THE RELEVANCE OF TRADITIONAL FOREST ECONOMICS RESEARCH

by

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Abstract.—Two future wood consumption models, one based upon a trend and the other upon a cycle seem to discredit the timber famine concept which has been a long held tenet of forestry in the United States. Instead, we may be facing a timber glut which will require some far reaching resource reallocation decisions.

My talk today is concerned with the relevance of traditional forest economics research. This of course begs the question as to what is traditional in forest economics research. Well, if you will look at the agenda for this meeting you will find that about 60 percent of the talks that follow mine are concerned in one way or another with timber supply. Looking back at the agendas of several previous SOFEW meeting about 69 percent of those talks dealt with timber supply. In 1982 a survey of forest economics research in Southern Universities showed that 66 percent of these studies were concerned with timber supply. It would seem fair to say therefore that traditional forest economics research is concerned with timber supply problems. And if you look back at the history of forestry in this country, you will find that timber supply problems have been the favorite topic of discussion among foresters. The general scenario is that a timber famine is just around the corner. As a matter of fact, the concept of a timber famine has always been an accepted tenet of forestry in the United States (5).

Note that this scenario does not suggest that we have a current timber supply problem, it is a future timber supply problem. You should also note that we've been having this future timber supply problem for the past 100 years or so and it hasn't arrived yet! Surely, this observation must have been made by others proceeding me! And surely it should have stimulated someone to ask: Why do we continue to believe in a timber supply problem that has been just around the corner for the past 100 years?

It would seem logical, therefore, to inquire as to what is the origin of the idea that we may have a future timber supply problem. One might suspect that this problem stems from the foresters education and training which is concerned with the care and tending of trees. Foresters know how to grow trees. Hence, they need a timber supply problem because they know what to do about it. I submit, however, that this idea has been handed down from one generation of foresters to another via the periodic forecasts that the U. S. Forest Service and others have made over the long history of forestry in the United States (14, iv). So lets look at one of these Forest Service

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projections, the 1982 report entitled "An Analysis of the Timber Situation in the United States 1952-2030", henceforth denoted as ATS (14). We need to look at only one because all the others convey basically the same idea.

When you examine this document, you can't help but note how crucially the timber famine idea depends upon the projections of future timber demand. If the future timber demand estimate were not so large, the timber supply problem would disappear! Because of the long term nature of forestry, such forecasts must rely upon demand projections that extend far into the future. While no one can be expected to accurately forecast over such a long time horizon, the demand projections that give rise to the timber famine should be able to withstand scrutiny. Projections of gross national product and population typically underlie these timber demand projections (11,12,13,14). It is essential therefore to examine the appropriateness of these two important economic variables for this purpose.

Real gross national product (GNP), a measure of the real value of goods and services produced by the Nation, is normalized in Fig. 1 to show relative growth rates in the series. In terms of 1967 dollars, real GNP has grown from $90 to $1211 billion from 1900 to 1983, about 3.2 percent per year. Physical things such as population and wood consumption simply don't grow in this manner! Thus real GNP is not a good indicator of wood use and should not be used as the basis for a wood consumption projection. If one were to project wood use on the basis of an assumed constant wood volume per real GNP dollar, the rising GNP dollars relative to wood use would cause a rapidly growing error between the projection and actual wood consumption.

The population (POP) of the United States, also normalized in Fig. 1, has increased from 76 to 234 million people since 1900, a growth rate of 1.4 percent per year. Again, this growth rate is greater than that of industrial wood consumption. Hence, overestimates of future wood use would occur if population is used as the basis for projection instead of GNP. However, the error would be very much smaller.

While the Nation's economic indicators have grown substantially over time, wood consumption has not kept pace, Fig. 2. Industrial wood consumption (IWC) is somewhat above its pre-World War II peak of 9.4 billion cubic feet which occurred in 1907. But its postwar peak of 14.5 billion cubic feet in 1978 represents only a 0.6 percent gain per year over this time period. The major industrial wood items are sawlogs (SL), pulpwood (PW), and veneer logs (VL). Although declining in relative importance, sawlogs still remain the largest item in the industrial wood mix accounting for nearly 52 percent of the industrial wood consumed in 1983. This is down from a high of 73 percent in 1907. While the level of sawlog consumption today is not much different from what it was in the early 1900's it did reach a historical peak in 1978. Pulpwood consumption (PW) is the second largest item in the mix. The industrial wood mix has been shifting from solid wood items to fiber over the past 83 years. The market share of pulp products grew from four percent in 1907 to nearly 35 percent in 1983. Veneer log consumption (VL) has also generally grown over the past 83 years and it now accounts for about 10 percent of the industrial wood mix. Plywood has been used as a substitute for lumber in construction but the market share gain in this product accounts for less than half of the market share lost in lumber consumption. More recently
Fig. 1. GNP, Population & Industrial Wood Consumption
1900-1983

Fig. 2. Industrial Wood Consumption

VL - Veneer logs
PW - Pulpwod
SL - Sawlogs
IW - Industrial Wood
plywood has been suffering from severe competition from the growth in the new structural panel industry (4).

The per capita consumption of industrial wood has fallen from 109 cubic feet in 1907 to 60 cubic feet in 1983, Fig. 3. This is due largely to the declining per capita consumption of lumber. It fell from a high of 82 cubic feet per person in 1906 to a low of 25 cubic feet in 1982. Only in the depression years of 1931 to 1934 was the per capita consumption of lumber lower than in 1982! An important reason for this decline in per capita lumber use is the rapid rise in the real price of lumber. When lumber consumption per capita is plotted over the real price of lumber we see a decline in consumption as price increases, Fig. 4. The rising prices may have stimulated technological change which has resulted in the substitution of other materials for lumber in construction. The per capita pulpwood consumption, on the other hand, has generally grown over the past 83 years, Fig. 3. However, per capita fiber consumption has leveled out since about 1965, indicating that pulp consumption and population are now growing at about the same rate. Veneer log per capita consumption has also grown over this time period; but, it too has now topped out or declined indicating that both of these industries are maturing.

A Future Timber Consumption Model

While industrial wood consumption has grown over time and there has been substantial change in its composition, its per capita use has had a slight negative trend since about 1940, Fig. 5. It has averaged 59.5 cubic feet per person with a standard deviation of only 3.9 cubic feet per person over the past 44 years. During this period the recorded high and low per capita usage were only 65.1 in 1978 and 51.0 cubic feet in 1982. Therefore, in considering demand projection methodologies, this trend ratio between consumption and population would appear to be a logical choice. So the trend was projected to the year 2030 to obtain an estimate of 55.8 cubic feet per person. This is to be compared with the ATS estimate of 86.2 cubic feet per person. The ATS estimate is nearly seven standard deviations higher than the past 44 year average! Which of the two estimates looks more realistic to you?

When the projected trend in per capita consumption is multiplied by the medium population projection for 2030 of 300.3 million, as reported by ATS, the result is an estimated industrial wood usage of only 16.8 billion cubic feet, Fig. 6. The comparable ATS estimate is 25.9 billion cubic feet. The accumulated discrepancy between the methodology suggested here and that used in the ATS would amount to 319 billion cubic feet over the period 1980-2030. The magnitude of this discrepancy suggests that there is substantial disagreement between the two approaches used in projecting future timber demand. As can be seen, my estimate follows closely the trend in the actual data while the ATS estimate is significantly higher than the historical data.

The estimate of 86.2 cubic feet of industrial wood per person in 2030 is particularly disturbing in light of its long term downward trend in per capita consumption. Such an estimate suggests a drastic increase in the introduction and acceptance of new wood products, a much more aggressive marketing of existing products, and the lowering of the cost of production to make wood more competitive. Yet, ATS provides no assurance that this is about to
Fig. 3. Per Capita Industrial Wood Consumption
Fig. 4. Lumber Consumption vs Real Price
1800-1983

CONSUMPTION, cu.ft. per capita

REAL LUMBER PRICE INDEX

1906
1918
1932
1945
1950
1982
1978
Fig. 5. Per Capita Industrial Wood Consumption
happen. There is no compelling evidence to suggest that a significant increase in per capita industrial wood consumption is likely in the foreseeable future.

Furthermore, I examined value-added per dollar of disposable income by industry for the period 1949 to 1985 and found a statistically significant negative trend in all three of the SIC wood using industries, Fig. 7. The trend was negative in the lumber and wood products industry (SIC-24), the furniture and fixtures industry (SIC-25), and the pulp and paper industry (SIC-26). These data suggest that through time consumers of wood products are shifting their purchases to other goods or services. Hence, changing consumer preferences as well as rising prices are forcing the per capita consumption of industrial wood down, not up!

Finally, my demand estimates were based upon the population projections reported in the ATS. But this population projection itself is likely to turn out to be an overestimate. The major components of population change are fertility and mortality rates and net immigration. Mortality rates have been declining and the level of legal immigration in recent years has been fixed at 400,000. Fertility is the component of population change that is subject to the greatest uncertainty in the future. Fertility rates reached a peak in 1957 but have since declined sharply, Fig. 8. The fertility rate for 1986 was the lowest rate ever recorded in the United States. And since 1972 fertility rates in the Nation have been below the level required for the population to replace itself with the projected mortality rates and in the absence of net migration. While there is a relatively high proportion of women in their prime child bearing ages, these women have a low fertility rate as a consequence of their delaying motherhood in order to pursue educational and career goals. Data show that these postponed births are seldom fully made up (15). Thus, in order for population to reach 300.3 million people by the year 2030, the social and economic changes that put women in the workforce will have to abate.

On the supply side, in spite of ATS's overly optimistic demand estimate, the physical depletion of the Nation's timber inventory is no longer considered a likely possibility (14, vi). But a problem remains. If, as suggested above, the timber famine forecasts have been successful in choking off timber demand, then how do you turn off this mechanism when it is no longer needed? Many of the other things we do will not really matter if our markets continue to erode away because of the fear created by a phantom called a timber famine.

An additional concern is a potential event that is looming on the horizon that could have disastrous implications for the various forestry participants. It is the Kondratieff, or long wave which has a period of 50 to 60 years. The nature of forestry projections suggests that foresters should be particularly interested in the Kondratieff cycle and its potential impact upon forestry investment and policy decisions.

The Kondratieff Cycle

Kondratieff's theory (6) of an economic long wave evolved from his study of commodity prices. He noticed that prices in Britain, France and the United States rose and fell with long, sweeping regularity and that the periods from
Fig. 7. Value Added per Dollar DPI

SIC-25 Furniture & Fixtures
SIC-26 Pulp & Paper

Sum of SIC-24 Lumber & Wood Products
Fig. 8. Fertility Rates, 1909-1986
peak to peak were strikingly regular -- from fifty to sixty years, Fig. 9. The price data for the United States plotted in the figure shows four complete long wave cycles along with a portion of the fifth cycle. The upswing portions of the cycles occur between the years 1744-1779, 1796-1814, 1843-1864, 1896-1920, and 1932-?. These producer price data suggest that we may have reached a peak in the latest Kondratieff cycle; but, it is too early to tell from this time series. For the time being, we will have to depend upon other criteria to make this judgement. The enormous infusion of money into the economy since the oil crisis has changed the character of the price series dramatically. The severe recession of 1981-82 does not even show up in the data! Downswings of the long wave occurred between 1779-1791, 1814-1843, 1864-1896, and 1920-1932. Although data are not available, Stoker (9, p. 214) suggests that wholesale prices reached a peak in 1714. This would provide another downturn during the period 1714-1743. Historically, the fallback in prices during a depression has averaged 61 percent from an average peak of 72.8 to an average trough of 28.5. By comparison the 1984 peak is 310.3!

The Kondratieff cycle is thought to be related to investment in major capital good industries. Cherry (2) states that the Kondratieff cycle which peaked in the 1810's could be explained by the massive investment in harbor and canal development, the second peaking after the Civil War by the building of the national railroad system; the third wave occurred after World War I, as the automobile industry built up its productive capacity and the states built their road systems; while the fourth Kondratieff cycle could be explained by the suburbanization of the post Korean War period, resulting in the Interstate Highway system and the two car family.

Sterman (8) suggests that the long wave arises from the interaction of two fundamental facets of modern industrial economies. First, the internal structure and policies of individual firms tend to amplify changes in demand, creating the potential for oscillation in the adjustment of capacity to changes in the desired level. Second, a wide range of self-reinforcing processes exist which amplifies the response of individual firms to changes in demand, increasing the amplitude and lengthening the period of the fluctuations generated by each firm. Through the process of entrainment, the fluctuations generated by individual firms become coherent and mutually reinforce one another to form the long wave. He has built a model that shows how fluctuations in capital goods production can cause long waves.

Schumpeter (7) saw cyclical fluctuations arising because innovations which are so essential to economic growth appear, if at all, discontinuously in clusters or bunches. This innovations theory has become the basis for many modern long wave theories. These theorists see the lack of innovation or the aging of previous innovations as the basic cause of depressions. They have shown that innovations appear in bunches during the depression phase of the long wave cycle (16).

Friedman and Schwartz (3) argue that the source of most economic cycles is the monetary sector. They suggest that the causal factor for recessions is the change in the stock of money supply. Batra (1) has expanded upon this idea and found long wave cycles in the money supply and government regulation that coincides with the inflationary and deflationary cycles shown in Fig. 9. He claims the "the perverse fiscal policies" of the 1920's, which gave tax breaks to the wealthy, caused the financial crisis of 1929. These tax cuts
generated a sharp rise in the concentration of wealth in a short period of time. This concentration of wealth lead to instability in the banking system and to speculative investments that evolved into a frenzy that fed upon itself until the speculative bubble burst and brought down the banking system. To support his thesis, he points to a large body of economic literature which indicates that recessions are caused by the unequal distribution of income. He further claims that the "pro-wealthy tax cuts" of the current administration are producing the same effects as in the 1920's, and that a depression by 1990 is now inevitable.

The Anatomy of a Long Wave

Clearly, there are a number of theories available to explain the long wave. The questions that remain are what can one expect to happen over the next decade or so and specifically how does this relate to the wood products industry? A typical long wave unfolds in four phases: recovery, prosperity, recession, and depression. Several of the above authors believe that we are in or about to enter the depression phase (1,8,16). A listing of current events would seem to confirm their diagnosis. Agriculture is already in the midst of a wrenching depression as are the oil and steel industries. Industry in general has been operating far below capacity for a number of years as aggregate demand has been weak. Job security has become the number one concern of the American people. Unemployment has been moderate, wage demands and prices are softening and inflation is subsiding. A huge debt has been accumulated and forces have come into play to resist further debt expansion in both the political and economic arenas. While nominal interest rates have fallen lately, real interest rates are rising placing a burden on debt service. A feeling of insecurity has set in and the political mood of the Nation has shifted to conservatism. Political attention has turned to material needs and economic policy is hotly debated in the legislature. The protection of wealth has become an overriding concern at the expense of civil rights, equity, and the environment. All of these factors are characteristic of the recession phase of the long wave. One of the major characteristics of the depression phase is debt liquidation. Over the past several years we have seen a growing number of banks, businesses and individuals in financial difficulty, including the federal government itself. The long wave phasing suggests that we will see a great deal more of this over the next several years. Considerable debt must be liquidated from the system before the next recovery phase can begin.

An Alternative Timber Consumption Model

If the declining phase of the Kondratieff cycle has begun or will soon begin, the demand for timber might be depressed over the next 20 years or so. To measure the effect of the long wave a model must have a cycle incorporated into it. But the inclusion of sinusoidal waves in our model is not based solely upon some random speculation about the long wave. The time history data, per capita industrial wood consumption from 1900 to 1983, represent the solution to a complex set of stochastic differential equations which correspond to the structure of the forest products industry. That solution contains sine and cosine functions and hence it is appropriate to include the sinusoidal waves whether a long wave exists or not. I am using an ad hoc
approach to modeling this system in the sense that our model represents that solution rather than the structural equations. However, letting the data speak for itself is a well established method in statistical analysis and is the basis for the Box-Jenkins approach to time series analysis.

A cycle, when translated into mathematical terms, is a sine wave of the form:

\[ A \cdot \sin(\omega t + \phi) \]

where \( A \) is the peak amplitude of the cycle, \( \omega \) (omega) is the radian frequency, \( t \) is time, and \( \phi \) (phi) is the phase angle in radians. In a sine wave, the frequency \( f \) is the number of crests which pass a point in one time period. Since the radian frequency \( \omega \) is \( 2\pi \) times \( f \), the period \( T \) of the wave is defined as \( 1/f \) or \( 2\pi/\omega \). The phase angle \( \phi \) measures the lag of the output with respect to the input, i.e. it adjusts the starting point of the model's sine wave to conform with the data. This phase adjustment can also be made by incorporating a cosine function in the model. This latter specification provides more flexibility in that it allows me to test for a second cycle that might be in the data.

My expectation is that the sine and cosine functions are likely to be asymmetrical because of the nonlinearities that exist within the system. Thus on a priori grounds I would expect these functions to explain a significant amount of the variation in the data and that the functions will be asymmetrical. And, if the long wave exists within the data, I would expect the periods of the sine and cosine functions to be in the neighborhood of 50 to 60 years.

Earlier I had discussed the sharp decline in per capita consumption from 1907 onward. An exponential term was added to the model to capture this decline. The equation estimated took the following form:

\[
\text{DCIWP} = 81.609 \cdot \exp(-0.006 \cdot T) + 20.992 \cdot \sin(0.108 \cdot T) + 15.209 \cdot \cos(0.131 \cdot T) \\
(2.812) \quad (0.001) \quad (1.522) \quad (0.008) \quad (2.604) \quad (0.009)
\]

\[ R^2 = 0.991 \]

where DCIWP is the domestic consumption of industrial wood per capita as a function of an exponential, two cycles and an error term which in turn are all functions of time. The numbers in parentheses are the asymptotic standard errors. The estimated equation tracks the data reasonably well, Fig. 10. In the early 1900's, the model peak is lower and precedes the actual peak by two years. During the Great Depression, the model trough is higher and lags behind the actual trough by three years. This type of performance would be expected on a priori grounds because the long wave is asymmetrical. It is characterized by a long upswing and a sharp decline. Further evidence of this asymmetry is given by the differences in the frequencies on the sine (0.108) and cosine (0.131) functions. Had the long wave been symmetrical these amplitudes would have been the same.

The fact that the radian frequencies on the sine and cosine functions are similar in magnitude provides verification that a long wave exists in the data. These radian frequencies translate into time periods of 58.2 and 48.0
Fig. 10. Per Capita Industrial Wood Consumption
years, respectively. No other cycle makes a significant contribution to the model. If one had, the frequencies would not have been of the same magnitude. Thus, the inventory, investment, and building cycles which most economists accept do not have a significant impact on per capita industrial wood consumption when viewed from a long range perspective.

The amplitudes on the sinusoidal functions tell us how much variation there is within the cycle from peak to trough. The difference between the amplitudes on the sine (20.992) and cosine (15.209) functions indicate where the peak and trough occur relative to where the model starts.

In the absence of some other a priori hypothesis about the future, this model formulation will allow the cyclical nature of the historical data to strongly influence the projection path. Such a forecast might be justified on the basis of the theory outlined above. Projections from this model suggest a continuous decline in per capita industrial wood consumption until 2011 in conformance with a downturn in the Kondratieff long wave cycle, Fig. 10. Consumption falls in that year to 24.7 cubic feet per person. However, as mentioned above, the model's trough is likely to be higher and later than the actual trough in the long wave. From this trough the equation projects a rise in consumption to 57.4 cubic feet per person in 2030. The comparable ATS figures for 2010 and 2030 are 84.6 and 86.2 cubic feet per person, respectively.

When we translate the model per capita estimate into total consumption we note two things, Fig. 11. First, wood consumption expectations vary greatly depending upon whether we are on the uphill or downhill side of the long wave. At the bottom of the Depression we could look forward to long term growth in wood consumption. Today, the future does not appear to be very encouraging. Second, my per capita estimate for this cycle model translates into 6.8 billion cubic feet for total consumption in 2011 and 17.2 billion cubic feet in 2030. The Forest Service projection for 2010 as reported ATS is 23.3 billion cubic feet and for 2030 it is 25.9 billion cubic feet. This model suggests that a downswing in the Kondratieff cycle could result in 538 billion less cubic feet of timber being consumed over the 50 year period than that projected by ATS! At current rates of consumption, this difference is enough wood to last the forest products industry 41 years. Thus a downturn in the Kondratieff wave would have a profound impact upon the timber supply issue allowing time for the forest to rejuvenate itself, as it did during the last downswing that occurred in the 1930's.

I have tried to demonstrate here this morning that the timber famine concept depends crucially upon an exaggerated timber consumption scenario. Two future wood consumption models, one based upon a trend and the other upon a cycle seem to discredit the timber famine concept. Instead, we may be facing a timber glut which will require some far reaching resource reallocation decisions. Note how both of our estimates for 2030 are nearly the same. Note also, how drastically different the outcome is depending upon the path taken to get there! We live in a highly nonlinear world. There is no reason to believe that wood consumption will continue on a upward linear trend. These startling conclusions are at odds with the generally accepted thinking and tenets of forestry in the United States. Nonetheless, they may provide some food for thought, namely: Is Forest Economics Research addressing the relevant issues? The significance of this question should not
be taken lightly. The concern here is with the appropriate allocation of
scarce economic resources. If the above analysis is reasonably correct, it
could have a profound effect upon all the various forestry participants,
including you, the timberland owners, the forest product manufacturers, and
the forestry schools.

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