Analysis of Forest Service stumpage prices in western Montana
Prices related to sale location and the marketplace

Candace Johnson-True
The University of Montana

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AN ANALYSIS OF FOREST SERVICE STUMPAGE
PRICES IN WESTERN MONTANA: PRICES RELATED
TO SALE LOCATION AND THE MARKETPLACE

By
Candace Johnson-True
B.S., University of Montana, 1976

Presented in partial fulfillment of the requirement for the
degree of Master of Science

UNIVERSITY OF MONTANA
1985

Approved by:

David W. Jackson
Chairman, Board of Examiners

Dean, Graduate School

March 14, 1986
Date
ABSTRACT

An Analysis of Forest Service Stumpage Prices in Western Montana: Prices Related to Sale Location and the Marketplace

Director: David H. Jackson

Within the last few years much attention has been focused on the use of transaction evidence procedures in the appraisal of timber. The majority of the models used in efforts like these quantify several basic sale characteristics used to predict bid price or stumpage value. This study is an extension of previous transaction evidence appraisal efforts. Significant advances are made through the introduction of measures of market structure, sale location, and existing inventories of stumpage. The resulting method can be used to appraise stumpage or to assign value to an inventory for sale, for tax assessment purposes, for planning, and for investment analyses.
ACKNOWLEDGEMENTS

This study could not have been completed without the encouragement and advice given me by my committee chairman, Dr. David Jackson. Special thanks to Dr. Alan McQuillan, who as a member of my committee also rendered invaluable guidance and support, and to the additional member of my committee, Dr. Maureen Fleming.

Additional thanks go to many at Champion International, especially to Jim Runyan, Ernie Corrick, and Andy Lukes, who generously allocated me the time and resources necessary to complete the study.

I am grateful to Tom Coston, Regional Forester, and other Forest Service staff members for the cooperation given me. A special note of thanks is extended to Jim Merzenich for the time spent answering questions and supplying information.

And last but not least, I gratefully acknowledge my family, Tim and Jordan True. Without their infinite support and patience I would never have concluded this project.
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Chapter 1

INTRODUCTION

Within the last few years much attention has been focused on the use of transaction evidence procedures in the appraisal of stumpage. As this method has been more widely applied, many analyses have been done which identify important factors affecting stumpage value and develop final regression models to be used in the appraisal of stumpage.

The majority of the models used in efforts like these quantify several basic sale characteristics and some market variables used to predict bid price or stumpage value. Often these models are stratified by area or forest because of the differences in the local marketplace which have not been quantified, but which affect the value of stumpage. Often, too, the models are adjusted over time as the economy and local markets for stumpage change. Variables may be added or subtracted from the model as often as every six months. Inclusion of some of these changing market factors in the models would enhance their stability and apparent usefulness to some decision makers.

Variables are often included in the transaction evidence stumpage appraisal models that measure distance to a marketplace. These variables are used to estimate the effects of haul cost on the sale value. But in fact, the haul distance used is often not reality, but is only the appraiser's estimate of the haul distance to a likely destination. Elimination of this measure and inclusion of a more objective location variable would further enhance the models and eliminate the assumption of this end-destination.
A better measure of sale or inventory location relative to markets, and quantifiable measures of market structure are urgently needed. The aim of this study is to develop some measures of market structure, and to relate them to the location of a sale. A model including such measures could be used to better estimate the value of an inventory. The resulting values can be used in appraisal, decision-making, planning, and in investment analyses.

While this is a case study of four specific national forests in western Montana, the methods developed could be modified and updated to be applied elsewhere.
Chapter 2

STUDY OVERVIEW

Objective

The objective of this study was to develop some measures of the structure of the market in which a sale exists, to relate the market to sale location, and to use these to predict sale value. The effort was not focused on developing a final predictive model, but on examining several possible relationships. A model was developed that describes timber sale value as a function of:

1) some basic timber characteristics, 
2) some administrative characteristics of the sale, and 
3) the market conditions existing at the time of the sale.

The approach taken here is an extension of that used by others to predict timber sale value. Most of the sale characteristics and market variables are information that is widely available for all sales or inventories. This particular analysis utilizes Forest Service data readily available to potential purchasers, and some data easily produced from other sources. Similar information can be obtained on other sales and timber inventories.

Sale Value

The economic value of stumpage is measured in the marketplace. It is very difficult if not impossible, to ascertain the value of stumpage in any other context. It is not the aim of this study to approach the issues concerning intangibles, such as aesthetics, the value of wilderness, etc. Nor is the objective examining competition, overbid, or addressing the issues pertinent to those areas. The intention is
merely to better quantify market value. The best directly available measure of market value of a timber sale is the high bid price paid for a quantity of stumpage in the marketplace. The high bid price was determined from Forest Service records.

Variables Related to Sale Value

Timber Characteristics

Several characteristics of a timber sale are commonly used to predict the value of a sale. These include the quantity and quality of timber, and measures of costs associated with harvesting the timber. A measure of these factors was defined, and data collected from Forest Service files to quantify each.

Administrative Characteristics

Other factors influencing sale value are administratively determined, but not characteristics of the timber resource itself. This category includes contract terms such as length or duration of the sale, method of sale, penalty clauses, deposits required, etc., which affect sale price. The only factor in this category included in the analysis is determination of whether a sale is a Small Business Administration (SBA) set-aside sale or not. This information is also collected from Forest Service files.

Market Conditions

The third category consists of external market factors affecting sale value. This category includes economic conditions existing at the time of the sale, as well as the structure of the local marketplace in terms of the number and kind of potential buyers that exist. Measures
of these are not directly available from the national forest, but information used to determine them is readily available from other sources. The development of the measures of market structure will be detailed in the next chapter.

Analysis

Regression techniques were used to examine some available measures of market conditions, sale and administrative characteristics, and how they relate to sale value. The results of this modeling effort can be used in the appraisal of stumpage for sale, or in the valuation of a quantity of stumpage and the decision-making processes affecting a stand of timber.
Chapter 3

LITERATURE REVIEW

By the end of the 1960's western Montana was heavily dependent on the wood products industry. Forty-three percent of total employment in the state in 1969 was attributed to that industry (Johnson, 1976). The timber industry has historically been centered in the western part of the state. Sawmills operated in half of Montana's counties in 1976, but 80 percent of the lumber production was concentrated in the seven western counties. Timber supplying the mills came from a variety of sources: 34 percent from private industrial lands, 17 percent from other private lands, and the remaining 49 percent from public lands (Keegan, 1980).

Since only timber directly owned by the manufacturer is not marketed in some fashion, the majority of the timber supplied in Montana is sold on the market, and the stumpage price is determined under a variety of conditions existing at the time of the sale. Once the decision to sell timber is made, the seller often uses some method of appraisal to ascertain the value of the timber under consideration. There are several appraisal methods available to be used and, depending upon the identity of the seller and the resources he has available, he may choose from them. The Forest Service, as a seller of timber, has traditionally used an analytical method called conversion return (Davis, 1966), but more recently that agency has begun to use an alternative method called transaction evidence appraisal.
Because traditional methods are cumbersome and time consuming, transaction evidence appraisal offers an attractive alternative. The primary advantage is the lack of need to consider potential end uses of timber when doing the appraisal, as well as production of stumpage values that are linked directly to stumpage market transactions (Beuter, 1971). Simply, a stumpage value is predicted using a series of similar recent transactions and the prices observed in those observations.

One of the first attempts to use transaction evidence was in appraising pine sawtimber in South Carolina (Anderson, 1961). The price for a stand of sawtimber was predicted, using regression techniques, based on the average pine sawtimber price, the volume per tree, the haul distance to the nearest mill, and the geographic location. Anderson (1976a, 1976b) later modified this technique and applied it to multiple-product sales, including in the analysis the average wholesale lumber price, some stand characteristics, and location as above. The average wholesale price accounted for the variety of products and the time period of the sale. Sales were grouped by location according to similar prices and number of bids.

Other examples of this technique include the work of Darr (1973) and Randall and Darr (1974), who tested the use of average stand diameter as a predictor of Forest Service stumpage prices. Johnson (1979) developed stumpage price equations using sale appraisal characteristics for some Forest Service timber sales dating from 1973-1975. Jackson and McQuillan (1979) extended previous work and developed a diameter variable that summarizes the size distribution of the timber included in a sale. They provided a model predicting the selling value
of timber as a function of this variable and other sale characteristics. Jackson and McQuillan (1978) further extended this work, using this model as a valuation technique in a timber supply study in Montana.

More recently, transaction evidence is being used successfully to appraise Forest Service timber in Region One (USFS, 1983; USFS, 1984; USFS, 1985). Sale characteristics and some economic variables are included in equations used to predict stumpage value. The minimum acceptable bid for the timber sale is set by adjusting the predicted price downward statistically. Sales are stratified to produce sets of equations for different geographical areas, and the resulting equations are adjusted frequently as the market changes.
Chapter 4

METHODS

The approach taken here is an extension of that used by others. The objective was to test some relationships between timber sale value and sale characteristics, not to develop a final predictive model. Regression techniques were used to develop a model explaining timber sale value. In addition to the sale characteristics and economic indicators commonly used as independent variables, several market variables were added to the model, resulting in the general form below:

\[
\text{Sale Value} = \text{function of (sale and administrative characteristics, and market characteristics)}
\]

Study Design

Given the objectives of this study, and limited time and resources, a pilot study was conducted. The hypotheses were tested on four national forests in western Montana: the Bitterroot, Lolo, Flathead, and Kootenai. Together these forests encompass the seven western Montana counties which accounted for 82 percent of the roundwood products harvested in Montana in 1976 (Keegan, 1980). Sale data was directly available from the Forest Service unless otherwise noted, and was collected for all sawtimber sales containing over one million board feet for which records existed at the Region One Office located in Missoula.
The sample consists of 203 timber sales located on the four selected forests. Data were collected for sales awarded from January of 1974 through December of 1980, and ranging in total value from $34,395 to $2,888,573 and total volume from 1.01 to 24.0 million board feet. All dollar amounts used were converted to first quarter 1980, and are expressed in per thousand board feet values. A list of all variable definitions, measurements and ranges is detailed in Appendix A.

**Determination of Timber Sale Value**

Sale value is the dependent variable and was measured using final adjusted high dollar bid price per thousand board feet for each timber sale. The adjusted bid price reflects the purchaser's valuation of the worth of a quantity of timber, as well as his estimate of costs, and an allowance for profit and risk. The final high bid value was directly measured, then adjusted by the addition of several items. The factors added to each sale's high bid price include ineffective road credits, environmental protection cost, temporary development cost, and road maintenance cost. Each of these is a fixed contractual cost per thousand board feet harvested which the purchaser is required to pay in addition to the stumpage price, thus adding to the effective price paid for each sale. Inclusion of these in the predicted value of each sale standardizes all sales with respect to each other and allows prediction of the effective total price a purchaser is willing to pay for stumpage.
Timber and Administrative Characteristics

Several sale characteristics have been chosen to describe each timber sale. These characteristics measure the quantity and quality of the stumpage included in a timber sale, and the harvesting and transportation costs involved in utilization of the stumpage. They are measured directly and may be characteristics of the timber itself, or administratively determined. Most of these variables are not unique to this study but are very similar to those used in other related modeling efforts. They are attempts to measure things affecting a purchaser's valuation of a sale.

Quantity of Stumpage

The first characteristic considered is the size of the timber sale. There are several measures which can be used to estimate sale size. The total net volume included in the sale and the length of the sale contract are two such measures. Although contract length is administratively determined, it is an index of sale size and is highly correlated with the quantity of volume included in the sale. These measures of sale size cannot be used together in a regression model because of the multi-collinearity that exists in the model.

Because it is the most direct measure, the final measure of sale size chosen was net stumpage volume. To a certain degree, large sales should be more attractive to purchasers because the large quantity of stumpage results in some security of raw material supply. However, at some point the usual correspondingly larger capital outlay and future uncertainty involved should reduce the attractiveness of progressively
larger sales to the purchaser. It was hypothesized, therefore, that the relationship between sale size and sale value should be curvilinear and positively sloped. In order to reduce the number of variables in the model the measure of sale size was expressed as the natural log of the total net sawtimber included in the sale.

Quality of Stumpage

A second important factor in determining stumpage value is the quality and type of timber included in a sale. Quality may be roughly estimated in terms of the size of the timber, defect present, and the purchaser's estimation of value based on quality, cost, grade recovery and other factors.

The size of the timber was measured using weighted average diameter. It was hypothesized that the relationship between average diameter and sale value is curvilinear and positively sloped. Another measure of the size of timber in a sale would involve incorporation of a logarithmic function that summarizes the size distribution of timber, as proposed by Jackson and McQuillan (1979). However, this information was not readily available for all sampled sales, so it was not used in this study.

Total percent defect was also recorded for each sale and a negative coefficient was expected for this variable.

The average purchaser's current value estimation including quality, cost, grade recovery, and other factors on similar volumes of stumpage is measured using the selling price log scale (expressed in
1980 dollars). It was hypothesized that a positive linear relationship would exist between sale value and selling price log scale.

Measures of Logging Cost

The third factor which a purchaser includes in his valuation of a timber sale is the cost associated with harvesting and removing the stumpage to conversion facilities. Although these costs vary by operator, and are themselves not directly observable, variables used to approximate them can be measured. Included are factors which affect the accessibility and difficulty of the logging chance such as the proportion of volume jammer and skyline logged, yarding distance for each logging method, percent of volume clearcut, harvest volume per acre.

The logging method is generally dependent upon the percent slope and to some extent the silvicultural characteristics and physical location of the stand. Only the average slope is available for each sale, and the majority of the time this average lies between 35 and 45 percent. Because it is an average, the variation in slope is lost, so this variable was not included in the analysis. Since the logging methods required generally reflect the physical conditions, inclusion of these variables should account for some of the variation in slope and cost expected by the purchaser. It is expected that as the volume of stumpage harvested using jammer or skyline systems increases, and as the yarding distances increase, the value of a timber sale will decrease. Several interaction variables were included in the model, as well as those mentioned above.
The percent of volume clearcut was included as a measure of the difficulty of logging. It was expected that as this percent increases, the value of a sale will increase.

Harvest volume per acre was also recorded for each sale. It was hypothesized that a positively sloped relationship would exist between this and sale value, but that the relationship should be curvilinear. In order to keep the number of variables to a minimum, this variable was expressed as the natural log of the harvest volume per acre.

**Transportation Costs**

Transportation costs must also be quantified. Generally this has been done in the past using the haul distance (paved and unpaved) estimated by the Forest Service to the appraised marketplace. It has been noted that this appraisal point is not in fact always the point to which the sale is delivered, but is usually the closest "reasonable" market estimated by the Forest Service. The actual costs observed by the purchaser will vary as the delivery point of the stumpage varies from that estimated by the appraisor. It is also true that stumpage from a particular sale may be delivered to several destinations, depending upon species, size of the material, and the end product. Forest Service haul distance has sometimes been significantly related to sale value, but it is interesting to note that several previous studies have found this variable to be not significant or of low value in predicting sale price (Jackson and McQuillan, 1979; USFS, 1985), probably because of the low amount of variation in haul distance.
relative to sale price. Accordingly, the Forest Service estimate of haul distance was not included in the proposed model.

But transportation costs, contributing a significant amount to the purchaser's costs, should somehow be accounted for. The problem is that a single point of delivery, if assumed, is often erroneous. We argue here that haul distance is an important cost factor, but because the actual delivery point is not known, the distance is actually more important in modeling efforts like this in terms of how it relates a sale to the surrounding marketplace. The marketplace in western Montana was described for our purposes as consisting of nine milling areas (see page 17 for a detailed description of this procedure), and further, a center was defined for each of these areas. In light of the above discussion relating distance to the marketplace, it was hypothesized that the distance from a sale to the center of each milling area would give us an estimate of all possible haul costs, and allow us to locate the sale in relation to the marketplace. Accordingly, the haul distances paved and unpaved were recorded from each sale to the center of each milling circle, using a current road map and electronic planimeter. The final distances computed were weighted, to mimic actual differences in haul cost between paved and unpaved roads, with the total distance used equaling paved distance plus three times the unpaved distance (USFS, 1984).

Administrative Characteristics

The only administrative variable we included in this study was a dummy variable identifying Small Business set-aside sales. This has
been shown in past studies to be related to sale value. Designation of a sale as a set-aside sale limits the potential buyers to small businesses, and because of the resulting lessening of competition, should result in lower sale value.

**Market Characteristics**

The primary thrust of this project was to identify some general market variables that could be used to describe the setting in which a quantity of timber is sold. It was hypothesized that holding sale characteristics constant, sale value will fluctuate as a result of changes in the following market factors:

1) the existing inventory of sawtimber available for harvest,
2) the condition of the economy, and
3) the marketplace. The marketplace may be quantitatively defined by:
   a) the number of mills,
   b) the milling capacity present (the demand for raw materials),
   c) the distribution of the milling capacity, and
   d) the location (relationship) of each sale with respect to the potential buyers, the milling capacity, and distribution of capacity.

**Inventory of Raw Materials**

The demand for raw materials and resulting changes in a sale's stumpage value, should be strongly related to the availability of other stumpage to the purchaser. During the period from 1974-1980, a large proportion of the timber harvested in western Montana came from private
lands, so the dependence on outside sources for raw materials was not complete. However, estimates of quantities of private sawtimber existing by location are not readily available. A significant portion of the sawtimber harvested was also from public lands, and information about this harvest was available. One measure of the availability of stumpage is the volume of uncut Forest Service timber under contract. Since the availability of this volume depends on its location relative to the purchaser, the volume was recorded for the national forest which the sale was located on. It was hypothesized that as the volume under contract (the alternate supply) increases, the value of a proposed timber sale will decrease.

Economic Conditions

Traditionally the demand for sawtimber has been correlated with the level of construction which depends to some extent on economic conditions. One measure of the level of construction is the number of housing starts, seasonally adjusted (in millions of units). It was expected that, because of the cyclical nature of the housing and construction industry, the demand for wood products would not be exactly correlated with the level of housing starts, but will lag somehow in relation to them. It was hypothesized that the value of a timber sale will be positively related to the 12-month trend in housing starts. The trend was expressed as the number of housing starts 12 months prior to the sale divided by the number of starts at the time of the sale and was recorded as a percentage.
Marketplace

The next task involved describing the structure of the marketplace and how it influences the value of a timber sale. The number of potential buyers, the milling capacity existing, the distribution of that capacity, and a sale's location in relation to all of these will determine to a large extent the value of the sale. None of these factors alone can determine the marketplace structure, but each must be considered in relation to the others. Let us first examine the simplest measure of each of these factors, then the expected interrelationships.

In order to examine the stumpage markets existing in western Montana, nine milling areas were identified. Milling areas were subjectively defined as the primary geographical centers of milling capacity. The areas tend to be population centers, and are often but not always equivalent to counties. The center of each area identified was designated as the town or city having the bulk of the milling capacity in the area (see Figure 1). For each of these nine areas, the key descriptive market characteristics were obtained for each year included in the relevant time period (1974 through 1980).

The number of mills was estimated for each milling area during each year under study. Another possible measure of the number of buyers is the number of potential bidders, but this number would have been more difficult to obtain. Many contractors and small purchasers exist, only some of whom are actively involved in buying stumpage. Exhaustive research into the bidding patterns, contractors, etc., was beyond the scope of this study. It was reasoned that the number of end users was a reasonable estimate of the potential number of buyers in each center.
Figure 1. Location of mill area centers in western Montana.
The number of mills was identified for each area for each year using a variety of sources, and cross-checking each (Keegan, 1980; DNRC, 1980; Anonymous, 1981; Hearst, 1981; Anonymous, 1980). All mills that were identified are included, regardless of mill size.

The plant milling capacity was determined for each milling area for each year using a variety of sources, and cross-checking each (Keegan, 1980; DNRC, 1980; Anonymous, 1981; Hearst, 1981; Anonymous, 1980). The capacity was measured in terms of annual sawtimber volume capacity (million board feet Scribner). The following assumptions and conversion from production figures were made in order to convert all capacities to the same scale (Keegan, 1980):

1) All mills operate 240 days per year,
2) Sawmills run two shifts per day, and
3) Plywood plants run three shifts per day.
4) Conversion factors used to equal 1 board foot Scribner:
   lumber production - 1.3 board feet lumber tally,
   plywood production - 2.42 sq. feet 3/8" plywood.

The results of compiling data from all sources and converting production figures to plant capacity are shown in Table 1. The capacities at each milling area at the date of sale were recorded for each lumber sale sampled.

Also very important when describing the market in which a sale exists, is the ownership of milling capacity. Certainly there will be differences in market power and sale value in situations where eight or nine mills share equal amounts of the capacity, as compared to the extreme situation where one mill owns 100 percent of the capacity in the area. In an attempt to quantify the distribution of capacity, a curve
Table 1. Plant capacity by mill area for western Montana.
Plant capacity expressed as units of raw material for all sawmills and plywood plants (million board feet Scribner).

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was constructed for each center for each year using techniques similar to the Lorenz curve method outlined by Bowman (1945). The cumulative percents of aggregate plant capacity were plotted arithmetically against the cumulative percents of mills owning that capacity, beginning with the smallest mill in the area. If mill capacity was equally distributed, the plotted distribution would result in a straight line as indicated in Figure 2. The more convex the plotted distributions are, the more unequal is the distribution of plant capacity. Assuming the area under the straight line to be equal to one, the areas under each actual curve were measured as a proportion of the area defined by equal distribution of capacity. The smaller the number, the less equal the distribution of mill capacity observed. Since capacity or size of the plant is related to size of the firm, which translates into economic or market power, more unequal distribution of capacity is related to concentration of market power. As the distribution becomes more unequal, the value of a timber sale should decrease because the stumpage market is less competitive (Mead, 1966). The concentration ratio was obtained for each milling area for each year, and the concentration ratio existing for each milling area at the time of the sale was recorded for all timber sales.

An alternative measure of concentration is the amount of capacity the largest mills control. This was calculated by dividing the capacity owned by the largest mill by the total capacity for a mill area, and was expressed as a percentage.

Now that we have described the marketplace in terms of the characteristics above, we must relate these descriptors to the timber sale.
Figure 2. Concentration of mill capacity plotted for the Kalispell/Columbia Falls mill area. The shaded area represents the actual distribution of capacity observed for that area for the period 1978-1980.
It can be suggested that as the number of mills, mill capacity, and distribution of capacity each increase independently, competition for a timber sale will increase and the value will increase as a result, all other things being held constant. However, each of these is interrelated to the others, and it is upon the compounded effect that sale value depends. Also, the relationship of sale value to these factors, together or combined, depends directly upon the location of the sale with respect to the number, capacity and distribution of mills.

The question then became a problem of how to relate the sale location to the marketplace. It was decided that the distance between each sale and milling center is a reasonable measure of location, as well as relatively simple to determine. For a description of the methodology used, see the section titled Transportation Costs (p. 14). The market variables were aggregated for each sale by dividing each mill area variable by the distance to the milling center and summing as follows:

1) Aggregate number of mills related to sale location is expressed as:

$$\sum_{i=1}^{9} \left( \frac{\text{NUMB}_i}{\text{DIST}_i} \right)$$

where

- \(\text{NUMB}_i\) = number of mills in mill area \(i\)
- \(\text{DIST}_i\) = haul distance from sale to mill center \(i\)
- \(i\) = subscript referring to each of nine milling areas

2) Aggregate mill capacity related to sale location is expressed as:

$$\sum_{i=1}^{9} \left( \frac{\text{CAP}_i}{\text{DIST}_i} \right)$$
where $\text{CAP}_i$ = plant capacity in mill area $i$
$\text{DIST}_i$ = haul distance from sale to mill center $i$
$i = \text{subscript referring to each of nine milling areas}$

3) Aggregate concentration of mill capacity related to sale location is expressed as:

$$\sum_{i=1}^{9} \left( \frac{\text{OCNC}_i}{\text{DIST}_i} \right)$$

where $\text{OCNC}_i$ = Lorenz concentration ratio for mill area $i$
$\text{DIST}_i$ = haul distance from sale to mill center $i$
$i = \text{subscript referring to each of nine milling areas}$

4) Aggregate concentration of mill capacity related to sale location is alternatively expressed as:

$$\sum_{i=1}^{9} \left( \frac{\text{MBIG}_i}{\text{DIST}_i} \right)$$

where $\text{MBIG}_i$ = capacity of largest mill in area $i$
$\text{DIST}_i$ = haul distance from sale to mill center $i$
$\text{MBIG}_i$ = percent of capacity owned by largest mill in area
$i = \text{subscript referring to each of nine milling areas}$

5) Aggregate mill capacity and number of mills (average capacity) related to sale location is expressed as:

$$\sum_{i=1}^{9} \left( \frac{\text{CAP}_i}{\text{DIST}_i \times \text{NUMB}_i} \right)$$

where $\text{CAP}_i$ = capacity in mill area $i$
$\text{DIST}_i$ = haul distance from sale to mill center $i$
$\text{NUMB}_i$ = number of mills in area $i$
$i = \text{subscript referring to each of nine milling areas}$

25
The aggregation of the market variables as above allows the summarization of each of the mill area/sale location variables into one for each sale, rather than the nine that would be necessary if all milling areas were to be individually included. It seems reasonable to do this because the value of a single sale should depend upon its aggregate location, i.e., its location relative to each milling center and the structure of each center.

**Model**

The value of a sale rests not only on some intrinsic characteristics of the sale itself, but also on the market. A regression model was proposed to test sale value as a function of sale and administrative characteristics, and some variables describing the marketplace. The form of the proposed model was:

\[
BID = B_0 + B_1 \ln SNVOL + B_2 SPLS + B_3 \ln DBH + B_4 ADEF + B_5 (PVJA * YDGL) + B_6 (PVSK * YDSK) + B_7 PVCC + B_8 \ln HVPA + B_9 SBA + B_{10} FSVOL + B_{11} HIREND + B_{12} \sum \left( \frac{CAP_i}{DIST_i} \right) + B_{13} \sum \left( \frac{CONC_i}{DIST_i} \right)
\]

where

- **BID** = the adjusted high bid price per thousand board feet
- **SNVOL** = net sawtimber volume included in the sale
- **SPLS** = weighted average selling price log scale
- **DBH** = weighted average DBH
- **ADEF** = average defect
- **PVJA** = percent of volume jammer logged
- **PVSK** = percent of volume skyline logged
- **YDGL** = mean external yarding distance jammer
- **YDSK** = mean external yarding distance skyline
PVCC = percent volume clearcut

HVPA = average volume per acre harvested

SBA = dummy variable used to identify SBA sales

FSVOL = National Forest uncut volume under contract

HTREND = twelve-month trend in housing starts

\[ \sum_{i=1}^{9} \left( \frac{\text{CONC}_i}{\text{DIST}_i} \right) \] = the aggregate mill concentration related to sale location

\[ \sum_{i=1}^{9} \left( \frac{\text{CAP}_i}{\text{DIST}_i} \right) \] = the aggregate mill capacity related to sale location

\[ \ln = \text{natural logarithm} \]

Other market variables were eventually substituted for the two specified here in the proposed equation. The equation is listed here only to indicate its general form.
Chapter 5

RESULTS

Introduction

The results of the effort to examine sale and marketplace relationships using a variety of sale and market characteristics are presented in this section. The analyses were done using a step-wise regression model available in SAS. All tests were one-tailed, as the non-zero significance and the sign of each coefficient was hypothesized. Since the relationships between variables were of interest, a regression model was developed and is described in Table 2.

The model explains 74 percent of the variation in bid price per thousand board feet (Table 2). As indicated by the prob-value in column five, all of the coefficients are significantly non-zero at the alpha equals .10 level, and most at the .05 level or above. The model is presented in this format because the goal was not to develop a final predictive model, but to test some relationships. Readers may screen the results and draw their own conclusions as to the appropriateness of each variable. The null hypothesis is rejected if the prob-value is less than the value of alpha chosen by the modeler. The results of the analysis, as presented here, include all variables that were significant at the alpha equals .10 level.

Sale Characteristics

Most of the variables used to describe the sales themselves were significant, and the signs of the coefficients were as expected.
Table 2. Final regression model developed when examining sale and market characteristics.

Dependent variable ............... BID = adjusted bid price

Multiple $R^2 = .74$ Standard Error of Estimate = 25.31

Analysis of variance:

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<tr>
<th></th>
<th>Degrees Freedom</th>
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<th>Mean Square</th>
<th>F</th>
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<td>333901.154</td>
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<tr>
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<td>182</td>
<td>116569.965</td>
<td>640.494</td>
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<table>
<thead>
<tr>
<th>(1) Variable</th>
<th>(2) Regression coefficient</th>
<th>(3) Standard error</th>
<th>(4) F value</th>
<th>(5) Prob-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT</td>
<td>-266.488</td>
<td></td>
<td></td>
<td>.0004</td>
</tr>
<tr>
<td>ln (SNVCL)</td>
<td>11.017</td>
<td>3.047</td>
<td>13.07</td>
<td>.0001</td>
</tr>
<tr>
<td>SPLS</td>
<td>0.450</td>
<td>0.035</td>
<td>164.15</td>
<td>.0001</td>
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<tr>
<td>ln (DBH)</td>
<td>88.888</td>
<td>11.075</td>
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<td>.0001</td>
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<td>ADEF</td>
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<td>0.414</td>
<td>5.74</td>
<td>.0176</td>
</tr>
<tr>
<td>PVJA*YDGL</td>
<td>-0.0007</td>
<td>0.0002</td>
<td>10.79</td>
<td>.0012</td>
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<td>PVSK</td>
<td>-0.561</td>
<td>0.079</td>
<td>50.28</td>
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<tr>
<td>ln (HVPA)</td>
<td>7.681</td>
<td>4.361</td>
<td>3.10</td>
<td>.0799</td>
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<td>SBA</td>
<td>-31.919</td>
<td>4.398</td>
<td>52.66</td>
<td>.0001</td>
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<td>FSVOL</td>
<td>-0.042</td>
<td>0.015</td>
<td>8.35</td>
<td>.0043</td>
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<td>HIREND</td>
<td>0.061</td>
<td>0.028</td>
<td>4.70</td>
<td>.0315</td>
</tr>
</tbody>
</table>

$$\sum_{i=1}^{9} \left( \frac{\text{CAP}_{i}}{\text{DIST}_{i}} \right) = 4.294 \quad 0.976 \quad 19.37 \quad 0.0001$$

$$\sum_{i=1}^{9} \left( \frac{\text{CAP}_{i}}{\text{DIST}_{i} \times \text{NUM}_{i}} \right) = -25.079 \quad 5.375 \quad 21.77 \quad 0.0001$$

29
The size of the sale as measured by the natural logarithm of net volume was found to be positively related to sale value, as was the weighted average selling price, the natural logarithm of the weighted average DBH, and the natural logarithm of the average volume per acre harvested. As total net volume, average diameter and average harvest volume per acre increase, the value of the sale also increases, but at a decreasing rate. As the weighted average selling price increases, the sale value rises. If all else is held constant, a one dollar rise in the average selling price of similar quantities of stumpage will result in a 45 cent rise in the value of a new sale.

The relationship between sale value and average defect was found, as expected, to be negative. A one percent increase in the percent defect resulted in a 99 cent decrease in bid price per thousand board feet.

When considering logging system variables, several interactive variables were included in the model. The product of the percent volume jammer times the yarding distance line skidded, and the percent volume skyline times the yarding distance skyline were included in the analysis. Both of these variables were significant. Percent volume jammer logged and percent volume skyline logged were tested together in place of the interactive variables and both found to be significant at the .05 level, as well as have the expected negative coefficients. Yarding distances alone were not significant. The best overall statistical results were obtained for the model using percent volume skyline logged and the variable combining jammer percent times the yarding distance. These two variables were therefore retained in the
final analysis. In further tests, either set of variables may be used, as the differences in the final model are small.

Percent volume clearcut was included in the original analysis, but the results showed this variable to be not significant at any level. A small negative coefficient was produced for this measure of logging method, which was the opposite of what we expected. Perhaps the effect of this variable is not as simple as first hypothesized. The negative coefficient may be explained by the fact that although as the amount of clearcutting rises the ease of logging in terms of sawing and skidding increases, much of the smaller material thus produced must then be removed from the site and merchandized, resulting in increasing costs. Both average diameter and harvest volume per acre are included in the model and should account for changes in the size and amount of harvested material. The lack of significance noted for percent volume clearcut may be due to the fact that this variable is accounted for by the two just mentioned, and thus is redundant. Because the coefficient was very small, and was not significantly non-zero at any level, this variable was excluded from the final model.

The relationships found between bid price and the sale characteristics were generally as expected, and similar to those found in other studies of this nature. No further discussion of these findings is necessary at this point.

**Set-Aside Sales**

The only administrative variable considered in this analysis was the dummy variable used to identify Small Business Administration set-
aside sales. The coefficient calculated for this variable was very
significant. While the coefficient was negative as hypothesized, it has
a larger impact on price than expected. Based upon the sales included
in this study, designation of a sale as SBA would result in a $31.92
decrease in value per thousand board feet.

The Market Place

Several variables have been proposed as descriptors of the market
conditions, including the volume of uncut timber under contract and the
trend in housing starts.

The national forest uncut volume under contract was found to be
significant and have a negative effect upon sale bid price. Although
the coefficient is small, multiplying it by the average uncut volume
found during this seven year period for the sales sampled here results
in a $14.59 decrease in value per thousand board feet.

A second market variable tested was the twelve-month trend in
housing starts. This variable was found to be significant at the .05
percent level, and was retained in the final model. In some models
tested, however, it was not significant. There are perhaps some better
overall measures of economic condition than housing starts.
Particularly at the current time, alternative measures should be
considered. The USFS (1985) has noted better results using mill
production data because stumpage prices no longer seem to be as closely
linked to housing starts as in the past. This is partially due to the
substitution of other products (both wood and non-wood) for plywood and
dimension lumber produced in this area, and the alternative sources of
wood products currently being used by the construction industry. During the period sampled in this study, however, housing starts were an adequate measure of the market conditions. The relationship to sale value is positive, with a one percent increase in housing starts over a twelve-month period resulting in a six cent increase in bid price.

**Mill Capacity and Its Distribution**

In addition to the two variables describing market or economic conditions, several variables were used to describe the market structure itself.

The market structure was first quantified using the aggregate mill capacity variable together with the Lorenz concentration ratio variable as described in the methods section. The Lorenz concentration variable was found to be not significant at the .10 level. Upon reflection, it seemed that while the ownership of capacity should be significant, this variable was not the best measure of the distribution. Because the area measured under the curve in Figure 2 reflects the overall concentration, not the average or the amount owned by size class of owner, we decided to use an alternate measure of distribution of capacity.

It was hypothesized that some estimate of concentration involving the amount of capacity the largest mills control would be a better measure of concentration. This hypothesis reflects the theory that larger mills have more economic power, usually control more in-house resources, and thus have more buying power (Mead, 1966). Mead suggests that there are fewer bidders on sales purchased by large firms, and sales purchased by large firms have lower value. Accordingly, the
percent of capacity owned by the largest mill at each center was
substituted for the Lorenz concentration in the equation, which also
included the mill capacity variable. The market structure variables
tested together in the model were:

\[
\sum_{i=1}^{9} \left( \frac{\text{CAP}_i}{\text{DIST}_i} \right) \quad \text{and} \quad \sum_{i=1}^{9} \left( \frac{\text{MBIG}_i}{\text{DIST}_i} \right)
\]

where \( \text{CAP}_i \) = capacity in mill area \( i \)
\( \text{DIST}_i \) = haul distance from sale to mill center \( i \)
\( \text{MBIG}_i \) = percent of capacity owned by largest mill in
area \( i \)
\( i \) = subscript referring to each of nine milling areas

It was found that both of these variables were significant, but that
they are highly correlated with each other (correlation coefficient =
.82). They therefore were not used together in the final model. The
high amount of correlation is probably due to the fact that the
proportion of capacity controlled by the largest owner in each mill area
in western Montana does not vary greatly, with the exception of Flathead
County. There are, in general, a number of small mills in each area,
and one or two large mills that account for the majority of the milling
capacity. In only one area does the largest mill own less than half of
the existing capacity, and the average owned by the largest mills is 67
percent. This number should indeed be strongly correlated with the
total capacity in each area, as we found in our modeling efforts.

It was also hypothesized that the number of mills alone might
explain a large portion of the variation in bid value. It was found
that the number of mills related to sale location, is a significant
measure of market structure. The number of mills was expressed as:
\[
\sum_{i=1}^{9} \left( \frac{\text{CAP}_i}{\text{DIST}_i} \right) \text{ and } \sum_{i=1}^{9} \left( \frac{\text{CAP}_i}{\text{DIST}_i \times \text{NUMB}_i} \right)
\]

where \( \text{CAP}_i \) = capacity in mill area \( i \)
\( \text{DIST}_i \) = haul distance from sale to mill center \( i \)
\( \text{NUMB}_i \) = number of mills in area \( i \)
\( i \) = subscript referring to each of nine milling areas

Both of these variables were significant, and use of these together resulted in the best statistical model tested. The measures of market structure, in the form used here, relate market milling capacity and the number of mills in existence to the location of the sale, and interactively both are related to bid price. The first variable is a measure of milling capacity relative to sale location. The second gives us an estimate of the average capacity at each center relative to sale location, and is perhaps a measure of the average market power existing relative to each sale and the average distribution of plant capacity.

In summary, we have identified several characteristics of the marketplace which are useful in establishing a bid price for timber sales. The market variables that are significant include the number of mills, the plant capacity, and a combination of the two, all related to sale location.
sales. The market variables that are significant include the number of mills, the plant capacity, and a combination of the two, all related to sale location.
Chapter 6

CONCLUSION

As agencies or organizations attempt to make procedures more efficient and accurate, many are currently using or becoming interested in using transaction evidence in appraising stumpage. Generally, models have been used to predict stumpage value as a function of some sale and market characteristics stratified by time and geographic location. This study is an extension of previous transaction evidence appraisal efforts that supplies additional information concerning how sale value is related to the market, the marketplace structure, and sale location. The results are significant in several ways.

Stumpage valuation done using methods like this is generally more cost-effective and more objective than other methods. This study adds to the current body of knowledge concerning factors affecting sale value, supplying information on how sale value is related to market structure. Several different variables were used in combination to describe market structure. Any one of them may, by itself, be an adequate measure of marketplace characteristics. In summary, the plant capacity and number of mills, when combined with the distance to the sale, were important marketplace variables.

This method can be used in appraising stumpage by any agency, organization, or private owner, as the market and sale information necessary to do so is readily available to both seller and purchasers, and to agencies, organizations and individuals other than the Forest
Service. Some development work will be necessary, but similar techniques can be applied in many cases.

Not only are the techniques described here useful in stumpage appraisal, but also in assigning a value to any timber inventory. Whether an estimate of value is necessary for potential sale, as an assessment of the value of assets, for tax purposes, or perhaps for long range planning, transaction evidence appraisal is a valuable tool. The location of a quantity of stumpage and its relation to the existing marketplace have been shown to be important factors in establishing the value of a timber sale. The same result applies to any inventory.

More should be said here about the importance of this information in decision-making, investment analyses, and planning. Management or investment decisions can be guided by using this technique if the decision criteria include economics. When making thinning and harvesting decisions, or prioritizing stands for treatment, location of a stand or inventory and its relation to the marketplace can now be added to the analyses to supplement other information.

In addition to the sale location and marketplace characteristics used in this study, one measure of the availability of alternative supplies of stumpage (Forest Service volume under contract) was shown to be significant in predicting sale value. Although additional measures of stumpage supply might be proposed, the conclusion can be drawn that the existence of alternate supplies of stumpage does indeed affect sale value. This factor should not be ignored when appraising stumpage or inventory, nor when planning harvests, timber sales, or long-range activities.
As was shown in other studies, designation of a sale as SBA negatively impacted the value of that sale. This is an issue only on government stumpage sales. However, the policy makers and the public should at least be aware of the impact of such designation on the value of a sale. Careful consideration should be given to the real cost (loss of revenue) of such a decision, along with the implications for the businesses involved.

In the course of this study, a regression model was developed to test the relationships between some variables and timber sale value. The model shown is not meant to be a final. The sample of timber sales used to develop this model was from the period 1974-1980, and is somewhat outdated. Market conditions in terms of number, size and location of potential buyers have altered significantly since that time. These methods should be tested on current conditions and sales in order to develop a final predictive model. The data base should also be expanded to include other mill areas and national forests, as well as perhaps inventories or timber sales from other ownerships.

One of the things attempted in this study was the measurement of the location of the sale. Time and resources limited this to the measure of haul distance to each milling center. It may be that a better measure of spatial location will enable the modeler to quantify the relationship of sales to mill centers more accurately. Working circles could be defined around each mill center and a sale located within each area more precisely, especially in relation to all of the mill centers. This would require use of computer mapping, or creation
of a distance direction/location matrix network to generate spatial relationship information.

This study has, however, quantified the relationship between sale location, market structure, some other market characteristics including supply of other stumpage, and the value of the stumpage. This relationship will be useful in estimating the value of any quantity of timber, in decision-making or investment analyses.
Appendix A

VARIABLE DEFINITIONS

<table>
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<th>Name</th>
<th>Definition</th>
<th>Range</th>
<th>Mean</th>
</tr>
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<tbody>
<tr>
<td>BID</td>
<td>Adjusted high bid value per MBF expressed in 1980 dollars. Includes the reported high bid + ineffective road credits + environmental protection costs + road maintenance costs + temporary development costs.</td>
<td>44.49-282.00</td>
<td>125.76</td>
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<tr>
<td>SNVOL</td>
<td>Net sawtimber volume (million board feet Scribner).</td>
<td>1.01-24.23</td>
<td>6.26</td>
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<tr>
<td>SPLS</td>
<td>Weighted average selling price log scale (1980 dollars) based on proportionate volume by species in each Western Wood Products Association species group.</td>
<td>3.21-543.75</td>
<td>342.53</td>
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<td>DBH</td>
<td>Volume weighted average diameter of trees included in the sale (nearest tenth inch).</td>
<td>8.9 - 23.2</td>
<td>14.3</td>
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<tr>
<td>ADEF</td>
<td>Average defect observed in the sawtimber, expressed as a percent.</td>
<td>1.3 - 47.9</td>
<td>10.5</td>
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<tr>
<td>PVJA</td>
<td>Percent of sale volume jammer logged.</td>
<td>0.0 - 100.0</td>
<td>13.8</td>
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<tr>
<td>PVSK</td>
<td>Percent of sale volume skyline logged.</td>
<td>0.0 - 100.0</td>
<td>14.8</td>
</tr>
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<td>YDGL</td>
<td>Mean external yarding distance line skidded (yards).</td>
<td>0 - 750.0</td>
<td>258</td>
</tr>
<tr>
<td>YDSK</td>
<td>Mean external yarding distance skyline logging (yards).</td>
<td>0 - 1500</td>
<td>305</td>
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<tr>
<td>PVCC</td>
<td>Percent of sale volume clearcut.</td>
<td>0.0 - 100.0</td>
<td>33.5</td>
</tr>
<tr>
<td>HVPA</td>
<td>Average volume per acre harvested (thousand board feet Scribner).</td>
<td>1.8 - 31.0</td>
<td>11.1</td>
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<td>SBA</td>
<td>Dummy variable used to identify SBA set-aside sales (0=no, 1=SBA sale).</td>
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<td>0.24</td>
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41
<table>
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<tr>
<th>Variable</th>
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<td>FSVOL</td>
<td>Forest Service uncut sawtimber volume under contract by forest sale located in and year of sale (million board feet Scribner).</td>
<td>53.6</td>
<td>626.5</td>
<td>343.4</td>
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<td>HIREND</td>
<td>Twelve-month trend in seasonally adjusted housing starts. This is equal to the number of starts 12 months prior to the sale divided by the number of starts at the time of the sale and expressed as a percentage.</td>
<td>27</td>
<td>279</td>
<td>140.3</td>
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<tr>
<td></td>
<td>Subscript referring to each of nine milling areas defined in western Montana.</td>
<td>1</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>NUMBi</td>
<td>Number of mills operating within each milling area. Only lumber mills and plywood mills were included. Mills producing other miscellaneous products such as cedar shakes were not included.</td>
<td>1</td>
<td>41</td>
<td>9.6</td>
</tr>
<tr>
<td>CAPi</td>
<td>Milling capacity existing in each area expressed as units of sawtimber material for each year (million board feet Scribner).</td>
<td>20.3</td>
<td>452.8</td>
<td>144.8</td>
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<tr>
<td>CONCi</td>
<td>Lorenz concentration ratio for milling area i.</td>
<td>.15</td>
<td>.91</td>
<td>.41</td>
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<tr>
<td>MBIGi</td>
<td>Percent of plant milling capacity owned by the largest mill within each milling circle.</td>
<td>30</td>
<td>100</td>
<td>64.6</td>
</tr>
<tr>
<td>DISTi</td>
<td>Distance from each timber sale to the center of each milling area. This is calculated as the paved distance plus three times the unpaved distance (miles to the nearest tenth).</td>
<td>5.0</td>
<td>302.0</td>
<td>168.5</td>
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LITERATURE CITED


Hearst, L.H. 1981. Personal communication. USFS. Region 1, Missoula, Montana.


