440.48. Note that this is total profit before taxes. No previous allowances for profit and risk or income taxes were made during cost collection or analysis.

The effort to develop pine excelsior was experimental. It was first believed that pine might be added as a supplement to aspen excelsior for certain applications and was, therefore, worth trying as a potential local outlet for small, poor quality logs. However, pine contains terpenes, a compound

Table 1— Unit summary of revenue, costs, and profit (loss) per ton.

Product	Revenue	Cost[a]	Stumpage		Profit (loss)
Unit 1—Smoothing Iron					
Waferwood	$31	$31.06	+ $1.51	=	(–$1.57)
Excelsior	$17	$23.35	+ $1.51	=	(–$7.86)
Sawlogs	$30.52	$22.64	+ $3.64	=	$4.24
Unit 5B—Found Park					
Waferwood	$31	$30.84	+ $1.32	=	(–$1.16)
Pulpwood	$18.82[b]	$16.87[b]	+ $1.32	=	$0.63
Posts-poles	$24.00	$22.81	+ $1.32	=	(–$0.13)
Sawlogs	$30.52	$20.86	+ $3.21	=	$6.45
Unit 5E—Found Park					
Pulpwood	$24.04[b]	$21.77[b]	+ $1.14	=	$1.13
Posts-poles	$24.00	$27.55	+ $1.14	=	(–$4.69)
Waferwood	$32.00	$35.37	+ $1.14	=	(–$4.87)
Sawlogs	$30.52	$30.52	+ $8.92	=	(–$3.76)
Unit 4—West Trail —"Snow Unit"					
Waferwood	$31	$36.20	+ $1.48	=	(–$6.68)
Sawlogs	$30.52	$26.42	+ $4.63	=	(–$0.53)
Joyce Unit					
Waferwood	$32	$27.10	+ $ 2.32	=	$2.58
Sawlogs	$30.52	$17.22	+ $ 5.21	=	$8.09

[a]Includes all costs described in text associated with logging and hauling logs to mill.
[b]Note: pulpwood revenue and costs are at the landing, not to the mill.

that has a characteristic pine odor and, when it occurs in sufficient concentrations, can be used to produce turpentine. Terpenes can also attract certain insects, such as termites, and in sufficient concentrations can interfere with the viability of seeds. Further, pine excelsior proved to be brittle and difficult to ship. These characteristics reduced the marketability of pine excelsior and, at this time, pine excelsior does not appear to be a viable product.

The effort to use ponderosa pine for waferwood was also experimental to a degree. Usually, wood materials of lighter density, such as aspen, are sought for waferwood used in the production of oriented stand board (OSB). However, Louisiana-Pacific at Olathe, CO, was willing to mix ponderosa pine from this area with other species as a test. This provided an excellent outlet for poor quality, small diameter material that would have been impossible to market elsewhere. The long haul distance of 160 miles to the plant contributed to losses for this product.

Unit 5B—This unit is also known as one of the Found Park units, and is located off Forest Road 521 on Ormiston Point. It is 108 acres. A total of 9,177 trees were removed from the unit during June 26 to November 11, 1996. Figure 1 shows the distribution of trees cut by diameter class. Ponderosa pine sawlogs at the landing weighed 72.81 lb per cubic foot with a standard deviation of 2.0 lb. The POL logs weighed 76.56 lb per cubic foot at the landing with a standard deviation of 4.03 lb. The removal resulted in the delivery of 1,397.44 tons of sawlogs to the Stonertop mill, 1,899.86 tons of waferwood logs to the Louisiana-Pacific mill, 353.07 tons of wood for posts and poles to Cannon Forest Products in Cortez, and 177.54 tons of pulpwood sold at the landing and ultimately delivered to Stone Container in Snowflake, AZ. This was a relationship of 36.5 percent sawlogs to 63.5 percent POL by weight and a removal of 35.4 tons per acre. Table 1 summarizes the per ton financial results by product for this unit. The total profit for the unit was $6,875.60.

Shipment of pulpwood to Snowflake, AZ, was another experimental attempt to evaluate potential markets. In this case, a trucker from Cortez was hauling house logs from an area near Snowflake to a location in Colorado. He needed a back haul to Snowflake and this provided an opportunity to explore this market. However, he estimated his costs resulted in a loss to him of approximately $8.00 per ton for the haul. Thus, this pulpwood market proved to be uneconomical to the trucker, although the revenue at the landing to the logger was near the break-even point.

Post and pole logs were sorted at the landing and trucked separately to Cannon Forest Products. It takes a reasonably straight, defect free, and uniform tree to yield a satisfactory post or pole. Forest restoration material, however, often contains large volumes of deformed, poor quality, small diameter material that does not fit post and pole specifications. Sorting out higher quality material can introduce additional costs. Also, the quantity of post and pole logs ultimately overwhelmed the small local mill capacity to buy and process the material.

Unit 5E—The second of the Found Park units is bisected by Forest Road 521 on Ormiston Point. It is 65 acres and almost equally distributed on either side of the road. A total of 5,307 trees were removed from this unit during May 29 to June 27, 1997. Figure 1 shows the distribution of trees cut by diameter class. In this unit, ponderosa pine logs at the landing weighed 71.68 lb per cubic foot with a standard deviation of 6.04 lb. This removal resulted in a delivery of 274.85 tons of sawlogs to Stonertop mill, 881.07 tons of waferwood logs to Louisiana-Pacific, 269.64 tons of wood for posts and poles to Cannon Forest Products, and 101.9 tons of pulpwood to Stone Container in Snowflake, AZ. This is a relationship of 18 percent sawlogs to 82 percent POL by weight and was a removal of 23.5 tons per acre. Table 1 presents the per ton financial data for this unit.

The loss for the unit was $6,473.71. This loss does not include any allowances for profit, risk, or income taxes. Factors contributing to the loss were a high stumpage rate for sawlogs coupled with the small amount of sawtimber removed from the unit. The high stumpage price resulted from cruise data that indicated there were more sawlogs in the unit than actually existed. Thus, the logger paid for material that did not, in fact, exist. This was a key reason for using a weight basis for subsequent sales of this low value material.

While pulpwood again appears to be profitable in this unit, the trucker had delayed in calculating his costs only to discover losses similar to those discussed in the narrative for Unit 5B. It is likely that the large amount of small material of poor quality created additional sorting and handling for post and pole logs, thus increasing costs.

This unit illustrates the financial losses that occur when there is a small percentage of sawlogs to POL material. It simply costs more to harvest small diameter material and when sawlogs are not present, overall costs increase. In addition, the stumpage cost for sawlogs was too high and that added to losses.

Unit 4—Also known as the West Trail unit, this unit is located off Forest Road 524. We refer to it as the "snow unit" because it was logged from November 11, 1996, to January 31, 1997, when the area was besieged with very cold weather and deep snows.

The unit is 95 acres. A total of 6,824 trees were removed from the unit. Figure1 shows the distribution of trees cut by diameter class. Ponderosa pine logs in this unit weighed 72.43 lb per cubic foot with a standard deviation of 4.6 lb. The removal resulted in the delivery of 1,152.51 tons of sawlogs to Stonertop Mill and 2,008.57 tons of waferwood to Louisiana-Pacific. This is a relationship of 36.5 percent sawlogs to 63.5 percent POL by weight. This was a removal of 33.27 tons per acre. Table 1 presents per ton financial results for this unit.

This resulted in a loss of $14,028.08. Factors contributing to this loss were increased costs from logging in deep snow and somewhat higher sawlog stumpage prices. The POL stumpage price was also near that of unit 1 and higher than units 5B and 5E. It is important to note that all of the other characteristics of this unit indicate it would have been a profitable unit, like unit 5B, if it had not been logged in deep snow. While it is often desirable to encourage winter logging of areas, this sale illustrates the importance of scheduling forest restoration sales during periods when costs will not be increased by weather conditions. It also underlines the need to provide flexibility for contract extensions when such conditions arise.

Joyce Unit—This unit is located in the Boggy Draw area, which is a favorable site for tree growth. It is 99.6 acres. A total of 3,101 trees were removed from this unit. Figure 1 shows the distribution of trees cut by diameter class. In this unit, ponderosa pine sawlogs weighed an average of 78.82 lb per cubic foot (the mean of two scaled loads). A total of 2,021.24 tons of sawlogs were delivered to the Stonertop mill and 142.46 tons of waferwood logs to Louisiana-Pacific. This is a relationship of 93.4 percent sawlogs to 6.6 percent POL by weight. A total of 21.72 tons per acre were removed from the unit. Table 1 presents the per ton financial data for this unit.

The total profit for this unit was $16,719.38. This unit is, from an economic standpoint, at the upper end of profitability for a forest restoration sale. It is at the opposite end of the spectrum from Unit 5E where the material removed was predominately POL. The quantity of larger trees on the site when the ecological prescription was applied resulted in the removal of more sawlog material than in the other units. The Joyce unit restoration would resemble a traditional timber sale if it had removed the largest trees from the site. However, the largest trees were left on the site in adequate densities and trees in excess of the prescription were removed.

Harvesting costs declined overall as a result of the removal of a larger proportion of sawlogs in this unit. The higher POL costs, which had been typical up to this point, were offset by the lower harvesting costs of sawlogs. In addition, the loggers had learned from our reports that POL was resulting in serious losses. In this unit they did everything possible to salvage material for sawlog use.

This unit illustrates that opportunities can arise to balance costly units (like 5E that have high proportions of POL), against units like this one to achieve break-even or profitable forest restoration projects. This may require combining scattered units at a variety of locations into one sale or adopting landscape scale restoration in order to modify costs.

Summary of Key Results

This forest restoration project incorporated five sale units covering a total of 492.6 acres and the removal of 31,163 trees (63.3 trees per acre) for use as sawlogs (6,075.8 tons), waferwood (7,254.71 tons), and other products such as posts and poles, pulpwood, and pine excelsior (1,047.15 tons). The loggers' costs in this study, for each step in the harvesting process except hauling, were less than USFS Regional averages and very comparable to cost studies from other areas. Forest Service and independent observers rated the restoration logging conducted by Ragland and Sons as excellent work.

Table 2 records a summary of profit and loss by unit. Total profit to the logger of $3,533.67 was 0.81 percent (less than

Table 2—Unit profit or loss.

Unit	Profit or (loss)	Per acre profit (loss)
1	$ 440.48	$ 3.52
5B	$ 6,875.60	$ 63.66
5E	$(6,473.71)	$(99.60)
4	$(14,028.08)	$(147.66)
Joyce	$ 16,719.38	$ 167.86
Total	$ 3,533.67	

1 percent) on gross revenues of $434,645.54. This approximates a break-even situation that is better than suffering a loss, but is hardly a model for a sustainable business venture. Usually, it is appropriate to expect profit and risk allowances of 10 to 15 percent for logging in this region.

Sale characteristics with the strongest correlation to unit profit were percent of sawtimber removed by unit (0.93356), number of trees per acre 12 inches d.b.h. or larger (0.92516), and cubic foot volume per tree (0.81464). Percent of POL was negatively correlated with unit profit (–0.93536).

Harvesting costs were also compared to unit profit. Individual harvesting cost elements that were most negatively correlated included felling, limbing, and bucking (–0.99989), loading of POL (–0.91372), and hauling of POL (–0.83338). Total POL costs were also negatively correlated (–0.88099).

The market conditions that existed at the time of this study were ponderosa pine sawlogs selling at $240 per 1,000 board feet, waferwood logs selling for $31 to $32 per ton, and post and pole logs selling for $24 per ton. Under those conditions, the analyses conducted in this study suggest that future restoration projects *in this area of Colorado* can be near the financial break-even point when material removed meets the following criteria:

1. Sawtimber should be at or above 40 percent of the total weight removed and POL should be at or below 60 percent of the total weight of material removed. Note the relationship of sawlogs to POL in figure 2 and then relate that to profit and loss in table 2. Utilizing trees in the 8 inch to 11.9 inch diameter class for the highest value product possible is critical to profitability. Payments for material removed should be based on weight scaling and not cruise data, given the variability of this material.
2. Six or more sawtimber trees 12 inches d.b.h. or larger should be available for removal per acre with an average cubic foot volume of 12 cubic feet per sawtimber tree removed. Given that forest areas are being reduced from 200 to 350 stems per acre down to half that number or less, this should not be viewed as a difficult problem in landscape scale projects. However, when units do not meet these criteria, they should be combined with other units to create break-even projects.
3. POL harvesting costs must be carefully managed. Note the summary cost distribution for waferwood logs in figure 3. Attention to cost control and record keeping is important when dealing with low value, small diameter material.
4. Felling, limbing, and bucking (FLB) costs must be kept as low as possible. Note the proportion of FLB costs to all POL costs in figure 3. In an analysis of the FLB cost per cubic foot of wood removed, mechanical felling was more expensive in all diameter classes in this study than manual felling. This is due both to the type of harvester used in this study and the scattered nature of the trees being cut. Also it is clear that forest restoration logging in adverse weather conditions should be avoided.
5. Loading and hauling costs for POL must be reduced. Note that the proportion of costs attributable to loading and hauling in figure 3 were 50 percent of all costs. It also suggests the need to strengthen and/or develop local manufacturing businesses that could use small diameter material and decrease hauling distances.
6. Stumpage prices for POL should be zero or less in some cases. Note in table 1 that the loss per ton for POL is often nearly equal to the stumpage paid for it. Also, as a general rule, the revenue from the lowest quality material, such as waferwood logs, must not be below $31 per ton to break even.

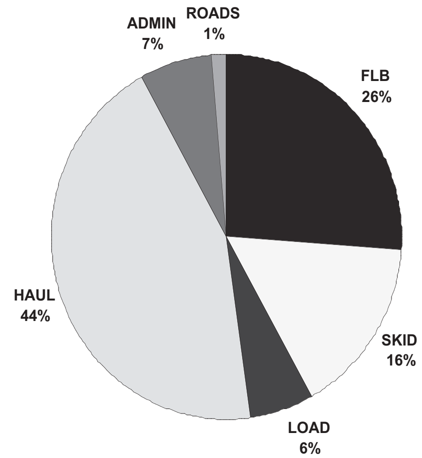


Figure 3—Cost distribution for waferwood harvesting.

Potential to Improve Profitability

Information developed from this study and other market studies by the author was used to persuade the USFS to revise its appraisal process for forest restoration projects in Region 2. Stumpage prices for ponderosa pine POL in Region 2 restoration projects may now be appraised at zero or even a negative value, because the basis for the project is ecological improvement of forest stands and POL material typically costs more to harvest than it is worth. In other words, this is recognition that POL is a liability, not a valuable product. This change would, for example, reduce the loss in Unit 5E from $6,473.71 to $1,204.28 and increase the profit in Unit 5B from $6,875.60 to $9,476.36. Thus, future restoration units with low value POL might actually be financially feasible if new appraisal policies are used.

In addition, tremendous demand for OSB in housing and commercial construction improved the market for waferwood logs immediately following this study. During the study, waferwood log prices paid at the mill were either $31 or $32 per ton. March 2000 waferwood log prices being paid ranged between $35 and $37 per ton. An average price of $36 per ton would have improved the profitability of this project to 7.3 percent. Similarly, a down turn in the OSB market or the ponderosa pine lumber market could adversely affect restoration projects. Thus, market fluctuations are important to consider when restoration projects are being planned.

We gained some insight into ways to reduce harvesting costs. Figure 3 shows the summarized cost distribution for one product, waferwood logs. Note that hauling and loading costs comprise a significant cost center as does felling, limbing, and bucking. Hauling costs could be reduced using more efficient trailers that better accommodate small diameter material. Research should be directed at the potential use of "hay rack" trailers or short log trucks with pup trailers commonly used for hauling pulpwood. Felling and bucking costs could probably be improved with mechanized equipment designed for harvesting small material. However, this requires further experimentation. If FLB could be mechanized efficiently there might also be some improvement in skidding costs. Logging should be planned to avoid adverse weather that increases costs.

We also have learned to avoid some products, such as pulpwood, that did not return sufficient revenue to cover costs or excelsior logs that are not technically feasible. Studies to improve utilization of wood wastes at the mills and the development of new products are also important to future profitability and sustainability of restoration projects.

Comparison of Forest Restoration Costs to Forest Fire Costs

In the previous analysis, the principal focus was on the identification of factors that could produce break-even or profitable forest restoration projects. This focus resulted from concerns that appropriated tax money would not be available for service contracts to accomplish restoration work.

However, there are important nonmarket benefits from forest restoration that might merit investment of public funds. One of these benefits is the reduction of catastrophic forest fire hazard. To analyze the economic benefit of fire hazard reduction, the costs or profit per acre from the five units were calculated and are presented in table 2. These costs were subsequently compared with local, State, and national fire suppression costs per acre.

The nearest large-scale fire to the study area was the 1996 Disappointment Fire that occurred in the pinyon-juniper forest type north of Dolores, CO. San Juan National Forest records show that this fire burned 3,840 acres and cost $992,000 to suppress. This is a per acre suppression cost of $258.33. That cost is almost double the worst-case restoration cost that occurred in Unit 4 (which had extraordinary snow costs and high stumpage costs). It is almost three times more expensive than Unit 5E, which had extensive amounts of POL and the highest stumpage costs in our study. Recall that the other restored units recorded profits. Also, all five restored units still have forests with large trees, pleasing esthetics, desirable wildlife habitat components, and ecologically functioning processes. The Disappointment Fire area, on the other hand, lost tree cover, esthetics, and wildlife habitat, while also requiring additional rehabilitation costs to reduce erosion and reestablish forest vegetation. Unfortunately the amount of those additional rehabilitation costs were not recorded.

From 1991 to 1996, U.S. Forest Service wildfires in Colorado cost an average of $482.78 per acre to suppress (USFS 1996). Property damage and rehabilitation costs for these burned areas were not recorded. During the period 1977 to 1992, national large fire costs averaged $570.98 per acre (USFS 1995). Again, property damage costs and rehabilitation costs for these fires were not recorded.

Suppression, property damage, rehabilitation costs, and subsequent flooding costs were studied for the 1996 Buffalo Creek fire that occurred in ponderosa pine near Denver. All costs after fire and flooding amounted to $679.47 per acre and are expected to climb to $2,000 per acre because of continuing flooding and water quality problems (Dennis 2000).

It can be argued that it may not be fair to compare fire suppression costs with forest restoration costs because no one can predict when and where a catastrophic fire will occur. However, because research in ponderosa pine forests suggests that fuel conditions for catastrophic fire are widespread and that fire can be expected to occur at some time, the comparison is not far fetched.

An estimate of expected fire suppression costs in restored forests versus suppression costs under current forest conditions was also developed as an example. Dr. Romme studied fire frequencies in the Five Pine Canyon area west of Units 5B and 5E. He found that fire frequencies during the past 30 years in the Five Pine Canyon area were similar to fire frequencies that occurred prior to Euro-American settlement. The Doe Canyon Fire occurred recently in this vicinity, just north and west of Units 5B and 5E, and serves as an interesting cost comparison. It covered 600 acres and fire observers noted that the fire was of low intensity and burned like a prescribed fire. Some of the area had been previously thinned, there are some open areas mixed with ponderosa pine forest areas, the terrain is fairly level, and it is likely that fire frequencies there have been similar to those identified by Dr. Romme in the adjacent Five Pine Canyon area. Fire suppression, in this case, consisted mostly of burning out from the roads. San Juan National Forest records show that the cost to suppress this fire totaled $7,500 or $12.50 per acre. Some small ponderosa pines were destroyed, but overall the forest remained intact. This better resembles the lower intensity type of fire expected in restored forests and may well suggest that the costs of future fire suppression in such areas will be much lower.

Commentary

Given the results of this project, I think two questions are pertinent to the future implementation of forest restoration projects in the Southwest. These are:

- Who is going to do the work and why should they do it?
- Why should appropriated tax money be used to finance forest restoration if well designed projects could pay for themselves?

It is clear that an ecological prescription must control project implementation to achieve the goals of forest restoration. Forest restoration projects are not traditional timber sales. Restoration of the forest to its inherent characteristics and processes is, after all, the basic purpose for these projects.

It is also just as clear that forest restoration is a risky, financially expensive proposition. In Colorado all of the forest industry businesses, except two, meet the qualifications for small businesses. Nearly all are family owned and operated, similar to the Ragland and Sons Logging Company studied in this report. It is presumptuous, therefore, to expect small businesses that characterize the forest industry of Colorado and the Southwest to make a silk purse out of a sow's ear, or low quality, small diameter material into a valuable product. Break-even projects or government subsidized programs may accomplish ecological objectives in the short term, but they will never result in the investments necessary to improve efficiencies, develop new products, and provide sustainable forest stewardship. Therefore, it is important to approach these projects with long-term financial sustainability in mind, providing loggers with incentives to function as forest stewards, providing a variety of restoration services such as watershed rehabilitation and wildlife improvement projects. By paying attention to factors that influence profitability, such as the use of new appraisal guidelines that recognize the low quality of this material and alertness to market fluctuations, agencies can improve the playing field for small businesses. A consistent supply of wood from well-designed projects with long-term contracts could encourage investments to improve efficiencies associated with harvesting and product manufacturing. To further aid in this, government could provide incentives in the form of tax advantages, low cost loans to create and strengthen small businesses, and applied research to improve harvesting efficiency and product development. For example, forest product studies currently under way through the Four Corners Initiative (Reader 1998) are intended to support profitability by increasing local utilization of material removed, improving manufacturing efficiencies, and creating new value-added products.

The lessons learned from our experimental forest restoration project are encouraging enough to recommend further projects, I hope, at the landscape level. I also recognize that other forest areas are so beset with worthless material that subsidies will have to support restoration.

Finally, restoration projects cost much less than forest fire suppression. Building a forest restoration infrastructure makes more financial sense than spending tax money fighting catastrophic forest fires.

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