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Understanding non-sawtimber markets will be important in designing hazardous fuel treatments.

Export Chip Prices as a Proxy for Nonsawtimber Prices in the Pacific Northwest

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Abstract

Forest-land managers use price data and market analysis to form expectations and make informed management decisions. There is an abundance of price data for sawtimber, but for nonsawtimber, the availability of price data is limited. This constrains the ability of forest-land managers to form reasonable price expectations for stands that contain both sawtimber and nonsawtimber. In this paper, I show that export chip prices are a reasonable proxy for nonsawtimber prices in the Pacific Northwest. This conclusion is supported by evidence of arbitrage between the chip export market and three domestic markets in the Pacific Northwest. As to the chip export market in general, I observed increasing chip prices from 1968 through 1995, a structural break in 1995 after which point we observe declining prices. I also found evidence of an inverse relationship between chip price and lumber production.

Keywords: Wood chips, nonsawtimber, chip prices, residue prices.

Introduction

Knowledge of nonsawtimber markets is increasingly relevant to forest-land management. Although forest managers and mill owners are well familiar with markets for sawtimber, less is known about nonsawtimber markets and price movements within these markets. Three factors have led to the increased importance of non-sawtimber product markets in the Pacific Northwest (PNW): (1) increased interest in reducing hazardous fuels, (2) increased interest in alternative energy sources, and (3) decreased average diameter of harvested trees. Fuel reductions often include the removal of small-diameter trees from stands that have little value as sawtimber. Therefore the value of nonsawtimber products will determine the economic feasi-

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bility of fuel reductions across the Western United States. Additionally, rising oil prices and increasing demand for alternative energy sources have piqued interest in the use of nonsawtimber products for biomass energy generation.

There are parts of the West where much of the managed forest landscape is almost entirely second- and third-growth stands with a high proportion of small-diameter trees. The decreasing average diameter of harvested stands is evidence of this shift (Haynes et al. 1995). In general, stands described as being small have an average diameter of about 8 inches and would produce few commercially valuable saw logs (4.5 to 11 inches small-end diameter). In spite of its increasing importance, relatively little attention has been paid to nonsawtimber markets in the PNW. Research in this area has been limited primarily by a lack of domestic price data.

The available nonsawtimber price data is for wood chips. There are two primary types of wood chips: sawmill residue and whole-tree chips. Historically, mill residue and nonsawtimber material have been viewed simply as a disposal problem (Hartman et al. 1975). Whole-tree chips are produced by a chipping machine that chips nonsawtimber material (less than 11 inches diameter at breast height). These chips are usually not as clean or uniform in size as mill residue chips. Although many stands in the PNW contain both sawtimber and nonsawtimber, the cost of chipping nonsawtimber material can be significant. Without information on domestic chip markets, it is difficult for forest managers to form price expectations. A detailed price series for wood chip exports from the PNW has been published for the last several decades (Warren 2005) by customs districts. The two that make up the PNW are the Columbia-Snake and the Seattle customs districts.

The focus of the present analysis is on the usefulness of the wood chip export price series as a proxy for domestic nonsawtimber prices in the PNW. This paper uses the most recent price series data to update a similarly titled study (Haynes 1999). The first section contains an analysis of the export price time-series: model specification and tests for trend and seasonality. The second section examines the relationship between the chip export price series and three domestic price series: fiber log prices from northeastern Oregon, chip and saw log domestic prices from the Puget Sound region, and utility log prices from northwestern Oregon. I examine the relationship between wood chip export prices and both PNW stumpage prices and lumber production in the third section. Finally, in the fourth section, we discuss the role of the Japanese chip export market on chip prices in the PNW. The paper concludes with a summary of the main findings and implications for forest-land managers.

Export Price Data: Model Specification, Trend, and Seasonality

Export chip market prices have been reported since 1968 in the U.S. Forest Service publication *Production, Prices, Employment, and Trade in Northwest Forest Industries*. Quarterly wood chip export prices for the period 1968:1[2] to 2004:4 from the PNW were calculated as the volume weighted average of chip prices from the Columbia-Snake and Seattle customs districts. The original values for the time series data are shown in figure 1.[3]

Figure 1 indicates a shift in the underlying determinants of chip prices between the third and fourth quarter of 1995. This break occurs soon after the northern spotted owl (*Strix occidentalis caurina*) controversy of the early 1990s. A possible explanation for such a break is the changing composition of harvested material for lumber production during this period. Suppose that before the early 1990s the
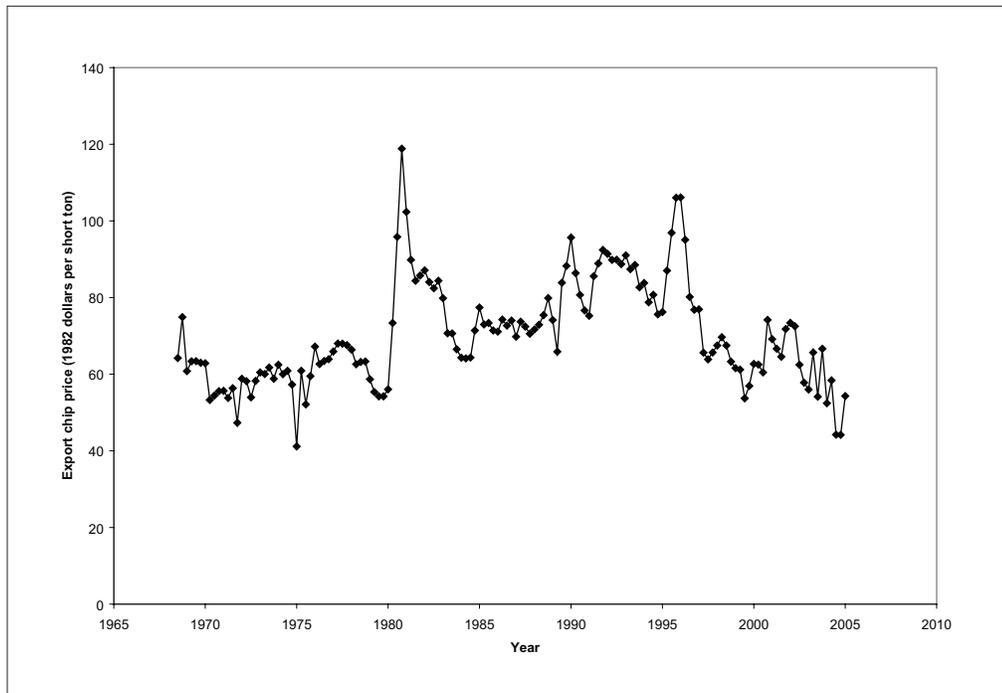

Figure 1—Export chip prices, Pacific Northwest (Seattle and Columbia-Snake customs district), 1968 to 2004. Source: Warren, various years.

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[2] Quarterly prices are noted as year:quarter. For example, the second quarter of 1999 would be written 1999:2.

[3] For all statistical analysis, I used the natural log of price.

forest industry was producing lumber from large-diameter trees, without much taper, which generated small amounts of wood chips per board foot of lumber. And suppose that following the listing of the spotted owl, only smaller diameter, tapered trees, which generate more wood chips per board foot of lumber, were harvested. This would increase the supply of wood chips in the market and depress chip prices. To test to see if there has been such a shift in the chip market, I divide the sample into two groups–1968:1 to 1995:3 and 1995:4 to 2004:4–and use the Augmented Dickey-Fuller (ADF) unit root test for stationarity.

Testing for stationarity is the first step in most time-series analyses. Stationarity ensures that the mean, variance, and covariance of the stochastic process generating the dependent variable do not change over time. The ADF test statistic indicates that the first group in the time-series is stationary at the 1-percent level of significance. With a test statistic of -3.026 and a 10-percent critical value of -3.203, I cannot reject non-stationarity of the second group. The absence of stationarity may be due to seasonality or a trend within data. First I tested for seasonality.

Seasonality refers to regular, seasonal fluctuations. For example, market demand for air conditioners exhibits seasonality because there is a peak in demand every summer. To test for seasonality in the export price data, it is necessary to quantify the seasonal fluctuations in the data. To this end, I first plotted the sample autocorrelation function (not shown). If the data exhibit quarterly seasonality, I would expect some degree of correlation between data points separated by four quarters. That is, I would expect to see correlation between price in time t and price in time t+4. Thus, seasonality can be identified by the presence of regular peaks in the autocorrelation function. The autocorrelation functions for the two periods analyzed: 1968:1 to 1995:3 and 1993:4 to 2004:4 did not exhibit regular peaks; therefore, I concluded that the price series is unaffected by seasonal fluctuations.

Table 1—Seasonal adjustments

Quarter	Columbia-Snake customs district	Seattle customs district	Pacific Northwest average
First	1.000	1.002	1.001
Second	0.996	0.998	0.997
Third	1.004	0.996	1.002
Fourth	0.999	1.003	1.000

To further test for seasonality, I calculated seasonal adjustments for the four quarters, following Haynes (1999). These adjustments, described in table 1, capture the deviation in the specified quarter's price from the average price for all quarters. Because all adjustments were close to one, I concluded that chip prices are not

affected by seasonal fluctuations. The absence of seasonality implies that both the yearly average and the quarterly average produce equivalent estimates and no seasonal adjustments are necessary.

I specified the time series model with a linear time-trend (to achieve stationarity) and a first-order autoregressive term (AR(1)). Higher order autoregressive models were tested, but based on the Akaike information criterion (AIC)[4] and Schwarz criterion (SC),[5] both of which measure goodness of fit, I concluded the AR(1) model provided the best fit. The model is specified as follows:

$$y_t = c + t\beta_1 + y_{t-1}\beta_2 + \varepsilon \qquad [1]$$

where y_t is chip export price in time t, c is the intercept, t is the time-trend, y_{t-1} is the previous quarter's chip price and ε is the error term. Here t is chosen to equal one in the first period and increases by one in each successive period. The linear time-trend coefficient captures trend, or constant changes in each time quarter. The AR(1) term captures the degree of correlation between quarterly prices. By including an AR(1) term, I was able to estimate the influence of last quarter's price on this quarter's price. I also included a dummy variable for three observations capturing the recession of the early 1980s (1980:2, 1980:3, 1980:4).

I used a Chow test (Chow 1960) to test whether the estimated coefficients were the same before 1995:3 as they were after. Results of the Chow test indicated that the structural break is significant at the 1-percent level, and a structural change did occur between 1995:3 and 1995:4. To control for the structural break, I divided the sample, at the break point, into two groups and estimated the model allowing slope and intercept to differ across groups. The results of the model estimation are described in table 2.

All of the independent variables are significant at the 10-percent level or better. The time-trend coefficient is 0.017 for group 1, indicating a positive price trend, and -0.0038 for group 2, indicating a negative price trend. Haynes (1999) reported a positive long-term price trend using data through 1997. However, with the addition of recent data, the opposite for chip prices can be seen after 1995:3. The AR(1) coefficient is 0.6416 for group 1 and 0.51 for group 2. This implies that up until 1996:3 a 1-percent increase in the previous quarter's chip price was associated with

Nonsawtimber prices have been declining since the late 1990s.

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[4] The AIC minimizes $\ln(SSE/T)+2K/T$, where SSE is sum of squared errors, T is sample size, and K is the number of regressors (Kennedy 2003).

[5] The SC minimizes $\ln(SSE/T)+[K*\ln(T)]/T$, where SSE is sum of squared errors, T is sample size, and K is the number of regressors (Kennedy 2003).

Table 2—Model estimation

Variables	Group 1 1968:1-1995:3	Group 2 1995:4-2004:4
Constant	1.4329***	2.5164***
Time	0.0017***	-0.0038*
AR(1)	0.6416***	0.5100***
Recession dummy	0.1293**	—

— = There was no recession in the second time period, hence no dummy.
Significance level: *** = 1 percent, ** = 5 percent, * = 10 percent.

a 0.6416 percent increase in the present quarter's chip price. After 1996:3, a 1-percent increase in the previous quarter's chip price was associated with a 0.51 percent increase in the present quarter's chip price. Although the correlation between quarterly prices has declined since 1995:3, it remains relatively high.

Arbitrage Between Domestic and Export Markets

The model developed in the previous section describes our basic understanding of chip export price patterns since 1968, but to determine if these prices are a reasonable proxy for domestic prices, we need to know the degree to which domestic and export markets arbitrage. Market arbitrage describes a situation where the two seemingly distinct chip markets—the domestic chip market and the export chip market—are in fact one. Suppose the price for chips is higher in one market than in the other, then a trader could buy chips in the low-price market and re-sell it in the high-price market. Traders will engage in, and profit from, buying low and selling high until chip prices are equalized and a single market has been established. This process of price equalization is termed market arbitrage.

If domestic and export markets arbitrage, we can infer the existence of a single chip market and conclude that chip export prices provide a reasonable proxy for domestic prices. Next I used domestic price data from Oregon and the Puget Sound region to test for market arbitrage between domestic markets and the export market (Columbia-Snake and Seattle customs districts). Similar price movements provide evidence of arbitrage between export markets and three domestic markets: northeastern Oregon fiber log markets, and Puget Sound chip and saw log markets.

Northeastern Oregon Fiber Log Prices

Fiber log prices in northeastern Oregon were obtained from Oregon State University Extension, in La Grande, Oregon. Individual fiber logs are usually 5+ inches in
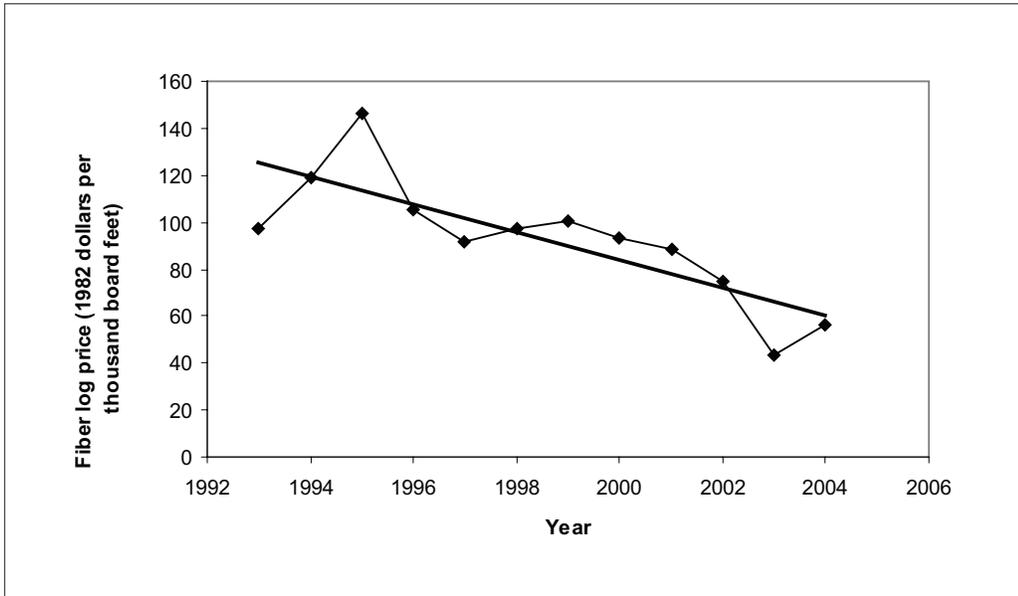
Figure 2—Fiber log price northeastern Oregon, 1993-2004. Source: Oregon State University Extension Service 2006.

diameter, and stands average at least 8 inches in diameter. Annual fiber log prices for the period 1994 to 2004 are shown in figure 2. These prices represent the mill-delivered price, not the price at the time of transaction.

The estimation of a regression model using fiber log data is prohibited by the small number of observations in this domestic price series. The trend lines fitted to the fiber log price series and to the export chip price series appear to be quite similar. For the period 1993 to 2004 there is a 52-percent decrease in fiber log prices and a 40-percent decrease in real export chip prices, both along the trend line. This coincidence of price movement is evidence of arbitrage between the domestic and export market. If we removed the transportation and processing cost differences and controlled for quality differences, we would expect the domestic and export prices to converge.

Puget Sound Chip and Saw Log Prices

Annual data from the Puget Sound on Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) chip and saw logs for the period 1994 to 2004 were taken from *Log Lines*. The Puget Sound region includes Clallam, Island, Jefferson (except coastal area south of Hoh River), King, Kitsap, Lewis, Mason, Pierce, San Juan, Skagit, Snohomish, Thurston, and Whatcom Counties. Chip and saw logs are generally 5 to 7 inches in diameter, on the small end, and 12 to 40 feet in length and yield both
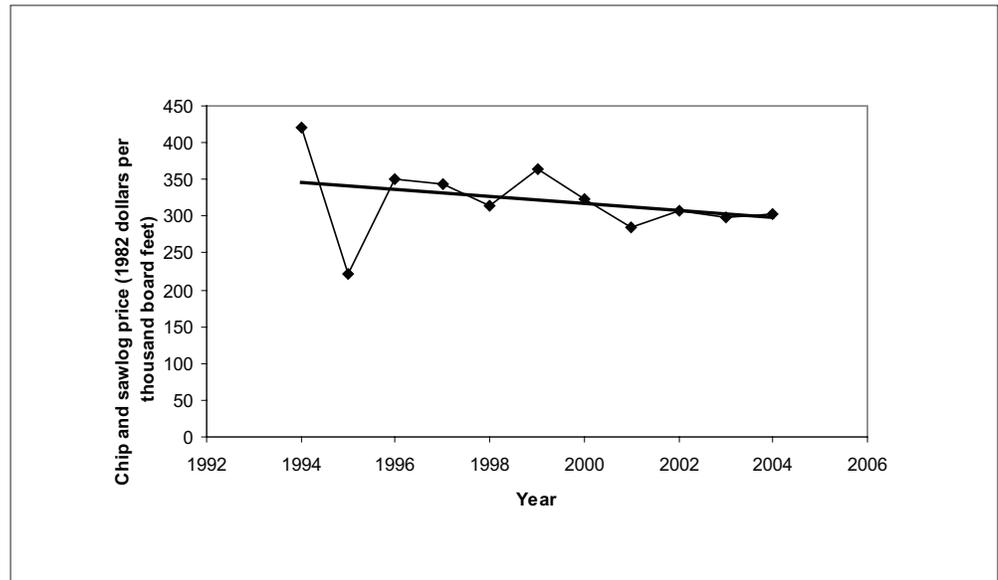
Figure 3—Domestic chip and saw log price, Puget Sound region, 1994-2005. Source: Log Lines, various years.

sawtimber and nonsawtimber products: two 2 by 4s and wood chips. Prices for chip and saw logs are reported in dollars per thousand board feet ($/MBF) and are shown in figure 3.

Again, the estimation of regression model is prohibited by the small number of observations for the domestic price series. Fitting a trend line indicates a slight downward trend. For the period 1994 to 2004, real chip and saw log prices decreased 13 percent while real export chip prices decreased 38 percent. This discrepancy might be due to the nature of the log. Recall that although a portion of chip and saw logs is used to produce wood chips, the remainder is used as sawtimber. For the period 2001 to 2004, *Log Lines* data indicate No. 2 Douglas-fir prices increased from $352/MBF to $367/MBF. Increasing sawtimber prices would moderate declining chip prices. Therefore, controlling for sawtimber price movements, domestic chip and saw log prices in the Puget Sound region provide additional evidence of market arbitrage.

Oregon Utility Log Prices

Quarterly price data for utility logs from 1977:1 to 2004:4 were obtained from the Oregon Department of Forestry (fig. 4). Utility logs are similar to chip and saw logs in character and use; in general, utility logs do not meet the minimum requirements for peelers and sawmill grades, and most of the log is used to produce chips. Visual
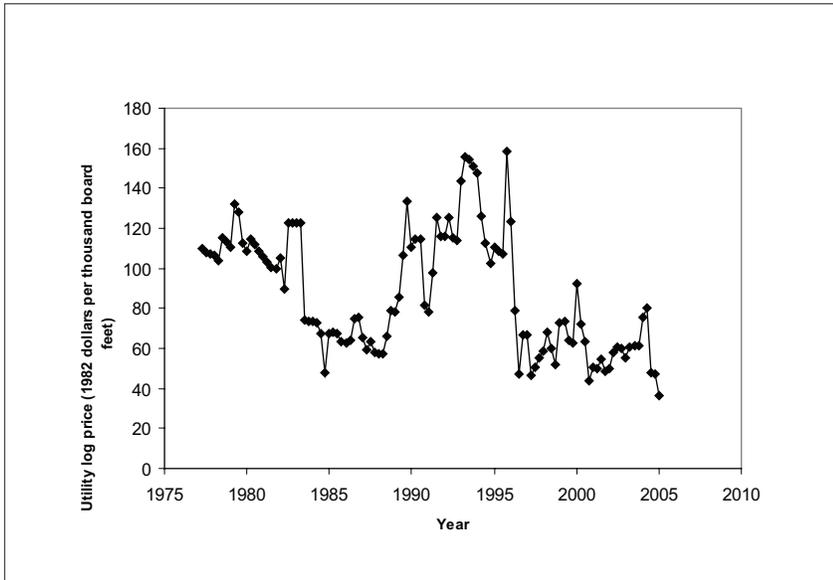
Figure 4—Utility log prices, Oregon Department of Forestry, 1997 to 2005. Source: Oregon Department of Forestry 2006.

examination of the utility log price series reveals both similarities and differences between its pattern and that of the chip export price pattern.

Utility log prices and chip export prices exhibit similar patterns after 1989. From 1989 through 1995:3, we see increasing prices, and after 1995:3, we observe falling prices. These movements are consistent with chip export price observations. The utility log prices, however, appear more similar to a step function than the relatively gradual chip price movements. With a larger data set, the structural break observed in the export price series in late 1995 also appears in this domestic series. Before 1989, however, domestic utility log prices and chip export prices exhibit opposite trends. The reason for this discrepancy is unclear. Nonetheless, the coincidence of price movement after 1989 provides evidence of arbitrage with the chip export market.

Related Markets

In this section, I discuss the connections between chip price and three related markets. Understanding the interrelationships between markets is important in order to determine how, and by how much, changes in one market will affect related markets. This discussion is not intended to be an analysis of chip price determinants, but provides an overview of market linkages. I explore how the supply of mill

residue from softwood lumber production could affect chip prices. Then I explored the relationship between stumpage price movements and chip price movements. Finally, I examined the relationship between Japanese export demand and chip price.

Softwood Lumber Markets

Lumber markets and chip markets are closely related because wood chips are a byproduct of lumber production. When lumber production increases, the supply of wood chips also increases and you would expect to see chip prices fall. Similarly, when lumber production decreases, the supply of wood chips also decreases and you would expect to see chip prices increase.

Because sawmill residue is a primary source of wood chips, you would expect there to be an inverse relationship between lumber production and chip prices. About 45 to 50 percent of every log that enters a sawmill ends up as chips (see Hartmann et al. 1975, tables II-7 and II-11). Therefore, the more lumber that is produced, the more chips there are on the market, and the more likely prices are to fall. Lumber production for western Oregon and western Washington are shown in figure 5. There appears to be a close relationship between lumber production and chip export prices. Periods of increasing lumber production are associated with
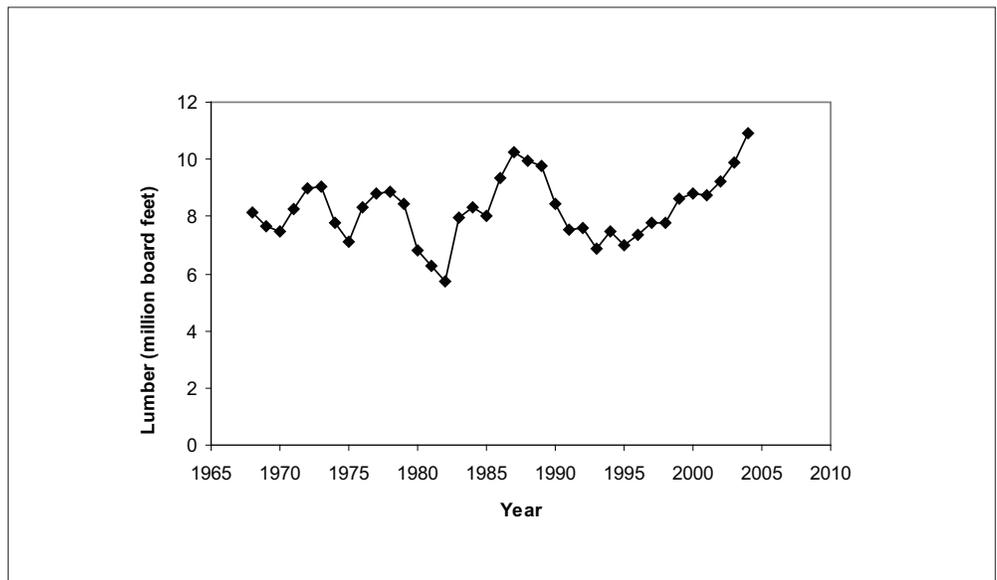

Figure 5—Lumber production, 1968 to 2004. Source: Western Wood Products Association, various years.

falling chip prices, and periods of decreasing lumber production are associated with increasing chip prices. This inverse relationship indicates that sawmill residue is the dominant supplier of wood chips to that market. This observation is relevant for land managers interested in whole-log chipping—whether for fuel reduction or biomass energy production: whole-log chips will have to compete in the chip market with supplies of sawmill residue, which is generally a cleaner and higher quality product.

Stumpage Markets

To gain further insight into the factors influencing chip price, I used a second-order vector autoregression (VAR) model to explore the relationship between domestic stumpage prices and chip export prices. A VAR model is used to estimate the interdependence between multiple time series. Here I estimated how closely chip prices and stumpage prices move together. I estimated this interdependence for three quarterly stumpage price series: Oregon Department of Forestry (ODF 2006) delivered log prices, average stumpage price of timber sold on state land in western Washington (USDA FS, various years), and average stumpage price of timber sold on state land in western Oregon (USDA FS, various years). For each stumpage price series, the second-order VAR model consists of an equation explaining stumpage price based on two of its own lagged prices and two lagged chip price observations. Higher and lower order models were considered, but the second-order model had the best fit.

Western Oregon and Washington stumpage prices include 108 observations, and ODF delivered log prices include 112 observations. The model estimates for the VAR model indicate there is no statistically significant relationship between ODF delivered log prices and export chip prices. I observed a similar lack of relationship between western Oregon stumpage prices and export chip prices. The VAR estimates did, however, indicate a statistically significant relationship between western Washington stumpage prices and export chip prices.

The observed significant relationship between western Washington stumpage prices and export chip prices may be due to the composition of Washington stumpage, which is characterized by a higher proportion of hemlock (*Tsuga* spp.) and fir (*Abies* spp.) than Oregon stumpage. The market price for hemlock and fir is less than the market for Douglas-fir; therefore, they are more responsive to changes in the chip market—they are more (less) likely to be chipped given an increase (decrease) in chip price.
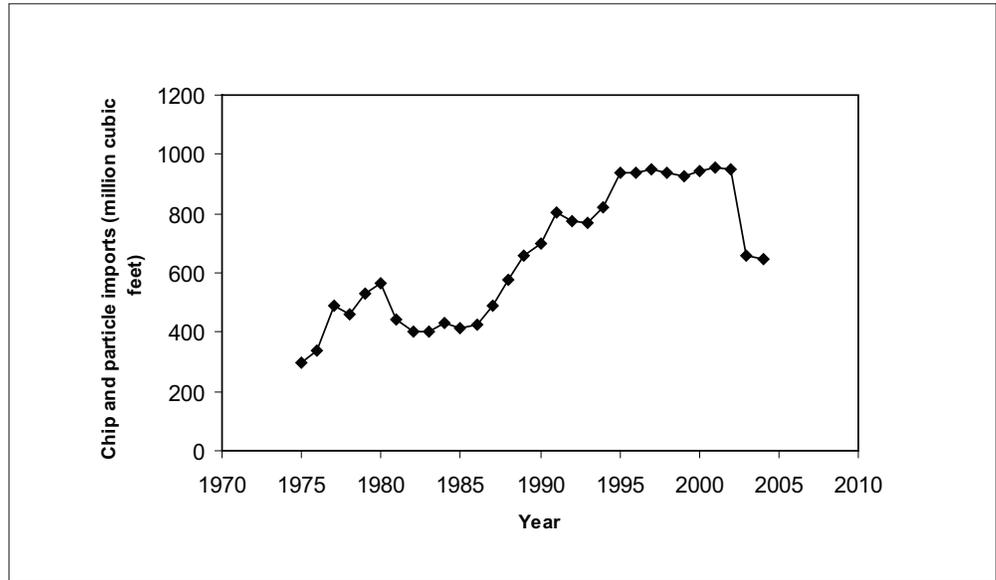
Figure 6—Japanese chip and particle imports, 1975 to 2004. Source: FAOSTAT 2006.

Export Markets

Given chip market arbitrage between domestic and export markets, price move-
ments in domestic chip markets are tied to demand shifts in export markets. More
wood chips from the Pacific Northwest are exported to Japan than to any other
country; between 1975 and 2004, the majority of total chip exports were sent to
Japan (Warren various issues). Figure 6 shows annual Japanese chip and particle
imports from 1975 to 2004. The Japanese export demand appears robust from 1975
through 1995 and generally trends up.

One example of the connection between the Japanese imports and Pacific
Northwest exports can be seen in the period 1985 to 1995. During this period, there
were sustained increases in Japanese imports, and chip export prices in the Pacific
Northwest were rising. Increases in Japanese demand would create upward pressure
on prices. This correlation does not imply causation, but may provide land manag-
ers with some insight into related markets.

Note that the exchange rates influence chip export market performance. In
Japan, price signals for wood chips are displayed in terms of yen, not dollars.
Therefore the exchange rate has important implications on the chip market. To
illustrate, in the period 1984 to 1996, the yen increased 28 percent, relative to the
dollar. During this period, the real cost of U.S. wood chips in Japan also decreased
by 28 percent. In response to lower prices, Japanese demand increased as indicated
by the steep increase in Japanese imports between 1984 and 1996.

Concluding Remarks

Although there is no absolute measure of how well export chip prices serve as proxy for domestic nonsawtimber prices in the PNW, we find evidence in support of its usefulness. This conclusion is based on evidence of arbitrage between chip export markets and fiber log markets in northeastern Oregon, chip and saw log markets in the Puget Sound, and utility log markets in Oregon since 1989. In general, the chip export market exhibits a long-term upward trend from 1968:1 to 1995:3 and a downward trend from 1995:4 to 2004:4, an inverse relationship to lumber production, and a positive relationship to Japanese export volume.

Given continued increases in lumber production and no significant increases in Japanese wood chip import demand, land managers can expect chip prices to continue declining. This expectation, which will form price forecasts used by land managers, is contrary to that found in Haynes (1999), which analyzed data through 1997 and found a long-term upward price trend. Stands throughout the PNW contain a mix of both sawtimber and nonsawtimber, and the potential value of nonsawtimber material will depend on chip prices. In the PNW, land managers can look to export chip prices and related markets to gain insight into domestic nonsawtimber markets. This insight is valuable to forest-land managers who are trying to form expectations about future price movements and make informed decisions in a dynamic market environment.

Export chip prices are a good proxy for nonsawtimber prices.

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	2.54	Centimeters
Feet (ft)	.3048	Meters

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