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Is Timber Scarce? The Economics Of A Renewable Resource

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IS TIMBER SCARCE? THE ECONOMICS OF A RENEWABLE RESOURCE

BY

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INTRODUCTION

Concern over potential scarcity of natural resources has been a major economic theme since the time of Malthus and Ricardo. The classical concept of resources was physical: it presupposed a finite stock of land, on which the economy depended for subsistence. The supply of natural resources available to the economy could never be expanded. John Stuart Mill declared that land was the fundamental constraint on economic growth:

> The limit to production ... must tum upon the properties of the only element which is inherently, and in itself, limited in quantity. It must depend upon the properties of land.[1]

Mill concluded that the limited supply of natural resources would cause agricultural prices to rise, while industrial prices would be reduced by the "progress of civilization." The rate of economic growth would then be determined by the balance between the tendency toward diminishing returns and the progress of civilization.

In recent decades, the Nation's resource outlook has been repeatedly appraised. Most appraisals have concluded that no serious resource barriers to economic growth exist, but that fossil fuel depletion will force fundamental changes in the energy sector. Conclusions regarding forest products differed, howeveL Several investigators found no reason for concern about future forest products availability. Landsberg, however, singled out forest products as the single major class of raw material likely to be in short supply by the year 2000.[2]

Barnett and Morse concluded that natural resources in general show no evidence of scarcity, except for timbeL Studying time series on labor productivity, costs, and relative prices, they found evidence of increasing timber scarcity, especially for sawtimber.[3]

Periodic analyses by the U. S. Forest Service have projected that timber supplies will fall short of requirements before the year 2000 without substantial increases in management intensity. Concern has also been expressed that the Nation's forests cannot supply the raw material required to complete the 25 million new units called for by the National Housing Goals. This issue has drawn the attention of a Presidential Task Force, and a series of congressional subcommittees.

OBJECTIVE

The objective of this study is to test the following hypothesis:

> The United States has experienced steadily increasing timber scarcity and faces increasingly severe scarcities in the future.

In addition, policy implications of this test will be discussed.

This will require four separate steps:

1. Specify the *meaning* of resource scarcity. Frequently, writers use definitions of scarcity that are economically unclear and lack usefulness in policy analysis. Of the many possible views of scarcity, this study adopts the following definition:

> Resource scarcity is a social problem resulting from a rising real price of natural resource products, within a specified frame of time and place.

This definition emphasizes the impact of resources on the consumer. For other purposes, it may be appropriate to study the effect on the raw material processors or on raw material owners. In such cases, prices at the *resource* level would be studied.

2. Adopt a set of scarcity indicators. It will be argued below that the trend of real price and the foreign trade balance form a complete set of indicators.
3. Analyze trends in scarcity indicators, allowing for bias in underlying data.
4. Analyze welfare impacts of changing resource prices.

In ensuing chapters, it will be shown that existing views of timber scarcity fail on two counts: they do not account for movements in scarcity indicators since World War II, and they rest upon questionable assumptions about the relation of forest products supplies to consumer welfare.

SCOPE

This study deals with a specific, narrow frame of reference. It deals with natural resources as *productive inputs* for satisfying commodity demands. The emphasis is on the supply of resource products, not of resources themselves. Analysis of welfare impacts will be restricted to the *consumer* level, although resource supply trends can cause policy-relevant problems at manufacturing or resource-ownership levels. Analysis is restricted to conditions approximating those found in the American forest economy. These include widespread private ownership of resources and industries selling products on relatively competitive markets. The results cannot apply to socialist or barter economies, since in such systems the concept of market demand is meaningless. The emphasis is upon meeting demands of American consumers for wood products, although it could be argued that this Nation should be prepared to supply wood products to other Nations less well endowed with forests.

This study is not concerned with the economics of conservation *per se* nor with policy prescription. It is aimed solely at improving the basis for *diagnosis* of natural resource supply conditions.

The concept of resource scarcity will not be applied to noncommodity values of wildlands. This study, however, will have implications for the conservation of noncommodity values. Decisionmakers will take different views of tradeoffs between timber and scenic values, depending on their beliefs about timber scarcity.

OVERVIEW

In Chapter One, the concepts "natural resource" and "resource scarcity" will be defined. Chapter Two will examine the separate problem of diagnosing scarcity. Specific indicators of scarcity will be given. Chapter Three will study the course of scarcity indicators for forest products within the recent century. Chapter Four will discuss what Barnett and Morse called "mitigations of scarcity in complex economies." This will include a brief technical history of the forest industries-a case study of responses to changing resource availability. Chapter Five will examine future demand and supply prospects for the timber economy. Chapter Six summarizes the conclusions of the study.

CHAPTER ONE

WHAT IS RESOURCE SCARCITY?

This chapter will define the terms resource and scarcity, and discuss potential causes of resource scarcity.

DEFINING NATURAL RESOURCES

Natural resources are one of the traditional triad of productive agents: land, labor, and capital. As Zimmerman writes, a natural resource is "the environment in the service of man."[1] According to Zimmerman, "MAN'S resources, to an overwhelming extent, are not *natural* resources. . . . The bulk of MAN'S resources are the result of human ingenuity."[2] This concept is a functional, relative one. It is thus impossible to speak of resources in only physical terms.

This study will be concerned only with those resources which are used as intermediate goods in some industrial process. Some natural resources, such as Christmas trees, duck hunting rights, or clams can be gathered or used directly by the consumer. Still, "market" prices may emerge. In the case of nonappropriable services, such as clean air or scenery, public good problems may lead to nonmarket forms of decisionmaking. But this study will leave these resource values aside.

A natural resource, then, may be defined as *a feature of the natural environment that is of value in serving human needs.* This definition implies that any appropriable natural resource will in a market economy possess a *capital value.* Economically speaking, this is the touchstone that separates "natural resource" from what Zimmerman called "neutral stuff." Capital value in turn depends upon prevailing technology, current and expected relative prices, and current and expected rates of interest. Implicit in the concept of capital value is the idea of choice or opportunity cost. A body of neutral stuff presents society with no choices. Thus, a natural resource might also be defined as any feature of the environment about which choices must be made. It need not be appropriable to be an object of choice.

It is essential to recognize the limited scope of what Ricardo called "the original and indestructible powers of the soil." Today, natural resources are employed jointly with manmade agents of production. Agricultural soil, for example, contains inputs of capital in the form of drainage and levelling services; forests benefit from fertilization, fire control services, and road construction. In few cases does an unaltered "natural resource" ever enter into production.

Another important distinction is between a natural resource and the services it provides. A forest provides many services-water, recreation, timber and the like. The services are what is demanded by consumers. A society's natural resource endowment is a part of the capital stock which gives off services to producers and consumers. The mix of services that can be produced, and the intertemporal distribution of those ;ervices, afford wide latitude for human choice.

DEFINING SCARCITY

The term scarcity is inherently ambiguous. One may speak qualitatively of abundance, adequacy, and scarcity, but these terms have no quantitative significance. Watkins speaks of the "inexpungable vagueness of the terms 'scarcity' and 'abundance' as applied to raw materials supplies." He suggests that the only solution is to speak of a "scale of adequacy.,,3

To define scarcity or surplus, then, requires a judgment that such conditions produce *social burdens*. Thus, $1 corn represents surplus because it lays undue hardship upon farmers and rural communities; $2 corn represents scarcity of shortage because it injures the livestock industry and other consumers of corn. The degree of surplus or scarcity is measured not by the deviation of price from its long-term trend, but by the socially significant burdens that result.

Surplus or scarcity is affected by the balance between supply and demand. The only objective measure of such relations-under competitive conditions-is the trend of market price. As we have seen, it is impossible to specify what is a "high price" or a "low price." All that can be described is the price trend.

The features of demand determine the *impact* of rising resource prices. If the long-run demand function is inelastic, as a result of low elasticities of substitution between a given resource and alternative materials, adapting to rising prices will be difficult. If longrun elasticity of demand is high, supply shifts will have less economic effect.

Scarcity analyses must be firmly tied to time and place. The level of raw cocoa prices, for example, is of little welfare significance in the United States. But the difference between a world price of 15 cents per pound and 25 cents per pound is of profound significance to the citizens of Ghana.

Recognizing these conceptual difficulties, the following definition will be used in this study:

> *Resource Scarcity* is a social problem resulting from a rising real price of natural resource products, within a specified framework of time and place.

By *real price* is meant the price trend of a natural resource product relative to the wholesale price index.

By *social problem* is meant a condition of current or potential welfare losses to members of the community under consideration. This study will emphasize consumer welfare.

Economic analysis of resource scarcity raises numerous problems of definition and measurement. These include ambiguities in the measurement of the price of resource products; the definition of scarcity in relation to other nations, and the analysis of welfare effects of resource supply trends. These issues are treated in the next chapter.

CAUSES OF RESOURCE SCARCITY

It is useful to distinguish between *causes* of scarcity and *effects* of scarcity. Confusing the two hampers definition and measurement. It is tempting to define scarcity by searching for its causes, and then to measure those causes in physical terms: "scarcity is running out of timber." Alternatively, one can define and measure scarcity in terms of its effects. Barnett and Morse, for example, examined the trends of real prices in natural resource industries. They found that the real price of agricultural output fell from 1870 to 1957, but rose for forest products. They concluded that timber was a scarce resource in that period.

Scarcities of resource *products* may result from a variety of causes, not all of which are connected with natural resources *per se.* Frequently, shortages of resource products result from inadequate supplies of complementary inputs or from lack of transportation. Thus, in Colonial times, firewood shortages in large cities were caused by the high cost of transportation, not by any physical shortage of timber.

Moving to the *resource* level, rising real prices of natural resources may result from anyone of the following general causes:

1. Rising demand with stable economic supply.
2. Declining economic supply with stable demand:
    a. Institutional or other.causes.

  b. Resource depletion.
  c. Shortage of complementary inputs.
  d. Management policies, such as speculation.
3. Discovery of low-cost foreign sources.
4. Declining rate of discovery of new reserves.
5. Declining real transportation costs.

Discovery of low-cost foreign sources (3) will raise the domestic price *relative* to the world price.

More generally, welfare losses can result from *surpluses* as well as from *shortages* of resource products. Surpluses periodically recur in world markets for primary products, frequently as a result of overinvestment in complementary inputs under conditions of elastic natural resource supply. Surpluses are especially burdensome in the case of tree crops such as coffee and cocoa. Governments of Third World nations devote considerable energy to stabilizing and raising prices of these products. This suggests that natural resource scarcity is not a serious concern in many world primary industries.

SUMMARY

Many natural resource studies implicitly assume that physical depletion, rising real prices, or deteriorating trade performance for a resource product are in themselves evidence of welfare losses. This chapter argues that *physical or economic measurements are not sufficient to prove the existence of a social problem resulting from inadequate resource supplies.* It is necessary to directly determine whether rising resource product prices *do in fact* cause social welfare losses. This process may encounter severe limitations of data and concepts. But it will at least clarify the assumptions about general community values that are used as a basis for policy recommendations.

CHAPTER TWO

DIAGNOSING RESOURCE SCARCITY

A useful definition of resource scarcity must be convertible into economically meaningful measurement concepts. The process is beset with many difficulties, which it is the burden of this chapter to discuss. First, measurements of resource supplies must be obtained. This means describing physical supplies, and also defining the factors affecting economic supply. On the basis of the analysis of resource supply, specific scarcity indicators may be adopted. These indicators would ideally be independent and exhaustive. In practice, however, the interdependence among variables requires the use of a broad range of economic data. Because of possible effects on economic supply, institutional data may be relevant.

In order to complete a scarcity analysis, it is necessary to explicitly examine the effects of resource supply trends on social welfare. This is admittedly difficult, but serves to force the analyst to specifically state the welfare premises on which policy recommendations are based. It exposes the logical fallacy implicit in the assertion that since the market will demand X billion cubic feet of timber by the year 2000, government must assure that no less than X billion cubic feet of timber will be available at that time.

MEASURING RESOURCE SUPPLIES

In Chapter One, resource scarcity was defined as *a social problem arising from a rising real price of natural resource products*. It was argued that the analysis of resouce scarcity consists of two parts: measurement of trends in real prices, and analysis of the welfare impact of these trends. In this section, conceptual and empirical problems of implementing this definition are discussed.

Resource scarcity arises from an unfavorable balance between demand and supply at the resource level. To isolate the causes of rising resource prices and resource product prices, it is necessary to distinguish clearly between physical supply and economic supply. *Physical supply* is the total recoverable quantity of resource in existence, under given technical and economic conditions. *Economic supply* is a schedule showing the flow of resource output that will be supplied at different price levels. Changes in economic supply, relative to demand, give rise to movements in factor productivity, resource rents, real prices of resource products, and the national trade balance in a given resource product. It is these movements which provide indicators of the existence of resource scarcity.

Measuring resources.-Studies of resource supply traditionally employ physical measures-of consumption, trade, reserves, future requirements. In such terms, resource supply is deceptively simple–it is easy to conceive of "running out" of a resource. With few exceptions, however, no purely physical measure exists of the boundary of a natural resource deposit. The "end" of a resource deposit at a point in time is a function of technology and relative prices. As a result, all physical measurements of resource stocks necessarily embody hidden economic assumptions.

When discussing resource quantities, it is necessary to distinguish between stocks and flows. Estimates of resource prospects rely upon comparisons between currently known or inferred reserves (stocks) and current or projected flows of consumption. Both stocks and flows can be measured in physical or in value terms. We have noted that physical measures are inherently ambiguous. What about value measures?

Theoretically, the market value of a natural resource stock is the present worth of the aggregate economic rent paid for control of the resource. The value of resource services currently consumed is likewise the rents paid for the current flow of output. These statements refer to the economic rent, in the sense of a differential surplus arising from longrun rising supply price. Economic rent measures market value at the resource level-which results from the balance of supply and demand. Rent is determined by the market's evaluation of: the total known supply; the supply expected to be discovered through exploration; the expected trend of demand; the expected trend of cost. Resource rents are thus related to many market variables. They may be increased or extinguished by changes in markets, technology, or transportation costs. Thus, the opening of the Great Plains by water and rail transportation raised the rent of land there, while reducing rent in New England.

One advantage of using dollar value measures of resource stocks and flows is that they provide automatic weighting for the effects of location and quality. Clearly, a stand of pulpwood timber in Northern Alberta is worth less than a comparable stand near a pulp mill in Southeast Georgia. Also, large clear logs are more valuable than small, branchy logs. Market prices recognize these differences.

Practically, resource rents are difficult to measure. Payments to resource owners typically include factor payments. For renewable resources-such as timber-such payments may include elements of quasi-rent. Data for estimating rents are practically nonexistent. Proxies must be employed. The dollar volume of extractive products is frequently used as a proxy for the value of current services of resources.

Measuring economic supply.-In the analysis of resource adequacy, the central concept is the behavior of economic supply, relative to demand, over time. Since economic supply must be measured as a physical flow per unit of time, it contains all the ambiguities of physical measures, as discussed above. Factors causing divergence between physical and economic supply include technical change, new discoveries, expectations, property rights structures and ownership patterns, and management policies.

1. Technical change, while it has been blamed for resource destruction on a wide scale, also has res'ource-creating effects. Chapter Four shows that resource-expanding technical change has been characteristic of the forest economy for over a century.

2. New discoveries have a dynamic influence on economic supply. In petroleum, current drilling experience gives an estimate of additions to proven reserves for a given year. The trend of additions to reserves-or of total proven reserves relative to annual production-is considered an indicator of supply trends. In the past, "new discoveries" have not been unknown in forest resources. Forest surveys in the 1930's to 1950's revealed the extent of timber growth in the South, which had frequently been underestimated. Research also revealed the magnitude of the raw material resource represented by sawmill and logging wastes.

3. Expectations, and changes in expectations, can induce resource owners to withhold resources or to dump them on the market for whatever they will bring. Most important are price expectations. But expectations related to trends in markets, technology, and costs are also significant. For renewable resources, expectations are critical since they determine how much of the currently accessible supply will be harvested, and how much will be held for future growth.

4. The structure and distribution of property rights can affect economic supply. Where private property rights are uncertain or nonexistent, as in the case of wildlife, individuals lack incentives to invest in their production. In the case of timber, private rights are relatively strong, and it is the distribution of those rights that is of interest. Large holdings in financially secure hands are usually managed for sustained yield. The economic supply is then roughly the current growth. On the other hand, where a large number of small properties exist, even less than the current growth may be sold, due to

owner indifference or hostility to timber harvesting. This has the beneficial side effect of promoting the buildup of growing stock. The extent to which such augmented growing stock will ever be part of the economic supply is uncertain.[1] In many areas, such as southern New England, the economic supply of timber is far below the potential harvest that would be prescribed on forestry grounds alone.

5. Management policies and institutional factors may affect economic supply. Variables such as taxes, tariffs, and interest rates may influence decisions as to the future profitability of resource production. This may lead to abandonment of known reserves, or to accelerated liquidation of reserves. It is said that the practice of timber bonding, common in the South and West as a means of financing old growth liquidation, led to wasteful overcutting in poor markets by firms struggling to meet fixed charges. As another example, when the Bureau of Land Management adopted sustained yield policies on its O&C lands in Western Oregon, thus reducing expected cutting rates, the effect on local timber markets was marked.

SCARCITY INDICATORS

There are essentially four theoretical indicators of resource scarcity trends. These are closely related economically, and are not strictly independent measures. They are: (1) the trend in real economic rents paid to resource owners, or the trend in rent per unit of product; (2) the trend in real cost of resource products; (3) the trend in real price of resource products; (4) the trend in the national trade balance in a resource product. Under certain conditions, the trend of real price is a measure of the trend of cost. The price trend also affects rents and, in relation to world prices, affects the trade position also. Resource rents apply to analysis at the factor market level, while cost and price measures apply to the consumer level.

Resource rents.-Ricardo emphasized the determination of economic rent as an essential part of the distribution of the social income. Ricardo's analysis showed an inexorable tendency for land rents to rise. Since competitively determined resource rents theoretically measure supply and demand at the resource level, the trend of rents would be an ideal measure of scarcity. Schultz, in a series of papers, has used the rent of agricultural land as an indicator of scarcity. He concluded that agricultural land was not a scarce resource.[2]

The trend of resource rent per unit of product, or the factor share of natural resources, gives a summary index of the behavior over time of three factors: the supply and demand for natural resources; the elasticity of substitution between resources and other inputs; and the bias of technical change (resource-using or resource-saving). Due to lack of data on these variables, however, the trend of resource rents will not be used in this study.

Trend in real cost, or factor productivity. -The Ricardian view of resource scarcity suggests that as output is expanded, resources of progressively lower quality will be used. Prices must rise to cover costs on these higher-cost units. Thus, resource scarcity may be measured by the trend of real cost or conversely, of factor productivity.

But resource supplies and quality are only one influence on the trend of productivity, and it is misleading to identify productivity trends entirely with resource supply changes. Further, in many natural resource industries, firms in effect create their own capital through activities such as exploration, proving up of new reserves, and tree planting. Measuring such capital and providing economically meaningful accounting over time, coupled with tax depletion options available to resource owner-processors, seriously complicates the measurement of total factor productivity.

The trend of real prices of resource products. -Measures of real price have been used by Barnett and Morse, Ruttan and Callahan, and Herfindahl. The real price of resource products has four advantages as a measure of resource supply trends:

(a) Measuring prices at the product level accounts for changes in the cost of mining or harvesting, processing, and transportation to mills (or consumers). It is perfectly possible for resource prices to rise while product prices are stable. From the Civil War to about 1900, the price of lumber was stable while timber prices rose. Prominent forces were the decline in real transportation costs, and improvements in milling.

(b) The price of products places the emphasis on consumers. No social problem, within the scope of this study, can arise if the real price paid by consumers for resource products is stable. **In** practice, however, most resource products are producer goods. Since many adaptations are available to users of resource products, a rising price of resource products is not a sufficient condition for scarcity. A broader analysis, however, would consider the welfare of firms engaged in resource processing as well as consumers.

(c) Under certain conditions, real price is an accurate measure of cost. This means that factor cost measures are unnecessary.

The trend of real price is an unbiased measure of cost under two assumptions.[3] First, there must be no short-run erratic influences that fail to average out over the long run. In the mining industries, this means that the process of acquiring additional proved reserves as working inventory of material in the ground should be systematic and orderly, for the industry as a whole. Large and unpredictable new discoveries at irregular intervals would reduce the usefulness of real price as an index of the trend of real cost. Second, the industry must be sufficiently competitive that prices remain near costs at all times.

These specifications are largely met by timber-using industries. The competitive nature of forest products markets is well known. There have been numerous unsuccessful attempts to control the lumber market; paper and newsprint markets have at times been highly concentrated, and price leadership prevails to this day for certain products. The plywood market, despite the presence of several giant producing and marketing firms, is kept competitive by a substantial fringe of independent producers. Stumpage markets, of course, are by nature imperfectly competitive.

(d) Data availability favors use of the products price measure. Price data at the FOB mill price level are widely available for most resource products. Data at the actual consumer level are more sparse. At the resource level, the picture is mixed. True resource level prices are not available for many primary commodities.

Trend in foreign trade balance.-An independent indicator of scarcity is the trend in trade balances for resource products. Although the trade balance is affected by currency valuations, political changes, and artificial trade restrictions, it does provide an indicator of scarcity in one country relative to the rest of the world. Clearly timber is relatively scarce in Great Britain, which has imported the bulk of its forest products for a century or more; it is relatively abundant in Canada, which exports much of its timber output. Vanek has used the net foreign trade balance as a measure of the degree of relative resource scarcity in the United States.[4]

Other measures. - Three other measures will be discussed here-resource quality, the rate of use relative to stocks or flows, and prices at the resource level.

1. Resource quality. Why not use the trend of resource quality as a measure of scarcity? Given knowledge of resources and market opportunities, firms will utilize the highest grade and most easily accessible resources first. As demand increases or as the resource stock declines, less desirable deposits

will be used. Smaller trees will be cut, and lower grade ores refined. Trends in physical characteristics of resource input would seem to provide an objective measure of the trend of scarcity. This could be true, if a resource possessed only one dimension of quality. But quality is not only multidimensional, it is also a function of technical knowledge in the resource industries.[5] For example, the continuous decline in average iron content of ores would appear to be a clear signal of increasing scarcity. But the shift to taconite, while necessitating large investments in beneficiation plants, also produced side benefits. Pellet shipments to mills actually save transport costs because their iron concentration is higher than conventional ores. And blast furnace costs for taconite are lower.

2. Rate of use relative to stocks or flows. The supply outlook for a natural resource is often obtained by comparing current or prospective consumption rates with known or estimated reserves. While simple, the method is probably not rigorously applicable to any resource. It is beyond criticism only in trivial cases, such as in calculating the mineral content of the oceans or the quantity of nitrogen in the atmosphere.

The estimated stock of any resource is a function of existing technology, current and expected relative prices, and the level of exploratory activity. For a renewable resource such as timber or rangeland, the resource stock varies over time with its biological condition.[6] Past and present rates of utilization determine whether the standing crop is rising or falling. In addition, technical advance is capable of changing the utility of the standing crop and thus expanding the resource even if the biomass is constant.

Assessment of trends in total timber volume are also plagued by changing species and utilization standards and by changing measurement concepts.

Conceptually, if competitive markets exist for the relevant resource products, estimates of reserves relative to consumption rates will affect intertemporal production plans and hence the market price. Thus, the actual data on stocks and flows add no information not contained in the real price.

3. Price at the resource level. Given the definition used in this study, prices at resource level are not appropriate indicators of resource scarcity. The scarcity definition used here considers product prices only. In investigations of the welfare of resource owners, processors, and their employees, however, resource level prices are clearly relevant.

The nature of timber markets assures availability of price quotes for standing timber. But for many other resources, comparable prices do not exist. Mineral prices are never quoted "in the Ground." The closest approximation is a wellhead price for petroleum, or an ore price, FOB some shipping point. These prices include payments for processing and transportation, and hence are not true resource prices.

For long-term studies, stumpage prices have several disadvantages. Data for private sales are sparse and of uneven quality. No adequate time series exist. For earlier years, published prices are rendered nearly useless by the habits of trading timberland by the acre, by cruises that underestimated lumber recovery, and by the changing standards of species utilization. These obstacles prevent drawing a clear statistical picture of the trend of timber prices for Eastern White Pine during its era of liquidation.

Indicators used in this study.-This discussion suggests that the trend of resource supplies in a given country can be summarized by two indicators: the trend of real price for resource products, and the net foreign trade balance in resource products. Apart from measurement difficulties, measures of resource rents and factor productivity carry no information not contained in these two indicators. The hypothesis test in the next chapter will rely upon these two indicators, but will discuss trends in consumption and production and summarize evidence on labor productivity for completeness' sake.

RESOURCES AND WELFARE

An implicit assumption in many resource analyses is that consumer welfare is a function of physical consumption of resource products. In fact, this assumption is rarely justified. This section will briefly discuss the impact of resource prices on consumer welfare and on the distribution of income.

Resource supplies and the consumer. -Effects of resource development on nonmarket values occupy an important place in conflicts over resource use today. Problems of common pool resources, control over bureaucracy, public goods, and option demand are all important. They are beyond the scope of this study, but views as to resource adequacy affect policy positions on adaptations to nonmarket values. Current high prices of meat, of lumber and plywood products, and of petroleum products are used as arguments for emphasizing commodity values in land use decisions. Future prospects for commodity supplies will in any event form part of a balanced approach to settling these conflicts.

Conservationists and professionals have often argued that consumer welfare is a function of physical consumption of resource products. Since high prices retard consumption, high prices are *prima facie* indicators of welfare losses. As the *Capper Report* asserted, "The ramifications of lumber shortages and high prices are limitless and have affected seriously practically our entire population.,,7

Consumer welfare, however, is a function of real income and wealth. Typically, natural resource products individually make up only a small share of a consumer's expenditures. **In** a dynamic economy, with real prices and real incomes constantly changing, it is difficult to measure the income effect of a price change for a particular resource product. Since consumers can and do substitute away from high-priced products, it is difficult on economic grounds alone to argue that significant welfare losses to consumers result from rising resource product prices. An example of consumer response to prices is the coffee price boom of the early 1950's. Housewives simply used less coffee per cup, and retained the habit after prices fell back to normal levels.

For an economic scarcity of resources to be a social problem, that scarcity must affect consumption of some good or service deemed socially important. **In** the colonial period, local timber depletion and high transportation costs led to winter shortages of fuelwood in major cities. These shortages caused great suffering among the poor, and certainly qualified as a social problem. Some towns took action to improve winter supplies of fuelwood.

Another case in which a social problem could arise is in the case of a necessity which occupies a large portion of the consumer's budget. Com in Ricardo's England is an example. Since com was the major item in consumer expenditure, a rise in its price could produce actual starvation. No resource product occupies a similar position in the United States today.

For firms purchasing raw material inputs, if expenditures for a given input remain unchanged, it can be said that the firm has not been harmed by the change in price. Olson used this criterion in examining the impact of tie prices on railroads. She found that total real outlays for ties were constant over a long period, and concluded that timber supplies were ample from the railroad viewpoint.[8]

The case of housing. -Typically, however, the link between resource prices and social problems is less direct. Today, it is widely alleged that high lumber prices are a serious barrier to progress in housing. Housing certainly qualifies as an area of social concern, as a large body of social policy testifies.

Recent increases in lumber and plywood prices have generated controversy over the effects of timber supply constraints on the level of homebuilding and on house prices. Evidence suggests that much of this concern is misplaced. Lumber and wood products account for only about 15 percent of structure costs, and about 5 percent of the homeowner's monthly ownership costs. From 1950 to 1972 the lumber and wood products wholesale price index rose by 62 percent, while construction wages rose threefold, land prices rose fivefold, and mortgage interest rates rose by 80 percent. Wood products, then, have not been a very important longrun influence on the price of new houses.

In relation to the level of homebuilding, the construction industry faces many obstacles in its effort to expand residential building. These include financial conditions, land and labor supply, local zoning and tax policies, and the inability of poor families to pay the costs of renting or owning standard housing.

Distributional aspects.-A final welfare aspect of resource scarcity is its effect on the distribution of income and wealth. This has two dimensions. First is the distribution of income among factors of production within a country. Second is the distribution of income among nations.

Ricardo gave much attention to the view that scarcity of agricultural land would endow landowners with an increasing fraction of the national wealth. Further, rising corn prices would raise wages and depress returns in manufacturing-"the profits of stock." This country's homestead policies were motivated in part by a strong belief that wide distribution of wealth in land is healthy for a democratic society. Despite this belief, however, most of the great fortunes in this country were built by the exploitation of natural resources such as furs, timber, or oil.

Rising natural resource prices, then, have important implications for the distribution of wealth. Whether resource prices rise as a result of lowered transport costs, improved technology, or high product demand, resource owners will benefit from rising capital values. Given the current unequal distribution of land ownership, rising resource prices will exacerbate the inequality of wealth.

Resource prices also affect the international distribution of income. In a world where some nations specialize in manufacturing and others in primary production, the terms of trade between these sectors take on a high importance. *Ceteris paribus,* rising gold prices benefit South Africans, and rising coffee prices benefit Brazilians. It is widely believed, however, that the secular trend in the terms of trade has been against primary producers, and promises to continue to be. This suggests that experts in international development are little concerned about the prospect of resource scarcity.

SUMMARY

As a step toward testing the scarcity hypothesis, this chapter reviews existing indicators of resource scarcity. These include the rent of resource services, the productivity of labor and capital in resource industries, the real price of resource products, and the foreign trade balance. Measures considered but not used were the trend in resource quality, the relation of production to known reserves, and the price at the resource level. The real price of resource products and the foreign trade balance form a complete set of scarcity indicators for our purposes.

Finally, the impact of natural resource supplies on consumer welfare was discussed. Rising prices of natural resource products will not constitute a social problem unless they occur for necessities which form a large part of consumer's budgets. This condition is probably not satisfied by any single resource product in this country today.

In the case of housing, timber supplies do not have a significant effect on the price or production of new housing units. Other constraints on output are far more important, even if less subject to simple remedies.

CHAPTER THREE

TESTING THE SCARCITY HYPOTHESIS

This chapter gives an empirical test of a timber scarcity hypothesis. The hypothesis is:

> The United States has experienced steadily increasing timber scarcity and faces increasingly severe scarcities in the future.

The test uses the scarcity definition and the indicators described in Chapter Two. This chapter describes the historical course of forest products prices, of production, of labor productivity, and of the United States balance of trade in timber products.

THE REAL PRICE OF FOREST PRODUCTS AND TIMBER

A theoretically correct and empirically workable indicator of resource scarcity is the longrun trend of real price. Emphasis on real price trends appears in the writings of Mason, Barnett and Morse, and Ruttan and Callahan. In a study of copper, Herfindahl gave the most thorough analysis of the use of real price as an indicator of scarcity.

Real price offorest products. -The rising longrun trend of real lumber price is well documented. Various investigators have given long run rates of increase in real lumber prices for different time periods ranging between 1.7 and 2.0 percent per year.[1] Although the point appears firmly established there are divergences that require explanation. Further, price trends in recent decades favor rejection of the scarcity hypothesis.

The real price oflumber has indeed risen markedly since 1900 (Fig. 1). The large increases in relative price, however, do not occur steadily. They appear principally in the building booms and inflationary periods following the three major wars. Omitting these periods, there remain three periods of stable or declining real price. These include the years 1907-1919, 1923-1932, and roughly 1950-1965. Housing construction was falling in the first two periods and stable in the last. The only years of rising price in the absence of strong demand and/or general inflation were 1932-1945. Instead of saying that lumber prices are subject to continuous inflation, it is more correct to say that major increases in production and demand are accompanied by increases

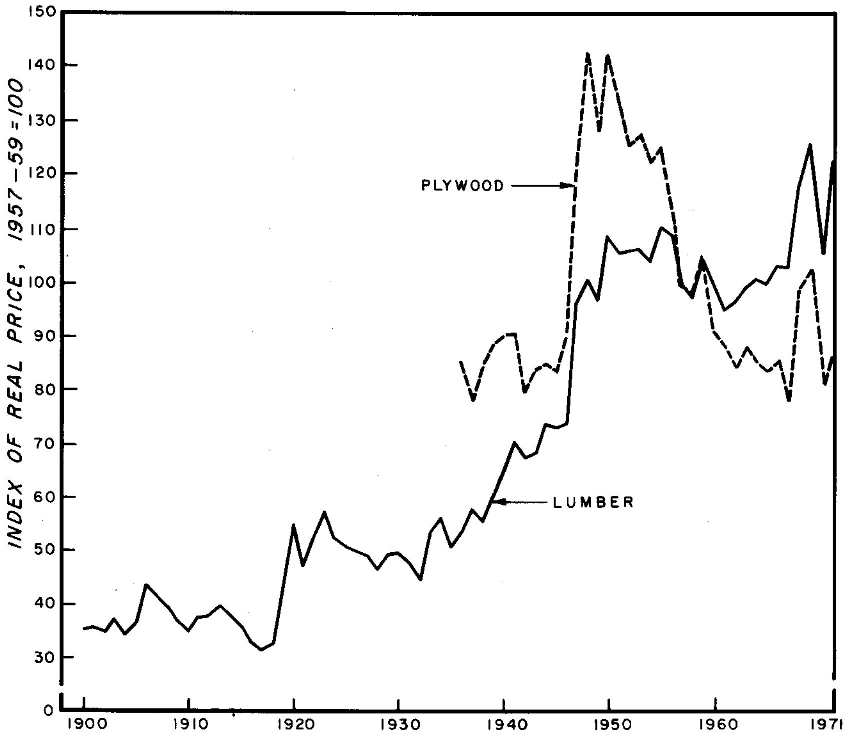

FIGURE 1. Real price of all lumber and softwood plywood, 1900–1971.

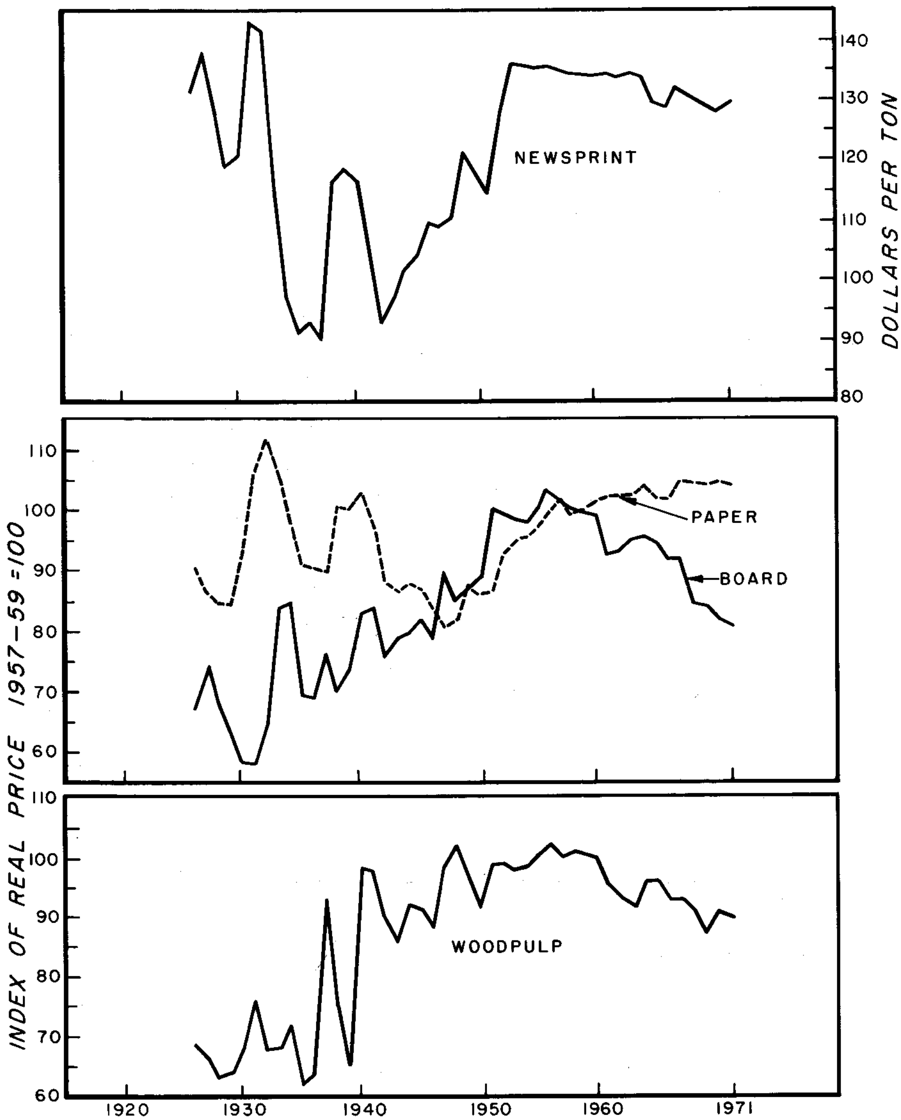

FIGURE 2. Real price of major paper products, 1926–1971.

in the relative price of lumber. The current post-1967 inflation in lumber prices confirms the pattern.

More damaging to the scarcity hypothesis, however, is the behavior of plywood prices. **If** large high-quality timber is economically scarce, the relative price of plywood should rise, since this product is uniquely dependent on such timber. **In** fact, the reverse has occurred. From 1948 to 1967, the real price of plywood fell markedly in relation to lumber prices. This occurred during a sevenfold expansion of output that reoriented raw material use patterns of whole regions and demolished markets for important lumber items. Timber cannot be scarce for lumber and abundant for plywood. **In** view of the characteristics of the industries, one would expect the reverse to be true. But the statistical record of real prices for lumber and plywood sheds considerable doubt on the hypothesis that sawtimber is a scarce resource.

These longrun price comparisons are biased by price indices which do not account for quality changes. The lumber industry today manufactures to higher technical standards and applies more services to its products. Some of these services were formerly applied by the consumer or not at all-at one time, carpenters building a house sawed and dressed much of the lumber on site. Price trends based on quoted values are thus biased in an upward direction, since they do not refer to goods of constant quality. Also, the declining size of dimension items means that 2x4 prices, for example, relate to ever smaller volumes of actual wood content.

Price indices for paper and related products provide additional checks on the scarcity hypothesis. The demand for paper, and hence for pulpwood, has grown spectacularly since the advent of chemical pulping in the 1860's. United States woodpulp output has grown especially rapidly since the 1930's. These products should then provide extreme tests of the timber scarcity hypothesis.

The real prices for woodpulp, newsprint, paper, and board present a mixed picture (Fig. 2). Comparisons over time are biased by overcapacity in the paper industry during the 20's and 30's. The price series exhibit two distinct periods-one of generally rising real prices from 1926 to about 1950-1955; and one of stable or declining prices since then. Paper is an exception-it declined until ab!out 1948 and rose thereafter. For products at the lowest processing levels, woodpulp and newsprint, the trends clearly suggest declining real costs since 1950.

Real price of standing timber. - Timbermen and economists have long noted a tendency for timber prices to rise. **In** 1905, Fernow summarized evidence from the United States, Prussia, and other nations to show that timber prices generally rise faster than the cost of living. Steer, in a comprehensive summary of stumpage price data determined that from 1900 to 1934 the real price of standing timber had risen. Thomson collected data from United States and German sources and asserted that the general rise of stumpage prices, related to resource depletion, was virtually an economic law. **In** the 1950's, timber prices rose relative to the general price level and also relative to prices of forest products.[2]

Sawtimber real prices show a slight rising trend until the 1940's (Fig. 3). After 1946, southern pine prices rose sharply, only to decline from 1952 to 1963, when increased lumber production and the new pine plywood industry caused prices to rise once more. Douglas fir stumpage shows a much clearer though erratic uptrend, due to the steadily increasing timber demand of the plywood industry, and more recently the growing log export trade.

The causes of the rise in sawtimber prices are numerous and complex. Especially interesting is the steady rise of Douglas fir timber prices through the fifties and early sixties, at a time of stable lumber prices and falling plywood prices. One factor may have been, as Trestrail pointed out, the demand for timberland as an investment good. Another factor was the trend of cutting on public versus private landholdings. As privately held timberlands were heavily cut, the demand for public timber rose dramatically in the Douglas-fir region. This rapid rise of demand for *public* timber may account for the steady rise in the price of national forest timber in that region, while southern timber prices were stable. **In** addition, the economic status of the two regions differed-the fir region was liquidating old growth and experienced only small increases in stumpage prices before 1940. The South, on the other hand, was experiencing rapid timber growth after 1950 and rapidly bringing second growth forests under management. Also, the different levels of competition for public timber may affect the price trends in different regions.

Technological advance has two effects on timber values. Increased value recovery and reduced costs tend to be captured by stumpage, the input whose substitutability is lowest. Also, extending operability into higher slopes and poorer stands raises the value of stands with better than average location, stocking, or composition. These factors strengthen the case for using prices of forest *products* as the primary indicator of resource scarcity.

Two qualifications must be set on the sawtimber price trends. First, they understate the true increase in price because of the decline in average size and log-grade over the period. Values for logs of standard size and quality would

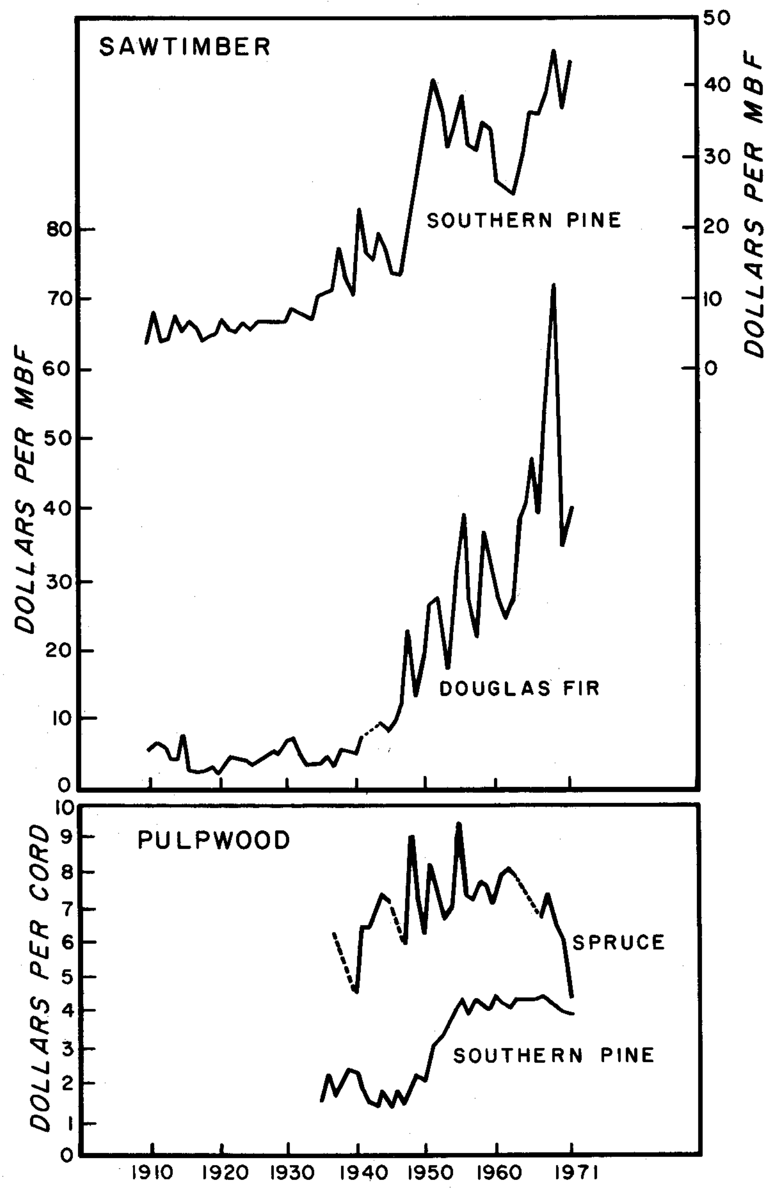

FIGURE 3. Real price of sawtimber and pulpwood stumpage, 1910–1971, 1957–59 dollars.

surely have risen more rapidly than do the series in Figure 3. On the other hand, technical changes have vastly increased the utility of logs of constant size and quality. The capacity of plywood mills to utilize small logs, the advent of chipping headrigs and specialized stud mills, and the growth of chip markets have progressively increased the rate of value recovery per thousand board feet of logs. The net effect of these offsetting factors cannot be assessed quantitatively.

Second, the data are not representative. The fir data are for National Forest sales, while the southern pine data are spliced from a series of private sales 1910-34 and national forest sales thereafter. The validity of these quotations as surrogates for regional values has never been established. In addition, changing standards of measurement and utilization affect the comparability of prices over time.

Pulpwood stumpage prices show a general rising trend but a modest one in contrast to sawtimber prices. The supply-demand structures for sawtimber and for pulpwood differed widely in this period. Spruce pulpwood prices rose steadily until the late 1950's, and then declined-a trend which may have been due to decreased reliance on spruce made possible by hardwood utilization. The price of southern pine pulpwood stumpage has been stable apart from the sharp jump from 1950 to 1955. The series for 1954-69 is for Louisiana, so that this trend may not represent the situation in the more highly developed timbersheds of the Southeast.

The supply of pulpwood timber has clearly expanded since 1930. Second growth stands and plantations provide easily accessible timber of uniform size that can be handled with light equipment. The great inventory gains in the eastern United States have been in just such timber. Also, improved technology has opened to use a vast quantity of low-value hardwoods that formerly had negligible economic value, and for which the pulp industry does not have to compete with other industries. In addition, increased residue utilization has dampened the demand for round pulpwood.

These facts show that there is no basis for the view that real prices of forest products have been rising as a consequence of a general timber scarcity. Real prices of important forest products, except lumber and paper, have actually declined since 1950. While stumpage prices have risen markedly over the longrun, the trend is not uniform between sawtimber and pulpwood timber, and it is influenced by institutional factors that do not relate to physical resource supplies. At certain times and places, however, local scarcities may have occurred and may persist today.

TRENDS IN PRODUCTION

To fully evaluate the significance of real price movements, production trends must be considered. Timber production from domestic forests was roughly constant from 1900 to 1970 (Fig. 4). This stability masks offsetting trends in the composition of wood use. In 1900, fuelwood accounted for 40 percent of production and sawlogs for 60 percent. This allocation remained stable until about 1940. Since 1940, however, the picture has changed radically. The rapid growth of pulpwood consumption, rising plywood output, and the decline of fuelwood use created an entirely new use pattern. In 1970, lumber accounted for only 45 percent of timber cut, while plywood and veneer logs took 8 percent and pulpwood took 33 percent. Fuelwood was only 6 percent of the harvest in that year.

Trends in per capita consumption of timber products illustrate the changed wood use pattern. From 1900 to 1970, total wood consumption per capita fell from 157 cubic feet to 62.5 cubic feet. Sawlog consumption fell from 72.3 cubic feet per capita to 29.4 cubic feet, while fuelwood fell from 63.1 cubic feet to 3.4 cubic feet. Pulpwood consumption, however, grew tenfold, from 2.2 cubic feet to 21.6 cubic feet, while plywood and veneer logs increased from a nominal quantity to 5.4 cubic feet.

The timber economy from 1900 to 1970 has been reallocating a roughly stable total drain upon the forest. More importantly, the *industrial demand* for timber increased appreciably. Shifts among products were accompanied by several instances of very rapid growth, especially for plywood and pulp and paper products.

TRENDS IN LABOR PRODUCTIVITY

Economists have often used factor productivity in resource industries as a proxy measure of scarcity. The reasoning is straightforward: declining quality of availability of a resource will cause labor and capital costs to rise relative to nonextractive industries. Potter and Christy adopted this concept in measuring logging and sawmill productivity from 1870 to 1955. Ruttan and Callahan compared gross output in forestry, land inputs, and labor inputs to assess resource scarcity in various periods. They concluded that while labor productivity fell from 1870 to 1920, resource scarcity could not have been responsible for this. Later, scarcity was a "brake on output expansion" in the

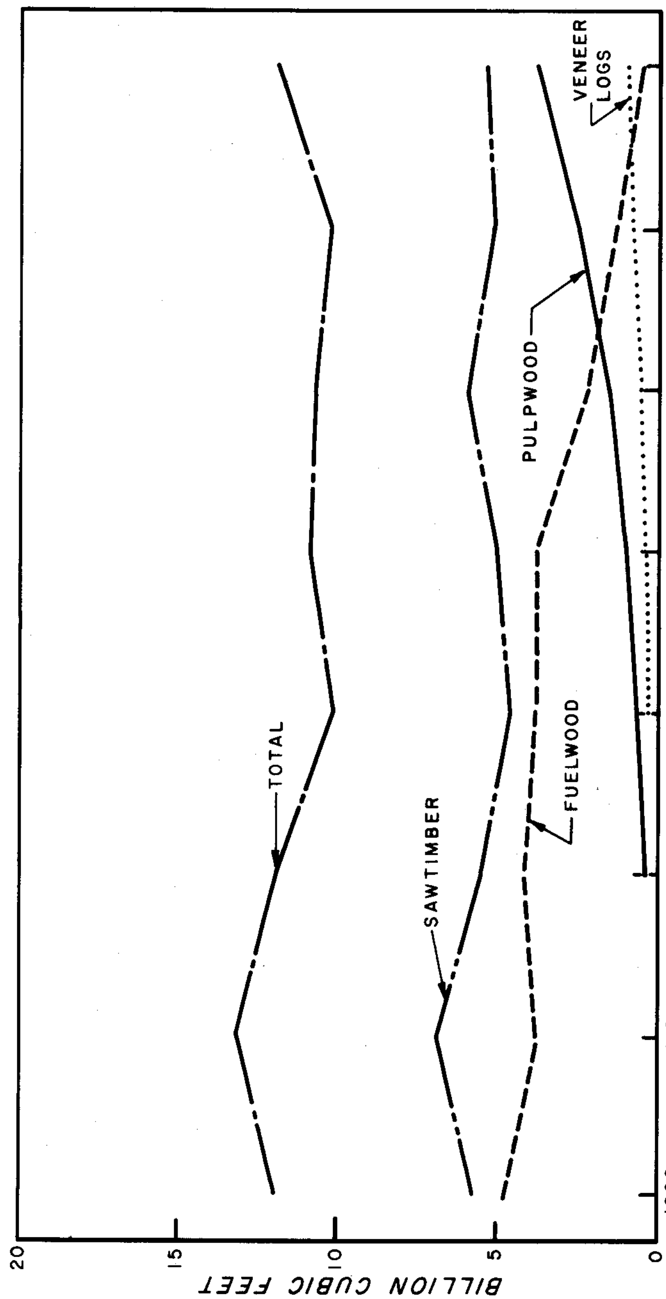

FIGURE 4. Estimated domestic production of round timber products, 1900–1970.

30's and 40's, but was overcome in the 1950's by technical advance. This analysis is more sophisticated than others since it allows for changing influences over time and does not attribute cost trends solely to resource scarcity.3

Barnett and Morse examined real cost trends for sawlogs, and the trend of cost of net sawlog output relative to a deflator of nonextractive GNP. They found that relative sawlog cost rose substantially. They saw this as strong confirmation of the scarcity hypothesis for timber.[4]

These studies assume that poor productivity performance in the logging industry demonstrates the existence of resource scarcity. Logging is a primary extractive activity which may properly be compared with mining and other extractive industries. It is the sector in which declining quality and availability of timber will be felt most strongly. But is logging productivity as it has been measured a convincing measure of scarcity? The answer involves several factors: the conceptual appropriateness of the productivity measure; data problems in applying the measure; and potentially offsetting productivity change at other fabricating levels.

Measures of productivity change.-Several measures of productivity change in the forestry sector are shown in Figure 5.The two series from Potter and Christy (series 1 and 3) showdeclines in logging productivity over the period. Other series refer to sawmilling. Series 2 is a crude measure of real value added per worker in sawmilling. Despite noncomparability between subperiods due to data limitations, the series suggests the opposite of the logging series. The two shorter series (4 and 5) represent Kendricks's estimates of labor productivity in lumber and wood products and in paper and allied products industries; both show clear increases.

Thus, productivity increases in milling and processing could have offset the declining productivity in logging. Whether this offset was complete is not clear. Kendrick's data showed that overall productivity in lumber and wood products advanced at 1.1 percent per year over1899-l954, compared to 2.2 percent for all manufacturing and 2.4 percent for paper and allied products. Zaremba, on the basis of price data, ventured the opinion that productivity may have declined over the same period. Elsewhere, he asserted that technical change in logging and milling had been roughly cancelled since 1939 by declining timber size and stocking and rising hauling distances. On the other hand, Kaiser found that labor productivity in SIC 24 (which includes logging) rose by 3.2 percent per year from 1947 to 1967, a rate close behind the average for all manufacturing of 3.4 percent and paper and products at 3.6

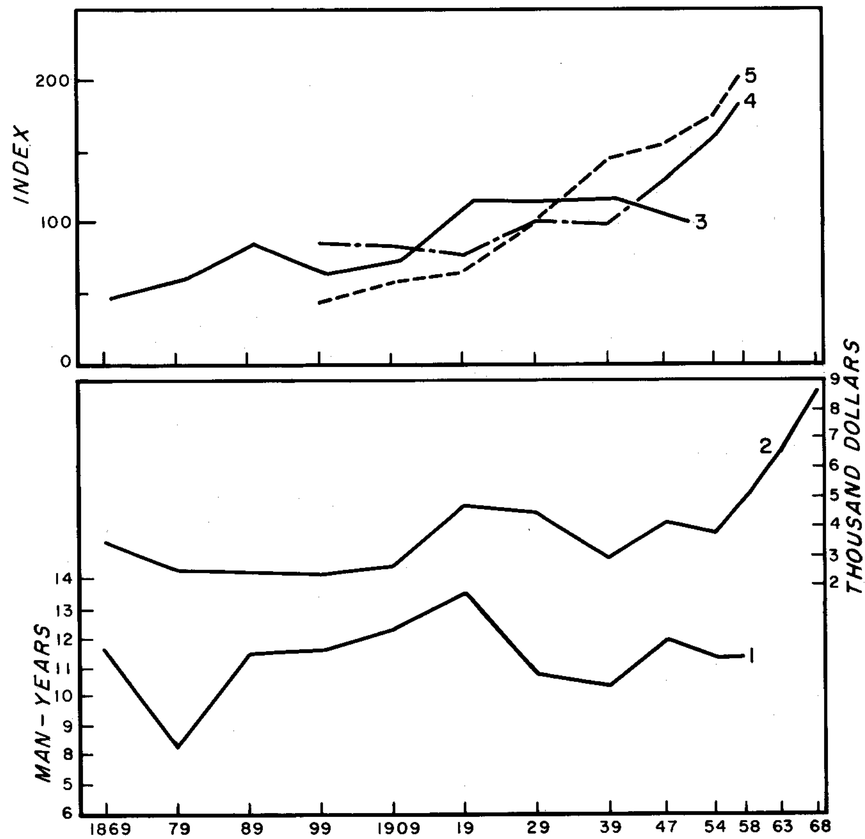

FIGURE 5. Estimated trends in labor productivity, logging, sawmilling, and paper sectors, 1869–1968. Series key: (1) man-years per million board feet in sawmilling; (2) census value added per man-year, deflated by lumber price index; (3) logging employment per unit of output, 1947–49 = 100; (4), (5) Kendrick estimates of output per manhour, lumber and wood and paper products, index, 1929 = 100.

percent. In any case, the weight of the evidence is so uncertain that broad conclusions cannot be drawn from these data alone.[S]

Next, the data series must be examined. A serious difficulty in estimating labor input in logging arises from the nature of the industry. In the past, logging units were highly mobile firms characterized by varying degrees of integration with processing. In some regions, logging was and remains a separate industry. Separating the logging industry itself for statistical treatment is a near-impossible task, although it was attempted by early manufacturing censuses. A rel"ated difficulty is that in some regions and time periods, logging has been a seasonal activity. This is one factor responsible for the lack of man-hour estimates for this sector. Lack of man-hour data severely limits the comparability of logging productivity data with other sectors. Further, logging is badly underreported in the most recent censuses, and it would be surprising if past censuses were any better in this respect.[6] The net effect of these deficiencies is unknown, but they argue for cautious interpretation.

Another data problem occurs in the sawmilling sector. In the past, much lumber was shipped unsorted, rough, and green. Such was the practice, for example, in the lumber rafting trade on the Mississippi. Services such as grading, drying, and planing were performed by wholesalers and retailers. The independent planing mill formed a separate industry. Today,. lumber is grade-marked, precision end-trimmed, preservative treated, and banded and wrapped in protective covering. So part of the increased labor input in sawmilling represents the application of more services to the product.

Implicit in the above analyses is the assumption that labor productivity trends in logging or milling are the sole result of changes in resource quality or availability. There is no theoretical reason why this should be so. Even if it is true that timber industries have a poor productivity record, this may be the result of other influences than timber supply conditions.

Relative rates of market growth are important determinants of productivity change. One reason, then, for the lagging productivity record of the lumber industry is its slow rate of market growth. Plywood, with a rapidly growing market since World War II, has shown declining real costs over most of the period. The commodity nature of lumber and lack of economies of scale at the plant level may be additional factors. In view of these diverse determinants of productivity change, simple unit labor input trends may be misleading indicators of the presence of resource scarcity.[7]

TRENDS IN FOREIGN TRADE

Thus far, resource scarcity has been analyzed within the bounds of our national economy. However, in a world economy it is impossible to discuss resource scarcity for one nation in isolation.

Theories of resource trade. -During the interwar period, the United States shifted from a position of net exporter of resource products to one of a net importer. This shift occasioned serious comment on its significance for domestic resource scarcity and for defense policy.[8] Vanek carefully documented the changing trade balance in resource products from 1870 to 1955. He concluded that increasing scarcity of resources, especially for minerals, was a dominant factor explaining the shift. Vanek emphasized the significance of scarcity in relation to other trading partners:

> ... over the past 85 years the United States has become steadily poorer in the natural resources relative to the rest of the world and more abundantly endowed with other factors of production. About the time of World War One, or a little later, the natural resources of this country became scarce as compared with the rest of the world.[9]

Vanek found that export and import unit values of resource products for the United States do not suggest increasing scarcity. But he suggested that the operation of "Malthusian forces" was expressed in a changed structure of resource trade, rather than in diminishing returns in resource industries.

Patton emphasized the importance of relative costs in determining the pattern of United States resource trade. Rather than appeal to domestic depletion or to changing domestic factor proportions, he saw the discovery of cheap foreign deposits as the chief factor in our increasing dependence on foreign sources for major products.[10]

Discussion of trade in primary products normally begins with the Heckscher-OWin theorem. This theorem states that a country's exports will tend to embody more services of its abundant factors than will its imports.[11] Thus, the United States in the 19th Century was an importer of capital and an exporter of natural resource services. Today, on the basis of factor proportions, the Heckscher-OWin theorem would suggest that United States exports would be more capital-intensive than its imports, since this is a capital-abundant and high-labor cost nation. Leontief, on the basis of his input-output studies, discovered that the opposite was true—a result now well known as the Leontief Paradox.[12]

The Paradox has been explained in a variety of ways. Some writers have argued that when the effect of higher stocks of human capital in the United States is considered, the Paradox is resolved.[13] Another explanation is the product-cycle theory. This concept holds that the comparative advantage of the United States lies in the development of new, high-technology products. As a given new product becomes established in world markets, other countries adopt the technology and progressively erode the comparative advantage of the United States. The examples of television sets, automobiles, and textiles conform to this pattern.[14]

The product-cycle theory is supported by the observation that the export performance of United States manufacturing industries is well explained by their intensity of R&D investment. Other evidence was presented by Branson and Junz.[15] They examined the trade balance of products at different fabrication levels within vertically integrated industries. They found that the United States trade balance was most favorable at the high processing levels. Thus, the nation imports crude oil while exporting synthetic chemicals. It imports iron ore while exporting sophisticated alloys. This pattern also appears in the forest industries. The United States is a net importer of newsprint, but a net exporter of alpha and dissolving pulps.

The product cycle theory provides a useful perspective on the current American balance of trade in forest products. Most forest products are raw materials embodying a low level of processing and employing relatively simple technology. The disappearance of our export surplus in lumber and the heavy dependence on net imports of newsprint are thus to be expected on economic grounds that have no necessary connection with resource scarcity. Later sections will document that our balance of trade in forest products has undergone significant improvements since the 1930's, and especially since 1950. That this has happened in a sector in which the United States appears to have scant relative advantage appears to be a strong argument that forest resources have become relatively more abundant in recent years.

Trends in forest products trade.-What does the long-term record show for the United States? For industrial wood the net imports as percent of apparent consumption grew from zero after 1910 to 14 percent by 1950 (Fig. 6). The trade balance in pulpwood, pulp, and paper products was at its worst much earlier, in the 1920's and 1930's, when almost 60 percent of total consumption was imported. The trade position moved into deficit for lumber and sawlogs during World War II and by 1970, net imports provided 12 percent of domestic consumption.

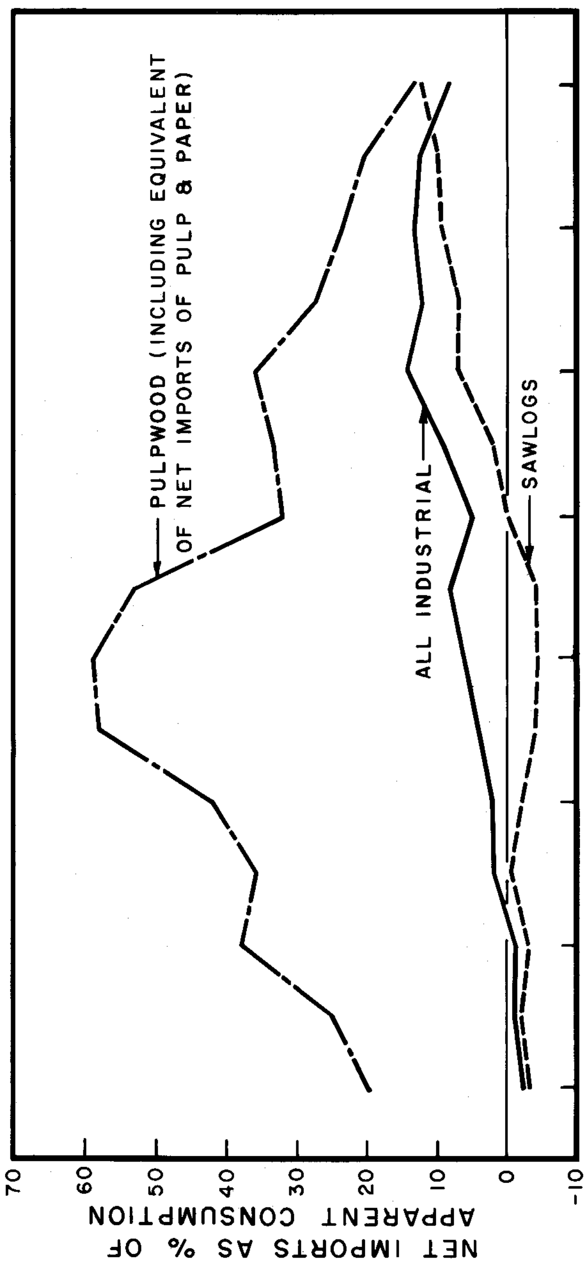

FIGURE 6. Estimated net imports as a percentage of apparent consumption, major timber products, 1900–1970.

The most impressive trend, however, is the continuous reduction of dependence on pulpwood and paper imports since 1920. This is due to the growing southern and western pulp industries. This trend has been strong enough to offset growing lumber imports, so that net imports relative to consumption of all industrial wood have fallen since 1950.

When particular commodity groups are examined, this impression is strongly confirmed. As a result of growing trans-Pacific trade in pulpwood and chips and substitution of sawmill residues and hardwoods for imports, the trade balance in pulpwood has been reversed (Table 1).

In 1950, pulpwood net imports totalled 1.4 million cords; by 1970, the United States had an export balance for the first time in the century with net exports of 700,000 cords. Net imports of paper, paperboard, and woodpulp (pulpwood equivalent) declined similarly, from 10 million to 5.5 million cords between 1950 and 1970. From 1930 to 1970, woodpulp exports grew 60-fold while imports only doubled. Net imports of paper and board alone grew from 13 percent of consumption in 1925 to 16 percent in 1950, then fell to 8 percent in 1970 (Tables 2, 3).

For newsprint, this country has historically depended heavily on Canada. In 1915, the United States produced 76 percent of its newsprint consumption; by 1950, domestic production was only 18 percent of consumption. Since

TABLE 1. United States Trade Balance in Pulpwood, 1909–1970.

Year	Net imports	Imports	Exports
		Thousand cords	
1909	908	...	...
1920	1,241	...	...
1925	1,470*	...	...
1940	1,374	...	...
1951	2,497**	2,510	15
1960	1,158	1,320	160
1965	1,150	1,305	155
1970	−700	1,120	1,820
1971	−305	1,225	1,530

Source: Hair & Ulrich, 1972, p. 74; 1964.
*peak prewar year
**peak postwar year

TABLE 2. United States Trade Balance in Wood-Pulp, 1930–1971

Year	Imports	Exports	Net imports
		Thousand tons	
1930	1,830	48	1,782
1940	1,224	481	743
1950	2,375	96	2,279
1960	2,370	1,142	1,238
1970	3,490	3,095	395
1971	3,488	1,952	1,536

Source: *Pulp & Paper, 1972 World Review,* p. 64, 66.

TABLE 3. United States Balance of Trade in Paper and Board, 1925–1971

Year	Consumption	Imports	Exports	Net imports
		Million tons		
1925	10.4	1.6	0.2	1.4
1939	15.9	2.7	0.2	2.5
1950	29.0	5.0	0.4	4.6
1960	39.1	5.7	1.0	4.7
1970	57.8	7.3	2.8	4.5
1971	58.4	7.3	3.1	4.4

Source: *Pulp & Paper 1972 World Review.*

TABLE 4. United States Trade Balance in Newsprint, 1914–1971.

Year	Consumption	Imports	Percent of consumption produced in U. S.
	Thousand tons		
1914	1,547	278	76*
1941	3,956	2,982	26**
1950	5,832	4,863	18
1960	7,270	5,410	27
1970	9,836	6,635	33
1971	10,002	6,881	33

Source: *Pulp and Paper, 1972 World Review.*
*1915
**1940

then, domestic production has risen, to 33 percent of consumption in 1970 (Table 4). Newsprint is a striking example, since it is a low-value, low-technology product. It is one which the product cycle concept suggests should be declining relatively in the United States. Taken together, the trends toward greater self-sufficiency in wood pulp, newsprint, and paper and paperboard argue strongly that the United States is a nation in which pulpwood has been becoming less scarce since the 1930's.

For lumber, the evidence is mixed. Since 1941 this nation has been a net importer of lumber. Net imports rose steadily through the 1950's and 1960's, reaching 6.5 billion board feet in 1971, or 15 percent of domestic consumption (Table 5). Canadian lumber continued to invade United States markets even during years when lumber prices and consumption were stable. This results from the lower cost structure of Canadian producers, which is based partly on a large supply of virgin timber. However, it is also a result of artificial restrictions and trade policies. The Canadian government makes Crown timber available at low prices to promote economic development. Also, coastal producers, who ship large volumes to the East Coast, are able to hire shipping in the free world market. American producers in the Northwest must use U. S. flag vessels, which gives them a severe freight cost disadvantage. Thus, the United States lumber trade balance has been affected by changing relative abundance of virgin timber resources, but to a degree that is strongly obscured by the effects of government trade and resource pricing policies.

With the rise of Japan as a major trading nation in forest products, the relative scarcity position of the United States shifted. The shift is readily seen

TABLE 5. United States Trade Balance in All Lumber, 1899–1971.

Year	Imports	Exports	Net imports	Consumption
			Billion board feet	
1899	0.7	1.5	-0.8	34.3
1920	1.4	1.7	-0.3	34.7
1940	0.7	1.0	-0.3	30.9
1960	3.9	0.9	3.0	36.0
1965	5.2	0.9	4.3	41.1
1970	6.1	1.3	4.8	39.2
1971	7.6	1.1	6.5	43.1

Source: Hair & Ulrich, 1964, 1971; *Survey of Current Business.*

TABLE 6. United States Trade Balance in Softwood and Hardwood Logs, 1950–1971.

Year	Imports	Exports	Net exports
		Million board feet log scale	
1950	268	48	-220
1960	112	266	154
1970	144	2,753	2,609
1971	84	2,292	2,208

Source: Hair & Ulrich, 1972.

TABLE 7. United States Trade Balance in Hardwood Lumber, 1929–1971.

Year	Imports	Exports	Net imports	Consumption
			Million board feet	
1929	124	480	-356	7,553
1950	283	111	172	7,546
1960	291	167	124	6,378
1970	337	128	209	7,300
1971	358	160	198	6,500

Source: Hair & Ulrich, 1964, 1972.

TABLE 8. United States Imports of Hardwood Veneer and Plywood, and Total Hardwood Plywood Consumption, 1950–1971.

Year	Hardwood plywood imports	Hardwood veneer imports	Hardwood plywood consumption
	MM sq. ft. surf. measure		*MM sq. ft. 3/8" basis*
1950	63	362	1,246*
1960	1,014	841	1,814
1970	4,168	1,606	3,729
1971	5,182	2,035	4,459

Source: Hair & Ulrich, 1972.
*1951

in the rapid rise of log and chip exports to that country in the 1960's. While log imports fell steadily from 1950 to 1970, log exports jumped from less than 300 million feet per year in 1960 to 2.7 billion board feet in 1970 (Table 6). The bulk of this trade was in species less favored by domestic industry. The export trade in chips was a stimulus to increased utilization of logging and milling residues.

These timber and chip exports are almost large enough, in total, to cancel the increase in lumber imports since 1960. In this perspective, the net trade position in sawtimber sized material may not have markedly worsened in the 1960's.

A different situation prevails for hardwoods, but even there the indicators are ambiguous. For hardwood lumber, net imports only provide 3 percent of annual consumption. Total consumption and net imports have been stable since 1950 (Table 7). In hardwood logs, the United States shifted from a net import position to a net export position between 1950 and 1970-imports fell by two-thirds while exports tripled. These data suggest that while this country is acutely aware of a "shortage" of good-quality hardwood timber, it still enjoys abundance relative to its major trading partners. A significant exception is in veneer and plywood. Vast supplies of suitable timber and low production and shipping costs have opened a growing market for Asian hardwood plywood and veneer in the United States. In 1971, hardwood plywood imports were 82 times the 1950 level; hardwood veneer imports were 5.6 times above 1950 (Table 8). By 1971, net imports made up 57 percent of domestic hardwood plywood consumption.[17]

Following a period of heavy reliance on outside sources of certain forest products, the United States has moved strongly toward relative self-sufficiency since about 1950. A primary force has been the shifting pattern of trading partners. In its colonial period, the nation was thinly populated and possessed large stocks of virgin timber. It traded with nations in which timber was scarce—Great Britain, France, the West Indies. Further, it possessed an absolute advantage in certain fields such as masts and naval stores. As the nation grew to industrial maturity, increased drafts on its forests, clearing for agriculture, and losses to fire caused the locus of timber abundance to shift northward into Canada. With this cheap source of roundwood near at hand, American consumption of paper products grew rapidly. Later, after World War II, lumber cut from Canada's vast supplies of virgin timber began to reach the American market. The United States gave every indication of being a timber scarce nation.

With the growing appetite of industrialized Japan for forest products, a new trading partner entered the pattern. In relation to Japan, the United States is a timber-abundant country.

Also significant, however, was the steady progress of technology. The development of a pulp industry in the South and Northwest facilitated the long decline in pulpwood import dependence. New technology for lumber production from small timber aided the domestic industry in its competition with Canadian imports, and fostered the rise of newly competitive lumber industries in the Rocky Mountains and the South. New plywood technology permitted rising demand to be accommodated from southern production, thus forestalling the need for increased imports.

Finally, improvements in timber volume and growth after 1950 caused a decisive turnaround in the nation's timber supply. This turnaround helped the nation reduce its import dependence for timber products while industrial wood consumption was rising.

SUMMARY OF THE TEST

Two necessary conditions for resource scarcity are the presence of a rising real price of resource products, and a deteriorating foreign trade balance in such products. This chapter has shown the following:

1. Although stumpage prices have risen markedly, prices of sawtimber products-lumber and plywood-have not behaved as the scarcity hypothesis suggests.
2. Real prices of paper and pulp products on the whole have fallen steadily in the postwar period.
3. Industrial wood consumption has risen slowly, so that real price declines are not the result of falling total demand.
4. Since about 1950, the overall trade balance of the United States, measured by the proportion of domestic consumption provided by net imports, has steadily improved. Over a wide range of products, net imports declined markedly. Log exports rose significantly. Sectors experiencing rising net imports, however, were important-softwood lumber, and hardwood plywood and veneer.

These results show that the timber scarcity hypothesis no longer applies in the United States. Most measures clearly suggest increasing scarcity during the 1930-1950 period, but the reversal since that time has been so clear and so broadly based as to leave the timber scarcity hypothesis virtually without empirical support. Scarcities at particular places and times or for particular items are not inconsistent with this argument, which asserts that no *general* timber scarcity has existed in this country since 1950.

What forces have been responsible for this turnaround in timber availability since 1950? To list them would be a history of forestry and forest industry in this country. Of great significance have been the resurgence of second growth forests, the effects of forestry programs such as tree planting and fire protection, changed patterns of wood use, and resource-expanding technical change.

Why has this study reached conclusions at variance with those of so many authorities? First, a narrower defmition of resource scarcity was used. Second, it is asserted that the data base for certain earlier conclusions is inadequate. Finally, the simple extension of the study period to 1970 permits identification of economic trends which were not evident even ten or fifteen years ago.

CHAPTER FOUR

EXPANDING ECONOMIC SUPPLY

Chapter Three has shown that the timber scarcity hypothesis must be rejected for the United States. Recent decades have brought persistent declines in real prices of major forest products. Our balance of foreign trade in timber products has steadily improved since 1950. And despite rising consumption of industrial wood, the quantity, quality, and accessibility of our forest resources have been improving steadily for at least thirty years. What forces have brought this about? A primary force has been the resource-expanding effect of technical change in timber growing, logging, and processing. This chapter will briefly survey technical developments that have made possible dramatic improvements in the timber supply, overcoming declines in timber size and quality.

ECONOMIC CHARACTER OF FOREST INDUSTRIES

Forest industries convert a highly heterogeneous, spatially scattered raw material–standing timber–into standardized commodities. The outputs range from producer durable goods like lumber to consumer nondurables such as facial tissues. There are several fundamentally different types of processes involved in this activity. These include:

1. Marketing roundwood in essentially unaltered form–poles and piling, preservative treatment.

2. Converting log inputs into usable pieces, a breakdown process similar to meat packing–lumber.

3. Converting logs into a homogeneous basic material such as chips or veneer, which is then reassembled into the product-plywood, particleboard.

4. Breaking down wood substance by physical and chemical means into fiber, to be reprocessed into final products-paper, paperboard.

Essential to these activities are timber growing and logging. The economic characteristics of these processes differ, with significant consequences for technical change.!

Substantial economies of scale exist in timber growing. Intensive timber management incurs large fixed costs in protection and administration, while the output per unit of area is relatively low. Hence, substantial acreages are required for economic operating units. Payout periods for some investments can be long, so that financial strength is a prerequisite.[2]

Relative to timber growing and processing, logging exhibits negligible economies of scale. In the past, railroad logging called for large units of operation. More recently, technology has favored small units. With growing mechanization in logging, the trend may now be returning to logging firms of larger size. However, in some parts of the country logging still has all the attributes of a cottage industry, being carried on seasonally by small proprietorships or partnerships.

Until recently, the lumber industry has been the largest user of timber. Techniques of production require individual handling of logs in sequence, under the supervision of skilled sawyers. Faster carriages, improved setworks, and better saws have raised productivity, together with related systems such as skrag mills, resaws, and faster edging and trimming equipment. But the optimal scale of a sawmill is limited by the need for sequential log-handling. Extremely large sawmills are simply batteries of similar equipment. The simplicity of the process limits the ability to break it into a series of simpler operations. And timber procurement tends to limit the size of plant that can be supplied at a given point. It is likely that the economic optimum sawmill size has not increased since the turn of the century. In recent decades, average mill sizes have risen due primarily to the elimination of small mills. Although saw mills can vary the product mix from given logs, the process remains one of breaking down logs, and sorting the pieces by size and grade.

Industries making panel products take this technology one step further. By breaking logs down into homogeneous materials for reassembly, mechanized flow processes can be used. Chipping processes offer wide scope for treating wood as an undifferentiated raw input. Veneer production on the other hand, however, mechanized, still requires individual attention on a log-by-log basis to prepare the veneer, which is sorted by grades to yield a homogeneous material for further fabrication.

The industries most suited for large-scale production are those which treat wood input as a uniform raw material, breaking it down into homogeneous fiber. The fiber can then be made up, again by high-speed machinery, into paper and board. Exploiting the advantages of continuous processes, pulp and paper mills have rapidly increased their plant sizes. This has permitted a productivity record that rivals or exceeds manufacturing as a whole.

Whether they merely cut round timber to size, or convert it through pulping to paper, the forest industries are engaged in converting heterogeneous natural products into standardized gradable products that can be sold by description. Different processes present different technical difficulties, but technical improvement has advanced most rapidly in paper and plywood, which use the most complex processes. These industries have in turn accounted for increasing shares of United States timber consumption.

TECHNICAL CHANGE IN FOREST INDUSTRIES

The lumber, veneer, and paper industries, in one form or another, have existed in this country since Colonial times. In the pre-Civil War period, lumbering was dominated by tiny firms producing for local markets. Barter was common-sawmills cut logs for a portion of the lumber yield. Before the age of wood pulp, papermaking was practiced in small plants employing a handful of craftsmen. The dominant forest product was fuelwood, which was the basis of the energy economy in industry, transportation, and households.

From the earliest colonial days, mills near tidewater on major rivers were oriented to export markets for timbers, masts, boards, and naval stores. In fact, a stage of water-based, export-oriented lumber production has marked the early years of every major forest region in the country. Thus, market-oriented firms coexisted with the more widespread traditional timber economy. The local timber economy based on small inefficient mills was extinguished at different periods in different regions, and still remains in modified form in some areas. Similarly, the various stages of technical evolution occurred in different regions at different times. Today, therefore, across the nation as a whole, the earliest forms of forest exploitation coexist with the most advanced.

With industrialization a trend toward large-scale logging and timber processing began, stimulated by expanding water and rail transport systems which created a national market. Two major developments-the advent of wood pulping and the extinction of the fuelwood market-reshaped the old timber economy based on local markets, barter, and household production. The transition to a fully industrialized forest economy was largely complete by the 1930's. The impact on the use and management of forest resources was profound. The orientation of the forest economy toward a national market made possible the application of modern technical and managerial methods. Opportunities and incentives for innovations were widened.

Dinsdale has applied Mumford's three phases of technical evolution to the forest industries. These are: the eotechnic phase, corresponding to the man-and-water-powered, local-market organization; the paleotechnic phase, based on steam power and liberated from water transport by the railroad; and

.the neotechnic phase, based upon electric power, advanced labor-saving machinery, and the modern business corporation.[3] This section will describe in general terms the evolution of these patterns through logging, milling and utilization, and end uses.

Logging.-In the eotechnic era, timber harvesting was carried out within severe technical limitations. **In** New England and the Lake States, animal-powered logging operations were confined by the winter hauling season and the need to move logs by water during the spring freshets. Although water transport was low in cost, its seasonality and unreliability produced an uncertain log supply that strained finances in an age of limited liquid capital. The pre-market era of logging was characterized by numerous adaptations to risk and to lack of cash. Among these were barter agreements with suppliers, payment of labor in kind, and financing of loggers by mills.[4]

The railroad freed logging from seasonality and permitted large-scale liquidation of virgin timber over the entire landscape far from drivable rivers. The high fixed costs of rail logging required the strong financing and assured markets that could only be provided by large-scale integrated corporations. The railroad was eminently suited to a particular phase of the paleotechnic industry-the harvest of large old growth timber. As the best old growth stands were liquidated, a new technical basis for logging was required.

In the early 1900's, the automobile industry provided a new technology. The use of trucks in logging has been traced to 1913. As the phase of old growth liquidation waned, they came into increasing prominence. **In** the early post-World War II period, trucks formed the basis of the pulpwood logging industry. The tractor, introduced in the 1930's, provided' an alternative to fixed skidders in assembling logs for loading. These developments provided a new technology for harvesting second-growth timber stands of lower stocking, size, and quality than old growth. At the same time, they took over in old growth logging as well.

Of greatest importance for timber utilization and silviculture has been the transition to neotechnic tree felling methods. The axe was wasteful of both manpower and the best part of the butt log. The crosscut saw economized on both. Further gains accrued from the early chain saws, ungainly two-man machines, which were introduced in the 1930's and 1940's.

Although the first patent for an "endless sectional sawing mechanism" was issued in 1858, the portable chain saw had been unused due to lack of demand and its heavy weight. Advances in chain design and in lightweight engines permitted its use in logging by the 1930's. As late as 1938, however, only one North American firm produced chain saws, and many used in logging were imported from Germany. World War II, by creating a military demand and a woods labor shortage, brought about the final development and use of portable chain saws in the woods.[5] Experiments with portable circular saws for pulpwood harvesting were abandoned as the improved chain saws grew in popularity.

The chain saw allowed broader alternatives in second growth timber management, and rendered operable large areas of poorly stocked stands. In the late 1960's, fully mechanized harvesting systems, based on hydraulic shearing of stems, made their appearance. These machines represent a new stage in adaptation to second-growth forests and to high labor costs.

Lumber.-The 19th century was a period of rapid advance in sawing methods. In 1800, timbers were pitsawn by hand or cut in crude water-powered mills. Much of the final preparation was done by carpenters on the job site, whether a homesite or a shipyard. By 1900, large market-oriented mills were cutting old-growth sawlogs, using mass-production methods of log handling, lumber handling, and marketing. The progress is illustrated by improvements in daily capacities:[6]

Hand powered pitsaw	100-200	board feet per day
Water powered single blade	500-3000	
Water powered sash saw	2000-3000	
Water powered muley saw	5000-8000	
Water powered circular ca. 1820	500-1200	
Steam-powered gang saw 1850	40000	
Steam-powered circular 1863	40000	
Steam band mill 1880	200-250000	

Headsaw improvements permitted large capacities. The developments from the crude muley saw to the bandmills of the 1880's economized on both timber and labor. These improvements called forth stronger and faster carriages, mechanical setworks, liverolls for lumber handling, and dry kilns. Most of these innovations were known in the 1860's, but were applied slowly. By the early decades of the twentieth century, sawmilling technology had reached a plateau. The exhaustion of virgin timber in successive regions gave impetus to new forms capable of using smaller old growth and the vast volumes of picked-over remnants and second growth stands of the eastern United States.

Available cheap labor and efficient power plants for small mills, coupled with strong demand in the 1950's led to a milling and distribution system based upon entirely new principles. Scattered stands were converted to rough green lumber by portable mills which could be moved several times a year. **In** the Southeast, lumber was assembled, dried, planed, and marketed by concentration yards. This system produced lumber from a degraded resource, permitting production to be sustained by forests which could not support the older capital-intensive logging and giant mills.

This system, however, was doomed by its technical innocence and by rising labor costs. **In** the decades after 1950, thousands of portable mills vanished from all regions. Output was concentrated in firms with the capacity to produce to a modern standard of quality, and utilize raw wood and labor with increasing efficiency. A radical new direction was taken, in which production of lumber and pulp chips is pursued as a joint process, in highly specialized plants. Timber utilization and labor productivity have steadily improved. **In** southern pine milling, labor requirements per Mbf fell from 9.5 manhours in 1946, to 7.1 manhours in 1957 and 5.5 manhours in 1961.[7] Output per manhour in the southern lumber industry rose at 3.4 percent per year from 1954 to 1967.[8] And in the Pacific Northwest, manpower per unit of wood input fell by 26 percent in logging, 42 percent in sawmilling, 50 percent in veneer and plywood mills, and 36 percent in. paper and allied products in the 1950-1963 period.[9] Developments characteristic of this period were chipping headrigs, improved waste utilization, and the capacity to produce lumber from veneer cores as small as 5-1/2 inches.

Technical innovation has considerably broadened the utility of the forest resource. Of prime importance has been the acceptance of less valuable species on the basis of their technical suitability rather than custom. During the virgin-timber period, only a small number of species were actually utilized. **In** some areas, repeated high-gradings were made as additional species became acceptable. As white pine timber dwindled, mills turned to hemlock and red pine to extend the resource. A similar broadening of species occurred as the high-grade Douglas fir and western white pine were cut out.

Paper and Pulping. -Papermaking is an old trade in the United States, which for most of its history had little relation to the timber economy. Prior to the Civil War, paper was made from rags or straw. Mills were small and raw-material oriented, due to the difficulties of assembling rags. By the 1860's, chronic rag shortages inspired attempts to find new raw materials. The original development of wood pulping was in Europe, but American firms soon saw the possibilities and imported the processes.[10]

Early pulping processes required wood that was soft, resin-free, and white in color. Favored species were poplar and spruce. The industry slowly adapted its location pattern to a timber-oriented system, and moved away from the cities. As long as spruce dominated, the comparative advantage in pulp and papermaking lay with Canada, as the trade trends until the 1930's reflect.[11] DUring this period, economies of scale were rapidly exploited in paper milling, and old mills either adjusted to specialty markets or passed out of existence. **In** 1849, under the pre-woodpulp technology, the average paper and pulp mill employed 15 workers. During the next thirty years, average plant size doubled, to 35 workers by 1879. By 1914, the average plant employed 122 workers. Due to increased paper machine widths and speeds, these figures understate the increase in average mill output.[12]

The wood pulp industry introduced a new element of demand into the timber economy, but involved no fundamental changes in the system. By the 1930's, however, rising pulpwood prices, rising imports, a changed resource situation, and new marketing methods all combined to produce a revolution in wood use. This revolution had two phases: first, an explosive rise in wood pulp demand, met by using new species and techniques, and second, a trend toward integration with the lumber industry.

New processes that permitted pulping southern pine, Lake States hardwoods, and Pacific Northwest sawmill residues provided a vastly increased resource base for pulp production. A trend toward mass marketing of food and consumer goods, together with a decline in bulk shipping, opened a new market for the strong kraft pulps based on new species. These cheap, strong papers in turn promoted the growth of packaging markets. Regrowth of Lake States and Southern forests promised a renewable raw material base for long-term production. Exploiting these new advantages took into the 1950's.

At the same time,. innovations in pulping and development of specialized chipping equipment led to the increasing use of sawmill waste products in the paper industry. Rising timber prices also contributed. The logical development of this trend was the chipping headrig, which converted the sawmill into a lumber and chip plant.[13]

Plywood. - The origins of the softwood plywood industry are found in the door plants of the Puget Sound area around 1900. Plywood production based on large clear "peeler" logs grew slowly as new markets and uses were developed. The development of waterproof glues in the 1930's turned plywood into a general purpose building material. But plywood was marketed even into the post World War II period as a specialty item for finish applications, to take advantage of the wide smooth surfaces it offered. **In** the immediate postwar years, it was discovered that plywood with exterior glues was a useful panel product for general building use. Its rigidity and ease of installation opened a vast market, in replacing lumber sheathing. Exploitation of this market continued into the 1960's, by which time the old peeler logs were becoming scarce, and constant improvements were needed to offset declining log size and quality.

Rapid methods of patching made possible the use of lower-grade logs for the sheathing grades. Strong demand for non-appearance grades, coupled with effective product grading, reduced dependence on the supply of clear face veneers. These developments lessened the need for clear logs, until by the 1960's, sawmills could bid the best clear logs away from plywood plants. As stumpage prices rose and log size declined in the Pacific Northwest, that region's comparative advantage in plywood production waned. As technical difficulties were overcome, production of southern pine plywood began in 1963. The southern industry grew rapidly, until by 1970 it produced one fourth of the national outpUt.[14]

The plywood industry grew to maturity as the integration of timber utilization was proceeding. By the late 1960's, the plywood industry was part of a modern timber utilization system. Logs down to 8" diameter could be peeled for veneer. Wastes were chipped for pulping. And the veneer cores provided the basis for stud production, either within the plywood plant or by outside firms.

SUBSTITUTION IN WOOD MARKETS

In the competition for markets, wood products have encountered substitutes in many ways. Occasionally, wood products displace other raw materials. Wood pulp replaced rags in papermaking, and pulp-based "non-woven" materials are replacing cloth in disposable garments. More frequently, wood products displace one another in the same market. Plywood replaced boards in sheathing, paperboard cartons replaced wood boxes and barrels, and particle boards have replaced plywood in some applications. A third form of subtitution is of more interest here-the replacement of wood by nonwood substitutes.

Substitution for wood has been rapid since early in the century. It has resulted from changing consumer tastes, improvements in competing materials, changing relative prices, and changing labor costs of installing and maintaining different materials. Losses of wood markets for wood sidewalks, railroad cars and automobiles reflect long-term trends of technology and economic structure. Improved competing materials, and higher demands made upon raw materials account for substitution in many fields. Modern high-rise construction requires structural strength for which wood is not suitable. Moreover, discriminatory building codes and insurance rates can restrict wood use.

Changing prices of wood products relative to substitutes have been one cause of wood market losses. So many other variables are involved, however, that price influences are difficult to isolate. One factor is the labor-saving effect of nonwood substitutes. Aluminum windows, doors, and siding cost more in place than their wood counterparts. But over time, their maintenance costs are lower.

Substitution against wood in one major sector-fuelwood-has removed a large source of drain upon the forest, and one which was extremely destructive of timber quality. Steel and concrete have taken structural load-bearing applications from wood but markets remain for products of small timber such as studs and light dimension. Substitution within the forest products sector-from lumber to plywood, paper, and chipboard-has economized on timber and allowed use of smaller trees and less desirable species.

Existence of economical substitutes for wood products complicates the appraisal of timber scarcity. If all the substitutes were perfect, there would be no reason for concern over timber supplies. Where substitutes are imperfect, the costs of wood "shortages" are measured by the higher prices paid for wood, which in turn are determined by the inconvenience or higher cost of available substitutes. As wood prices rise, more effort is devoted to economizing its use. Thus, the supply of timber affects its own demand by promoting the creation of substitutes. This dynamic process is partly responsible for the steadily improving timber situation in this country.

MEASURES OF RESOURCE EXPANSION

To more clearly point out the role of resource-expanding technical change, it is instructive to see what portion of our current wood input is obtained from trees which were "neutral stuff" decades ago. In so doing, however, the results must not be overstressed, since processes of input substitution and changes in regional comparative advantage are also at work. Thus, the results presented here embody forces other than strictly resource-expanding technical change.

In the lumber industry, the progressive introduction of new species into commercial use has expanded the utility of hitherto unused forests. The sequence of exploitation from white pine to red pine and then to hardwoods in the East is faimiliar. In 1899 the largest three species (White pine, Southern pine, and Douglas fir) supplied 73 percent of the lumber; in 1970, they supplied 56 percent.

In the pulp and paper industry, even more spectacular examples are available. In 1970, 27 percent of the domestic pulpwood consumption was from hardwoods-most of which were thought useless decades ago. Forty percent of the input was in the form of chips, most of which are sawmill residues-in the Northwest, 60 percent of the pulpwood input comes from mill residues. Between the 1920's and the 1950's, southern pine grew from a negligible role to supplying more than 40 percent of the nation's pulpwood.

These trends have clearly improved the nation's timber supply experience in recent decades. As shown in Chapter Five further opportunities of this kind remain untapped.

CASES

Railroad ties and timber. -Olson's work provides a valuable case study of economic responses to changing conditions of resource supply. The strongest influence on the tie market from the Civil War to the early 1900's was the decline of transport cost. Later, the increased flexibility offered by motor transport greatly expanded the available economic supply of tie and timber raw material.[15]

Apart from the supply-expanding role of lower transportation costs, Olson identified three primary opportunities facing railroad wood users. These were substitution, improvement and preservation, and design.

As knowledge of timber characteristics grew and problems of treating different species were overcome, a wider range of species was used for ties. In the post-Civil War period, railroads relied on white oak, chestnut, southern pine, and cedar. Later, other oaks, hardwoods, and Douglas fir became acceptable.[16]

Economies in wood utilization closely followed economic stimuli. The technology for wood preservation was available in 1885, but little used. In fact, the transition to treated ties was incomplete by 1920. Hewn ties were replaced by sawn ties, which improved quality, and economized on wood. Tie grading was gradually adopted, and was promoted by the U. S. Railroad

Administration of the World War I years. Heavier rails and rolling stock led to use of larger ties. These larger ties, with higher investments in treating costs, were then protected from mechanical wear by tie plates.

The final opportunity was in design. As the major transcontinental rail lines were completed, engineers turned attention to better practice in maintenance and replacement of timber bridges. Engineers found that improved design made possible substantial economies in timber use. Improved design of trackwork came later, and also had the effect of reducing material costs.[17]

After World War I, a major stimulus to innovation came from rising labor costs. In railroad construction and repair, it was found that innovations which conserved labor also economized on timber. Increased tie lives, for example, reduce both labor and timber costs. Since the 1920's, the average number of replacement ties used per mile of trackage has declined strongly.

Naval stores.-The early naval stores industry was uniquely dependent upon virgin stands of longleaf and slash pine. The vast timber resources of the southern United States gave it a dominant position in the world naval stores economy. In 1908-1909, the United States supplied 80 percent of the world's turpentine output; by 1968, despite rapid growth in other continents, it was still a world leader, supplying 42 percent. The share of world rosin output fell from 63 percent in 1938-1939 to 44 percent by 1968.[18]

By the early 1920's, the imminent disappearance of old growth southern pine was apparent. In the words of the *Capper Report:*

> So pronounced is the depletion of the timber upon which our naval stores industry depends for its supplies that it is commonly regarded as a dying industry.... The indications are ... that the production of gum naval stores in the southern pine belt will within 10 years have been reduced to such an extent that export markets and even our own must look elsewhere for our main supplies.[19]

Despite significant technical improvements, the gum naval stores industry has continuously lost ground to other sources of rosin and turpentine. The earliest competition was from wood-distillation processes utilizing pitch-soaked pine stumps left over after removal of old growth timber. Steam-distillation requires old-growth stumps, however, so that this branch of the industry is slowly declining as stumps are mined.

The growing source of naval stores is the sulphate industry. Sulphate turpentine and tall oil are important byproducts of the South's growing sulphate pulp industry. The cost advantage of sulphate naval stores has steadily driven gum naval stores out of the market. In 1940, negligible amounts of sulphate turpentine and tall oil were produced. Naval stores output was roughly balanced between gum and steam distillation. By 1968, however, gum production was insignificant, while tall oil accounted for more than one-third of the rosin output, and sulphate turpentine held five-sixths of the turpentine output. Total consumption of turpentine and rosin were roughly stable over this period.

The experience of naval stores illustrates the maintenance of production by turning to raw materials from a wholly unexpected source. Industry dependence on virgin timber has been broken. Research continues, to provide technology for the operation of efficient, multi-product orchards of high gum-yielding trees. The prospective growth of the sulphate pulp industry, however, may preempt the market potential for a new gum industry based on second-growth forests.

Housing. -Technical change in homebuilding has resulted in major shifts away from traditional materials. Changes in wood use have resulted from a complex of factors. The Stanford Research Institute estimated that house size and architectural style trends accounted for half of the reduction in lumber use per unit from 1920 to 1950. This study expected the downtrend in use per unit to continue until 1975.

The net effect of trends in house size and use per unit can be seen by examining wood use per square foot of floor area. From 1959 to 1968, lumber used per square foot fell from 9.23 board feet to 7.38 board feet. Plywood use, however, nearly doubled, rising from 1.60 to 2.99 square feet. These data apply only to FHA-inspected single family new homes.[20]

Even when one wood product replaces markets of another, timber resources can be economized. Ellefson reported that to cover 100 square feet of floor area with lumber requires 10.1 cubic feet of timber (121 bf of 1x8). By contrast, the same task can be performed by 100 square feet of 5/8" plywood, which only requires 5.2 cubic feet of timber to produce. Thus, a labor-saving change of materials can also save timber. Replacement of plywood by composition boards in some uses can be expected to economize still more on timber resources.[21]

Changes in relative prices, house design, and consumer tastes have strongly rearranged traditional wood markets in housing. From 1959 to 1968, for example, the following shifts took place for FHA single-family houses.[22]

	1959	1968
	Percent	
Masonry wall	18	12
Lumber siding	13	5
Nonwood siding	56	70
Hardwood strip finish flooring*	94	52
Plywood roof sheathing	50	74

*Nonslab houses

The decline in use of masonry walls is a response to rising labor costs. This did not result in widened wood markets, however, for markets were taken from brick and from wood by nonwood substitutes for exterior wall covering.

TECHNICAL PROGRESSIVENESS

The forest industries, logging and lumber in particular, are often said to be technical laggards because of their competitive structure and because they spend insufficient sums for research and development. The thesis that competitive structure obstructs progress is oversimplified. It is by no means clearly established that industry concentration is correlated with progressiveness. As Scherer concluded:

> The main lesson to be drawn from a review of the qualitative evidence is that no simple, one-to-one relationship between market structure and technological progressiveness is discernible. What is needed is a subtle blend of competition and monopoly, with more emphasis in general on the former than the latter. . . . [23]

In competitive industries, technology for major productivity improvements is likely to be originated by the firms which supply equipment and materials. Thus, the paper industry benefits from advances in engineering and materials which permit faster-running or wider paper machines. Furthermore, even in concentrated industries a major part of process development is done by machinery suppliers.

Competition in lumber milling has spurred rapid diffusion of innovations. An example is the case of chipping installations. From 1952 to 1960, about 900 southern sawmills installed them.[24]

In comparing the rate of research and development (R&D) outlay per dollar of sales across industries, several cautions should be observed. Two of the most important are the type of product and the degree of government supported research. Forest industries produce much of their output as standardized producers' goods. Most of these products do not lend themselves to product differentiation. In many industries, however, much R&D is devoted to new products and to product differentiation. For all manufacturing, only one fourth of 1966 R&D outlays were used for internal process improvement.[25] A useful comparison would be between forest industries and other industries on the basis of actual amounts spent for R&D on internal process improvement.

Also, much research spending in high-technology industries is government supported. Government financed 53 percent of the industrial R&D in 1966. The proportion of spending financed by government ranged from a negligible share in the wood products field to 86 percent in the aircraft and missile industry. Still, the private expenditures per sales dollar varied widely, from 0.5 percent in lumber and wood products to 3.5 percent in aircraft and missiles.[26]

A review of developments in wood technology does not support the hypothesis of stagnation. Processing methods and new products have evolved rapidly in recent years. Advances in wood laminating and fabrication, overlays, and new applications for pulp products are prominent examples.[27]

SUMMARY

Technical progress in the forest industries has emphasized methods for utilizing new species or smaller timber sizes, for improving utilization of logging and milling wastes, and for improving product quality. Outlays for expenditures on product differentiation are small, compared to other industries. Simple comparisons of industry structure and gross expenditures for R&D, therefore, add little to understanding technical progress in forest industries.

The prime significance of technical change in forest industries has been its resource-expanding role. This process is often overlooked when technical progressiveness is evaluated by measuring progress in labor productivity. It has been the rapid pace of resource-expanding technical progress, combined with improved timber inventories in recent decades, that accounts for the current favorable trend of timber scarcity indicators.

CHAPTER FIVE

OUTLOOK FOR TIMBER SUPPLY AND DEMAND

Above chapters have discussed the use of economic data such as real prices, productivity trends, and trade flows in evaluating timber scarcity. Results showed that timber resources have become economically more abundant since 1950.

But what of the future? Analysis of time series data give limited insight into the future. This chapter looks ahead to face this problem. First, past timber resource appraisals are reviewed. Then, the timber resource outlook is briefly summarized. Further sections treat the implications of zero population growth for timber demand and summarize opportunities available for meeting rising wood demand.

PAST APPRAISALS OF FOREST RESOURCE ADEQUACY

In 1910, Gifford Pinchot argued that America's remaining timber supplies would last "little more than a single generation." Writing when lumber production was at a historical peak, he foresaw a crisis:

> ... the United States has already crossed the verge of a timber famine so severe that its blighting effects will be felt in every household in the land. The rise in the price of lumber which marked the opening of the present century is the beginning of a vastly greater and more rapid rise which is to come.[1]

Forest Service and related studies.-The prospect of timber famine was a major theme in the early conservation movement. The timber famine concept was a major ingredient in the appeal to timbermen to practice forestry-the doctrine guaranteed ever rising stumpage values, which would make forestry profitable.

In the *Capper Report* of 1920, the Forest Service presented a major analysis of the forest situation and a coherent legislative program.[2] While noting that the postwar inflation of lumber prices was affected by freight car shortages, bad weather, temporarily low stocks, and woods labor shortages, the authors assigned a major role to cumulative forest depletion. Specific examples of ill effects of high wood prices were cited in the furniture, handle, and railroad industries, as well as in housing.

As of 1933, the nation was still depleting growing stock, even at depressed levels of demand. Losses from fire and insects were catastrophic. Logging and milling wastes accounted for much of the timber harvested. The writers of the *Copeland Report* believed that a reasonable goal for forest policy would be to "balance the nation's timber budget" by raising annual growth to equal the current drain of 16 billion cubic feet of growing stock.[3]

The 1948 Forest Reappraisal drew a gloomy picture of the forest resource outlook.[4] It found the timber economy operating at a net deficit: "Our forests are still operating in the red." In 1944, a year of relatively low timber consumption, sawtimber drain exceeded sawtimber growth by 53 percent. In terms of growing stock, growth was nearly equal to drain. The report pointed to the decline in size and quality of timber, and emphasized that drain was primarily in sawtimber while growth was concentrated in small size trees.

The Forest Service issued a massive review of the forest situation in 1958 under the title *Timber Resources for America's Future* (hereafter TRR).s The demand analysis concluded that a middle-range projection of 22.4 billion cubic feet could be required by the year 2000, for an increase of 83 percent over 1952 consumption. Although growth and cut for the nation as a whole were basically in balance by 1952, the report projected that even the lower demand projection could not be met if existing trends continued. To meet the medium projection of demand would require a 36 percent increase in sawtimber inventory, and a 122 percent increase in sawtimber growth.

The 1965 study *Timber Trends in the United States* (hereafter "Timber Trends") was the first report of substantial additions to inventories for the nation as a whole (inventories had been constant between the Reappraisal and the TRR). Part of the improvement resulted from a stable harvest-the 1962 cut was 10.2 billion cubic feet, less than in 1952. Looking ahead, however, Timber Trends projected an increase of requirements to 21.3 billion cubic feet by the year 2000. Increased harvests to meet this demand could continue until 1990, when growing stock depletion would begin.[6]

Two years later, a 1967 analysis of paper and board demand concluded that Timber Trends had seriously underestimated prospective demand for pulpwood. This study projected that woodpulp demand in 1985 would be 2.2 times higher than 1966. This was 44 percent above the Timber Trends estimate, implying that timber growth could fall short of cut as early as 1980.[7]

A 1967 Forest Service Planning, Programming, Budgeting study examined prospects to 2060. Demand was projected in a range between 17 and 26 billion cubic feet in 2000 and as high as 30 billion in 2060. The midrange projection for 2000 was 21.6 billion cubic feet, essentially identical to the Timber Trends and **TRR** estimates.[8]

In an interim report on its latest resource review, the Forest Service reported continued improvements. Although commercial forest area declined slightly from 1962 to 1970, total timber growth was 14 percent higher. The report considered the effect of different price level assumptions on timber demand. A relative price rise of 60 percent for lumber, 30 to 40 percent for plywood, and 16 to 20 percent for paper and board would reduce softwood timber demand projections from 74.4 billion board feet to 48.7 billion board feet by the year 2000.[9]

ALTERNATIVE VIEWS

Olson provides the most complete appraisal of early Forest Service predictions. She believes that by employing a naive theory of prices, and by overlooking potential economic adjustments to changing timber supplies, the Forest Service misunderstood the timber resource outlook. Mrs. Olson asserts that the timber famine was averted, but not "by following the doctor's advice."[10] The wide publicity given to timber depletion, far from providing the basis for solutions, had perverse results:

> The most serious consequence of alarmism ... was probably the bias it introduced into the consumer's own research. The Forest Service, to reduce drain of recurrent large-volume uses, urged the substitution of metal and concrete, as in crossties and bridges.
>
> Alarmism and urging of substitutions also tended to demoralize the lumber manufacturers. Their pessimistic view of future markets was one reason for their lack of research.[11]

Olson suggests that the emphasis on physical requirements and supplies, hardened into a dogma that resulted in an agency stance of a "perpetual emergency."

In 1946, Shames presented an 18-year forecast (one building cycle) of prospective lumber demand.[12] He concluded that the average yearly consumption would be only 5 percent larger than occurred in a similar period following World War I. The estimate assumed a stable population of 158 million by 1980. The most important factors stabilizing consumption were the slowdown in population growth and shifts in its composition.

Perhaps the first penetrating and critical look at conventional wisdom regarding timber supplies was taken by a nonforester, Luther Gulick. In 1951, Gulick urged that the day for "shock technique" had passed. He described several factors in the postwar lumber price inflation, concluding: " ... those who argue that there is a 'growing timber shortage' on the basis of lumber prices and price indices from 1940 to 1948 are dealing superficially with a far more complicated set of price factors."[13] Studying the trend of stumpage prices, he asked:

> If timber is gradually running out, why should prices stand still for over thirty years which include a great construction boom? The answer is clear: the threatened shortage is still a long way off ...[14]

Later, Zivnuska examined the 1958 Timber Resource Review. He argued that the need for 72 billion board feet of timber per year by 2000 would depend upon the ability of the forest industries to improve productivity and develop markets in order to sustain demand for that much timber. He pointed to the decline in national log production during the mid-fifties, despite an 11 percent rise in population, an 11 percent rise in real GNP, and a 6 percent rise in housing starts.[15]

More recently, Trestrail, in a study of stumpage prices concluded:

> There are substantial reasons to be very skeptical about the popular notion that timber and timberlands, in general, will appreciate in value relative to other tangible assets over the coming decades.[16]

Trestrail criticized the Forest Service for being unable "to entirely shake off the increasingly untenable resource-scarcity philosophy of the early conservationists."

OTHER RESOURCE APPRAISALS

In the wake of raw materials shortages in the early days of the Korean Conflict, the President's Materials Policy Commission (Paley Report) studied the nation's raw material outlook to 1975. The Commission accepted the growth goals of 18-20 billion cubic feet given by the Reappraisal, and foresaw no critical timber supply problems up to 1975.[17]

In 1954, the Stanford Research Institute released a study of timber demand prospects to 1975, done under contract for the Weyerhaeuser Timber Company.[18] The report concluded that the prices of lumber and plywood would rise relative to competing materials, but less rapidly than in the 1946-1954 period. Despite rising prices, however, markets would absorb higher lumber output with increased imports and recycling of salvaged material. Timber consumption in domestic plants would rise by 14 percent between 1952 and 1975.

The massive study of *America's Needs and Resources* (issued in 1955) by the Twentieth Century Fund adopted a new approach to estimating raw materials requirements.[19] By examining a series of broad social categories of needs, such as food, housing, and health care, the analysis arrived at requirements for meeting current social standards, rather than effective market demand-a direct incorporation of welfare criteria. For 1960, *America's Needs and Resources* predicted a 9 percent increase in timber consumption and no problems of prices or resource supply.

A longer time span-to the year 2000-was used in the analysis released by Resources for the Future in 1963.[20] This study projected population, labor force, and GNP trends and translated these into a bill of raw material needs. A tripling of energy and metals requirements, nearly tripling for timber, and a doubling for farm products and fresh water withdrawal uses were projected. Analyzing resource supplies, Landsberg concluded:

> Neither a long view of the past, nor current trends, nor our most careful estimates of future possibilities suggest any general running out of resources in this country during the remainder of this century.

In contrast, forest products would be in short supply:

> Limitations of domestic supply are more likely to be a barrier to meeting projected demand for forest products and services than for any other major category of resource materials.[21]

A different approach was used by Barnett and Morse. Their analysis is essentially historical. It consists of an attempt to answer the question: "have natural resources been scarce in the United States?"[22] Barnett and Morse conducted several tests of resource scarcity. Their strong test was the trend in real cost (capital plus labor) per unit of value added in resource industries. The weak test used the real cost trend relative to GNP as a whole. Other indicators examined were trends in trade balances and relative prices. Partial indicators, such as the share of labor force in extractive industry, the share of extractive products in national income, the substitution against resource products, and direct measures of quality were also used. Barnett and Morse concluded that timber resources, unlike agricultural and mineral resources, were scarce in the United States from 1870 to 1957.

The National Commission on Materials Policy, in a 1972 Interim Report, devoted a short section to timber resources. The Report emphasized potential near-term shortages of softwood lumber and plywood. The writers stressed that higher timber prices would encourage use of nonwood substitutes. This is undesirable, they concluded, because of the high environmental costs of producing these substitutes.[23]

FOREST RESOURCE OUTLOOK

Several questions arise, in considering the evidence presented in Chapter Three. It may be true that the timber supply has improved recently, and that consumer welfare is not threatened by rising wood products prices. But will this continue to be true? Considering the potential economic supply of timber, the realizable growth and possible reductions in commercial forest land will timber scarcity threaten in the future? Will the demand for housing and for paper increase at such a rate as to lead to overcutting, given prospective population trends?

Timber supplies have received strong boosts in the past half-century from unique developments that will not be repeated. The decline of agriculture in the South, Northeast, and Lake States released millions of acres to forest uses. Improved technology permitted utilization of southern pine first for pulp and paper, later for plywood. Utilization of mill residues and hardwoods for pulping is approaching the practical maximum in some areas. These benefits have already been realized. Are there further opportunities in forest management and wood utilization to justify the expectation that technical change will continue its resource-expanding role as in the past? Can demand be reduced as an aid to resource conservation?

SUPPLY TRENDS

The area of commercial forest land in coming decades can reasonably be expected to decrease.

From 1962 to 1970, commercial forest land fell by 8.4 million acres. The Forest Service expects the land base to decline by 5 million acres per decade for the next 50 years.[24]

In 1962, Timber Trends estimated the total growth on growing stock at 16.3 billion cubic feet, and the total cut at 10.1 billion. Growth was projected to rise to 18.2 billion cubic feet by 1980, and decline thereafter under the impact of rising harvests; total growing stock would decline after 1990.[25]

Estimates of the maximum "realizable growth" feasible under good forest management are substantially higher than this. **In** 1920, the *Capper Report* suggested a maximum realizable growth of 27-3/4 billion cubic feet.[26] More recent reports have used a similar figure.

Vaux estimates that it is possible to "maintain timber supply at levels adequate to meet a doubling of demand between now and 2020 without a significant further rise in the longrun stumpage price trend. . . . " His calculations show that by 2020, high intensity management could yield net growth of 30.2 billion cubic feet, compared with projected removals of 28.2 billion. This program would cost a total of $15 billion above present levels of investment, or $76 per thousand cubic feet at a 4 percent discount rate. The investments would have to be concentrated in the 1970-80 years for their yields to appear by 2020. The probability that such a program will be implemented, of course, is slight. Vaux cites a lower estimate by Duerr, that the nation's maximum longrun growth will be only 20 billion cubic feet.[27]

These aggregative estimates ignore the problems of economic supply. **In** many regions, private owners are unwilling to sell stumpage for timber harvesting. Further, the prospects for gaining a higher level of investment and forest practice on much of the nation's private nonindustrial land are dim.[28] The longrun economic supply, therefore, will probably be much less than 27 billion cubic feet.

OUTLOOK FOR TIMBER DEMANDS

Timber Trends projected an increase in the domestic harvest of growing stock from 10.1 billion to 21.6 billion cubic feet by the year 2000.[29] For the year 2020, the Water Resources Council projected a rise of industrial wood consumption of 65 percent over 1962, including a rise in pulpwood consumption of 241 percent.[30] The 1967 Forest Service **PPB** study gave a medium projection of demand for domestic growing stock for the year 2060 of 58 billion cubic feet, more than five times the current cut, and more than twice the "realizable growth" of the *Capper* and subsequent reports.[31] Studies done for the Public Land Law Review Commission projected total timber consumption by 2000 of 23.8 billion cubic feet, consisting of roughly

TABLE 9. Outlook for Timber Demand: Public Land Law Review Commission Medium Projections to Year 2000 (Roundwood Equivalent).

Item	1968	1980	2000
	Billion cubic feet		
Lumber	6.4	6.5	6.2
Veneer & Plywood	1.3	2.0	3.1
Pulp & Paper	3.8	8.5	13.1
Other	1.5	1.9	1.4
Total	13.0	18.9	23.8

Source: R. S. Manthy, *Probable Future Demand on the Public Lands,* for Public Land Law Review Commission. (Springfield, Va.: NTIS, #PB 195 043) p. 96.

constant lumber consumption and a tripling of pulp and paper demand (Table 9).

Population Growth.-The sensitivity of the projections to population growth rates is evident. In the 1930's, experts expected the population to level off below 200 million before 1970 and then decline. Recent experience suggests that the Census Series D projections are reliable for forecasting. This projection yields 288 million by the year 2000. Steady progress toward a zero growth rate (ZPG) is the basis for the Census Series X, which projects 256 million by 2000. This series achieves ZPG by the year 2040.[32]

Because of the implications of ZPG for resource demand, and the uncertain nature of future population trends, this chapter will estimate forest products demand for four future population totals. These will be:

1. Year 2000, population approaching stability (PAS), after Serow's estimates. This would total 238 million persons, with roughly 77 million households.
2. Year 2000, Census D projection: 288 million persons, with about 93 million households.
3. Two ultimate stable populations (ZPG) of 300 and 400 million.

Per capita demand.-Much uncertainty surrounds projections of future per capita demand. The projections in Table 9 clearly envision a decline in per capita consumption for lumber, and an increase for paper products. Historically, paper consumption has risen with increased GNP and higher per capita incomes. On this basis, the Forest Service has projected an increase in per capita consumption to 711 pounds per year by 1980. This rate of increase, to the year 2000, implies a consumption of 1000 pounds per capita.

It is difficult to see how consumer welfare would suffer if this high target for per capita paper consumption is not met. Indeed, it is possible to argue that our national per capita consumption is already too high. Americans consume about 566 pounds yearly, while Swedes use 398 pounds, and West Germans use 275 pounds. The municipal burden of solid wastes is roughly one-half paper by weight. Confronted with the rapidly rising costs of solid waste management, reduced paper consumption will become an attractive possibility. In any case, for the purposes of policy making and resource allocation, production of timber for meeting paper demands in excess of 600 pounds per capita must rank exceedingly low in the nation's scale of priorities.[33] On the other hand, the nation can well afford concern over future lumber output, in view of its role in housing. The outlook for lumber supply, then, is of some interest on welfare grounds for coming decades.

An alternative projection of forest products consumption is offered in Table 10 which simply projects consumption at the 1970 per capita rate. This procedure sheds much light on the United States timber outlook. One can make the future timber outlook appear favorable or unfavorable, simply by selecting alternative assumptions about paper consumption. By using stable per capita consumption, the total timber consumption for a population of 400 million is the same as projected by the PLLRC for the year 2000. This is despite the fact that the projections offered here include an especially liberal allowance for lumber needs.

Therefore, unless it can be shown that continuation of current per capita rates of consumption of forest products is socially unacceptable, it would appear that the forest resources of the United States can easily support a population of 300 million in perpetuity. A population of 400 million could be supplied at current consumption standards, while remaining well within the limits of the "realizable growth" estimate of 27 billion cubic feet. Owing to the uncertain level of economic supply mentioned earlier, however, this rate of timber harvest could strain the economic supply severely. On the other hand, if the nation were to reduce its paper consumption standard to the more modest Swedish level, only about 21 billion cubic feet of timber would be required by 400 million people. This suggests that policies to manage demand are as essential as policies to increase supply.

TABLE 10. An Alternative Outlook for Timber Demand—Per Capita Consumption at 1970 Rates for Stable Populations of 300 and 400 Million, Industrial Wood Only.

Item	1970*	Population		1970 per capita consumption
		300 Million	400 Million	
		Billion cubic feet		*Cubic feet*
Lumber	5.3	9.0	12.0	30
Pulp & Paper	4.4	6.6	8.8	22
Plywood & Veneer	1.1	1.8	2.4	6
Other	0.5	0.6	0.8	2
Total	12.8	18.0	24.0	60

Source: Per capita consumption rounded from data in Hair & Ulrich, 1971.
*Rates implied by rounded factors in last column. Actual industrial wood consumption in 1970 was 12.1 billion cubic feet.

IMPACT OF STABLE POPULATION ON HOUSING DEMAND

A stable population of 400 million persons will probably require a stock of roughly 143 million housing units, more than double the 1970 stock (Table 11). But even with a stable population, the housing demand for forest products will not cease. Maintenance, repair, and improvements will continue to consume lumber and plywood. Replacements of obsolete, dilapidated, and demolished dwellings will continue.

Many uncertainties concern the size and character of the housing stock that will be demanded by a future population of 300 or 400 million. The number of households will depend on social patterns-whether the elderly continue the trend toward separate households, whether headship rates (the proportion of population heading households) rise or fall. In a stable population, per capita incomes will probably be larger than for a growing population of the same size, owing to the lower proportion of people in dependent age groups. Will productivity gains be realized in earlier retirements or shorter hours? Will these more wealthy people buy larger houses, bigger lots, or summer houses in the country? Will these houses contain more wood?

What will be the composition of the ultimate housing stock? Will these wealthier, smaller families live in larger detached homes, or in condominiums and row houses? When the suburbs built in the 1950's and 1960's show their

TABLE **11.** Population, Households, and Housing Units, Alternative Growth Paths.

Year	Population	Households	Housing units
		Millions	
1970	203	60	68
2000 PAS*	238	77	85
2000 Census D	288	93	102
Ultimate Stable**	300	97	107
Ultimate Stable**	400	130	143

Sources: 1970, Statistical Abstract of the United States. 2000, W. J. Serow, "Implications of Zero Growth ... " AJAE, 54, (December, 1972).
*Population approaching stability.
**Estimates of households use 3.1 persons per household, while housing units allow 10 percent more units than households to account for vacancies and second homes.

age, will they be replaced with similar, larger dwellings? Or will higher land prices and changing tastes result in their replacement with multi-unit dwellings that economize on land and building material? What will be the pace of migration and regional population movements? Will changing tastes and transportation modes revitalize city life, or will suburbanization continue?

One trend is likely, in a society with rising family incomes. The mobile homes of the sixties and seventies will progressively be replaced by more permanent structures. The Housing Goals foresee a total of 4 million new mobile homes by 1978. Replacement of these units will provide a substantial latent demand for conventional housing.

These imponderables will affect the demand for new housing units, and the types of units built, when the population reaches stationarity. The demand for forest products will vary as a result. The wide range of possible future housing demand patterns makes projecting forest products needs a hazardous business indeed.

THE FOREIGN TRADE OUTLOOK

The above discussion considers total consumption of forest products in the United States. To translate this into timber demand, it is necessary to assess the future trade balance in timber.

Several future trends can be visualized. Within a few decades the comparative advantage of Canada in lumber production, based on old growth timber, will diminish relative to the United States. If domestic sawtimber is absorbed in import replacement, timber harvests will rise faster than consumption.

In pulp and paper, the South is the world's greatest concentration of production capacity. Its comparative advantage is evident from increased exports of kraft pulp and linerboard. As incomes rise in the less developed nations, world demand for paper is certain to rise. The United States will be in a favorable position to benefit from this market. Competition from Cananda and the Soviet Union may hinder United States export expansion, at least until those nations make the transition to second-growth timber economies. Finally, demands for North American and Siberian paper products may be moderated by successful development of pulping processes for tropical hardwoods and agricultural fiber residues such as bagasse.

This discussion makes clear the wide range of uncertainty concerning the future foreign trade position of the United States in the world timber economy. Due to its superior technology and its productive forest resources, the nation clearly possesses a comparative advantage in forest products over most nations of the world. Whether domestic market growth will prevent this comparative advantage from being expressed in a rising export trade is uncertain. Whether the United States, as a timber-rich country, has a responsibility to other less well endowed nations to help supply their wood needs is beyond the scope of this study.

OPPORTUNITIES FOR THE FUTURE

The improved timber supply of recent decades was made possible by a series of historical forces that will not be reproduced again. These included:

1. Release of land from agricultural use over wide areas of the South, New England, and the Lake States.
2. A severe decline in roundwood consumption during the Depression, which temporarily reduced cutting pressure on young stands.
3. Gradual realization of benefits of fire control and forest management, especially in the South.
4. Technical advances permitting utilization of new species for lumber, paper, and plywood, and increased utilization oflogging and milling residues.
5. Disappearance of firewood demand.

These boosts to timber supply will not recur. Are there major opportunities in the offing which will enable continued progress in resource-expanding technical change? Following sections briefly describe some likely opportunities in forestry, wood technology, and demand reduction.

Forestry opportunities.-The forest resource still offers many outlets for profitable investment in raising timber growth. Studies have shown that investments yielding 6 percent and above could be made on the public forests which would raise output from 4 billion cubic feet to 5.5 billion. If investments yielding 4 percent are accepted, sustained yield could be raised to 7.6 billion, or nearly doubled.[34] Opportunities of similar attractiveness probably exist on private lands. Roughly one-fifth of the nation's commercial forest land is less than 40 percent stocked with growing stock trees. This includes 36 million acres of nonstocked land.[35] Large areas, especially in eastern forests, are burdened with heavy volumes of cull trees.

Mortality remains high. In 1962, mortality accounted for 5.6 billion cubic feet of wood, an amount more than half as great as the total harvest of 10.1 billion cubic feet. Of this volume loss, 42 percent was caused by insects and

TABLE 12. Actual and Potential Productivity of United States Commercial Forest Land, 1962.

Region	Actual	Proportion of commercial forest land capable of producing more than 50 cubic feet per year
	Cubic feet/year	*Percent*
North	28	74
South	37	86
Rocky Mountains	14	45
Pacific Coast	43	90
United States	32	77

Source: Timber Trends, pp. 80, 97.

disease, and 32 percent by weather and other causes.[36] The payoffs to increased disease and insect control, and salvage of dead material, promise to be high. Economic and technical obstacles await solutions.

As a result of these factors, United States forests are producing wood far below their biological capacity (Table 12). For the nation as a whole, commercial forest land produced 32 cubic feet of wood per acre per year. By contrast, fully 77 percent of this land could produce more than 50 cubic feet per year under management.

Technical opportunities. - The forest industries face a long list of technical challenges for which solutions will certainly be forthcoming in coming decades.

A recent study estimated that a volume of unused residues equal to 4.4 billion cubic feet was produced in 1968. This was roughly one third of the volume of timber harvested. It was estimated that by the end of the 1970's economic and technical developments would make feasible the recovery of 4.7 billion cubic feet of wood.[37] This is roughly equal to the entire increase in wood use projected for a population of 300 million in Table 10.

Particleboard plants are utilizing planer mill shavings and sawdust, thus extending the timber resource and solving a difficult disposal problem for sawmills. These products, with further improvement, can be expected to grow in importance and replace plywood in a wider range of uses. As this occurs, opportunities for resource expansion will multiply. Trees of inferior species, poor form, and small size will have a market. This will extend the utility of existing timber resources, and provide a market incentive for further timber stand improvement.

A challenge of long standing is the utilization of lignin. A large portion of paper mill BOD effluent consists of lignin and wood sugars. Equipment for control of these effluents can add 20 percent to the cost of a pulp and paper mill. Given these costs, serious research efforts can be expected to find uses for these materials.

The development of chipping in the woods points to the possibility of total tree utilization, in which chips including bark and leaves are used as part of the furnish for paper, paperboard, and particleboard. It is not unreasonable to expect further progress in this area. Improved utilization of logging residues, desirable for many reasons, will also yield additional industrial raw material.[38]

Opportunities in end use markets. - Two major opportunities are more efficient wood utilization and recycling.

Labor-saving and material-saving innovations in the housing sector are slowly coming into use. For example, prefabricated stressed-skin panels, which consist of glued units of studs and plywood sheathing, enhance strength and rigidity so that less wood is required. Another innovation is the prefabricated roof truss. Ellefson calculates that such trusses could save as much as 1,700 board feet oflumber per house.[39]

In the paper economy, opportunities for reducing consumption of virgin woodpulp are abundant. Recycling represents an important avenue for meeting paper demands. The recycling rate in the United States has been declining steadily since the high re-use rates imposed by necessity in World War II. The rate now stands below 20 percent. A study by consultants to the Forest Service concludes that a recycling rate of 35 percent is feasible. Other nations have much higher recycling rates than that.[40]

SUMMARY

Merely demonstrating that United States timber supplies have vastly improved in recent decades does not provide assurance that future demands can be met. To be confident that long-term wood supplies are adequate, it is necessary to determine that (1) American forests are capable of growing sufficient wood to meet reasonable consumption standards for a growing population, and (2) potential opportunities for intensive forest management, improved wood utilization, and more efficient use in end use markets exist to assure that the consumption standards can in fact be met.

This chapter has suggested, on rough calculations, that the forest resources of the United States can provide a reasonable standard of forest products consumption for a population between 300 and 400 million people. In addition, the outlook suggests that major opportunities for increasing timber growth and promoting more efficient wood use exist. These opportunities, if pursued, make it likely that the growth needed to sustain higher consumption will be forthcoming.

Considering these options moves the analysis beyond the limits of the original concept of scarcity used above. The emphasis on consumer welfare avoids endowing demand forecasts with spurious concreteness. At the same time, when demand can be controlled to aid resource management, the concept of scarcity takes on a new meaning. Also, it is in order to consider the re-allocation of timber demand away from paper uses and into lumber. Today's technology permits this, and imaginative policymaking could bring it about. Attention then shifts to social methods of controlling product demand, to achieve harmony with long-run resource productivity. This includes balancing uses at the resource level as well as the product level. Thus, it is possible to enjoy a high standard of forest products use and at the same time apply forest management restrictions that recognize the values of nontimber forest benefits.

CHAPTER SIX

CONCLUSIONS

LINES OF THE ARGUMENT

Today, contradictory policies are being urged, on the basis of differing views of the timber resource situation. On the one hand are conservation groups, arguing for expanded wilderness preservation and cost-raising restrictions on private timber management. On the other are the homebuilders, the timber industry, and the Forest Service, urging increased funding for traditional forestry programs, on the ground that the nation faces an imminent timber supply gap. Policy could benefit from a clearer diagnosis of the basic forces affecting the economic adequacy of our timber supply.

This study formulates and tests the following hypothesis:

> The United States has experienced steadily increasing timber scarcity and faces increasingly severe scarcities in the future.

This appears a fair summary of current literature on the subject of timber supplies.

To say that a resource is scarce implies a definition of scarcity. Scarcity can be defined at several levels. At the resource level, physical measures are often used-"the timber is being depleted." Such a measure is economically ambiguous, however, and leaves the significant question-the effects of this depletion-unanswered. The next level is the market for resource services or their products. Economists speak of rising or falling real prices of lumber or plywood. This permits identifying the effect of changing resource supplies on the prices of things consumers buy. Finally, the analyst can focus on the social significance of resource product prices. This directly incorporates community values into the analysis.

Dealing with scarcity at any of these levels cannot resolve the ambiguities and value problems at stake. But a direct focus on social welfare forces value premises into the open. For these reasons, the following definition of resource scarcity is adopted:

> Resource scarcity is a social problem caused by a rising real price of natural resource products.

Considering the welfare significance of resource prices calls for careful identification of value statements, statements which are often submerged.

When the depletion of timber is described as resource scarcity, there is an unspoken assumption that this will harm consumers. If a consumer uses less wood, or tobacco, or cotton, it is assumed that his welfare has declined. In an affluent economy, any single raw material accounts for a small portion of consumer outlays. New products are constantly being introduced, substitutions are occurring, and tastes are changing. Unambiguous measures of the welfare significance of resource prices are simply not available.

If the scarcity hypothesis were true, certain empiricaL regularities would characterize the timber economy. These are listed in the following tabulation, along with the results of the empirical studies in Chapters Three to Five.

Implication	*Trend since 1950*
Real price of products will rise	
Paper	No
Lumber	Yes
Real price of timber will rise	
Pulpwood	No
Sawtimber	Yes
Growing stock and growth will fall	No
Foreign trade balance will deteriorate	No
Consumer welfare will suffer	No
Labor productivity will fall relative to other industries	Ambiguous
Future needs cannot be met	No

These trends, while containing a certain amount of ambiguity, clearly indicate that the scarcity hypothesis should be rejected. Decisive shifts in the nation's timber economy have caused major scarcity indicators to diverge from paths predicted by the hypothesis since about 1950.

Do these trends truly signify an improved timber supply? Or are they merely a statistical accident, a coincidental movement of some economic time series? The factors underlying these movements can be grouped into two classes-temporary factors and sustained long-trun factors which can be expected to continue.

In recent decades, timber availability has benefited from the strong resurgence of second growth forests. In addition, the land base has been agumented by millions of acres released from agriculture. Further, the benefits of custodial forest management-fire control and disease protection-are being realized. Also, during the past century a rural road network has been built up which renders most stands accessible to harvesting. Finally, the drain on the forest from fuelwood consumption has all but vanished. Clearly, these gains were temporary and will not recur.

However, there are several long run forces which suggest optimism for the future. These include the remaining opportunities for forestry investments on private and public land, rising yields from managed plantations, and the continuing benefits of resource-expanding technical change.

Studying the relation between resource prices and consumer welfare presents perplexing difficulties. There is little foundation for the view that rising forest products prices have an important effect on the cost or production of housing. Further, the worst predictions of prospective forest depletion are based upon continually rising consumption standards for paper products. Lacking evidence to the contrary, it seems fair to assume that a stable per capita consumption of paper would imply no social welfare losses. In this perspective, it appears that the United States enjoys a timber-producing capacity equal to the needs of a population double its present size.

The above analysis assumes that improvements in forest practice and in utilization technology will continue. And the assertion that timber supplies will be adequate assumes that ways will be found to curtail low priority uses of timber.

IMPLICATIONS

The conceptual framework developed in this study does not settle the discussion of resource scarcity and its economic effects. It does, however, open a fruitful way out of the dead end into which many resource studies run-calling for prodigious efforts to keep up with a projected runaway demand. The concept of resource scarcity can be used to evaluate past resource supply trends. These trends are then connected with consumer welfare by analyzing their effect on socially valued goods and services. It is then clear that it is rare for any single resource product to have strong effects on consumer welfare.

In this perspective, it is possible to manage demand as well as supply. This is ultimately the only way out of the trap of ever-rising consumption versus finite resources. Demand management can be based on trade-offs between different uses of land resources and different uses of resource products. Planners might define one set of trade-offs between wilderness and timber, and another between paper and lumber, or between different consumer uses of paper. The goal would be to control demand to a level within the capacity of the nation's longrun forest growth potential, given the appropriate restrictions in favor of nontimber forest services.

One element in defining these trade-offs is the social cost of substituting alternative materials for wood products. For both paper and lumber, nonwood substitutes exist. The social costs per equivalent unit in terms of air and water pollution and soil disturbance appear to favor the woodbased raw materials.[1]

Social policies embodying these decisions will be based on assessment of social costs and gains of alternative materials policies. The policies will require continual adjustment to keep abreast of changing economic, technological, and social realities.

By refusing to treat market demand as sacred, policymakers can add demand-management to their kit of tools for managing longrun timber supply. Society would rely on a mix of policies including resource protection, intensified management, and control of demand. Renewable resource management could then be based on a true long-run policy of sustained material production in harmony with environmental quality.

APPENDIX TABLES

TABLE 1. Real Price of All Lumber and Softwood Plywood, 1900 to 1971. Wholesale Price Index, Deflated by All Commodity Index 1957–1959 = 100.

Year	Softwood Plywood	All Lumber
1900	...	35.2
1901	...	35.8
1902	...	35.1
1903	...	37.1
1904	...	34.6
1905	...	36.8
1906	...	43.5
1907	...	41.5
1908	...	39.8
1909	...	37.0
1910	...	35.2
1911	...	37.7
1912	...	38.1
1913	...	39.8
1914	...	37.8
1915	...	36.1
1916	...	33.1
1917	...	31.6
1918	...	32.8
1919	...	42.0
1920	...	55.0
1921	...	47.0
1922	...	52.7
1923	...	57.2
1924	...	52.1
1925	...	50.2
1926	...	49.8
1927	...	48.8
1928	...	46.4
1929	...	49.1

Year	Softwood Plywood	All Lumber
1930	...	49.3
1931	...	47.6
1932	...	44.9
1933	...	53.5
1934	...	56.1
1935	...	50.9
1936	84.7	53.6
1937	78.0	57.6
1938	84.2	55.3
1939	87.9	60.2
1940	89.8	65.1
1941	90.0	69.9
1942	79.0	67.0
1943	83.4	68.1
1944	84.4	73.3
1945	82.9	72.9
1946	90.0	73.4
1947	120.7	95.4
1948	141.8	100.1
1949	127.8	96.4
1950	141.5	108.2
1951	133.1	105.1
1952	125.1	105.3
1953	126.8	105.8
1954	121.7	103.8
1955	124.9	109.9
1956	111.2	108.7
1957	98.3	99.5
1958	97.9	96.6
1959	103.8	103.9
1960	90.0	99.1
1961	87.3	94.4
1962	83.6	95.9
1963	87.4	98.6
1964	84.9	100.2
1965	83.0	99.4
1966	84.8	102.5

Year	Softwood Plywood	All Lumber
1967	77.5	102.2
1968	97.6	116.9
1969	101.1	124.9
1970	81.2	105.2
1971	86.2	121.6

Sources: Plywood: **TRR,** p. 446 to 1943; 1944 to 1971, *Agricultural Statistics.*
Lumber: Hair & Ulrich, 1972.
Series deflated by wholesale price index for all commodities.

TABLE 2. Real Price of Major Paper Products, 1926-1971.

Year	Wholesale price index, 1957-59 = 100			Newsprint dollars/ton rolls, New York deflated by WPI
	Woodpulp	Paper	Board	
1926	68.4	90.3	67.3	131.50
1927	66.3	86.4	74.2	137.80
1928	62.8	84.5	67.5	127.80
1929	63.7	84.5	62.8	119.00
1930	68.5	92.8	57.9	120.50
1931	75.4	106.5	58.1	142.90
1932	67.7	111.8	64.9	141.60
1933	67.9	105.0	83.9	114.20
1934	71.7	96.6	84.9	97.60
1935	61.9	90.9	69.4	91.30
1936	63.8	90.5	69.0	92.80
1937	92.6	90.0	76.1	90.00
1938	74.7	100.7	70.7	116.30
1939	65.4	100.2	74.2	118.50
1940	97.9	103.0	83.0	116.30
1941	97.3	97.3	83.9	104.60
1942	89.4	88.3	76.3	92.60
1943	85.5	86.7	78.8	96.80
1944	91.7	87.9	80.0	101.90
1945	91.0	87.2	81.9	104.00
1946	88.2	83.5	78.8	109.40
1947	97.8	80.7	89.8	109.10
1948	101.4	82.0	85.2	110.90
1949	96.5	87.3	86.9	121.00
1950	91.5	86.1	88.8	117.10
1951	98.2	86.5	100.1	114.30
1952	98.5	92.6	99.6	127.90
1953	97.7	95.0	98.5	135.40
1954	98.1	95.7	98.4	135.40
1955	100.6	97.7	100.1	135.10
1956	101.7	100.2	102.9	135.20
1957	99.7	100.6	101.1	134.90
1958	100.3	99.4	99.6	133.90
1959	100.1	100.0	99.3	133.60

Year	Wholesale price index, 1957–59=100			Newsprint dollars/ton rolls, New York deflated by WPI
	Woodpulp	Paper	Board	
1960	99.5	101.3	98.7	133.50
1961	94.7	101.9	92.2	134.00
1962	92.6	102.0	92.5	133.60
1963	91.4	102.1	94.4	134.00
1964	95.6	103.1	95.9	133.60
1965	95.7	101.6	94.0	129.20
1966	92.5	101.3	91.7	128.60
1967	92.4	104.0	91.7	131.90
1968	90.2	103.7	84.8	130.10
1969	86.7	103.2	83.5	129.30
1970	91.4	104.2	81.9	128.40
1971	90.8	103.8	80.4	129.80

Sources: Woodpulp–1926–66 from Hair, 1967, p. 118; 1967–71 from *Agricultural Statistics*.
Paper, Board–1926–65, Hair, 1967, p. 116, 117. 1966–71, *Survey of Current Business*.
Newsprint. *Business Statistics* and *Survey of Current Business*.
All series deflated by all commodity wholesale price index 1957–59 = 100.

TABLE 3. Real Price of Sawtimber and Pulpwood Stumpage, 1910–1971.

Year	Sawtimber		Pulpwood	
	Douglas fir	Southern pine	Spruce	Southern pine
	Dollars per M		*Dollars per cord*	
1910	5.70	3.90	...	...
1911	6.50	7.90	...	...
1912	7.10	4.00	...	...
1913	4.50	4.50	...	...
1914	4.30	7.80	...	...
1915	7.60	5.50	...	...
1916	2.60	6.80	...	...
1917	2.50	5.30	...	...
1918	2.50	4.20	...	...
1919	3.20	4.90	...	...
1920	2.10	5.20	...	...
1921	3.60	6.90	...	...
1922	4.70	5.30	...	...
1923	4.50	5.40	...	...
1924	4.10	6.50	...	...
1925	3.70	5.70	...	...
1926	4.00	6.60	...	...
1927	4.80	6.70	...	...
1928	5.50	6.80	...	...
1929	5.20	6.70	...	...
1930	7.00	6.80	...	...
1931	7.30	8.50	...	...
1932	4.80	7.90	...	...
1933	3.30	7.50	...	...
1934	3.70	7.10	...	...
1935	3.90	10.30	...	1.60
1936	4.80	...	...	2.26
1937	3.40	11.20	6.36	1.70
1938	5.80	17.00	...	2.09
1939	...	13.70	...	2.37
1940	5.30	10.50	4.65	2.33
1941	7.50	22.60	6.48	1.88
1942	...	16.50	6.48	1.48
1943	...	15.40	6.72	1.42
1944	9.10	19.20	7.38	1.76
1945	8.60	16.10	7.25	1.38

Year	Sawtimber		Pulpwood	
	Douglas Fir	Southern pine	Spruce	Southern pine
	Dollars per M		*Dollars per cord*	
1946	10.00	13.50		1.82
1947	12.20	13.40	6.03	1.48
1948	22.60	18:70	9.10	1.93
1949	13.30	23.60	7.20	2.28
1950	18.90	30.80	6.35	2.17
1951	26.30	35.80	8.25	3.10
1952	27.40	41.00	7.45	3.40
1953	21.80	36.90	6.75	3.68
1954	17.40	32.00	7.00	4.09
1955	31.00	34.30	9.65	4.30
1956	39.20	38.90	7.40	4.00
1957	26.50	31.80	7.30	4.30
1958	21.70	31.00	7.80	4.25
1959	36.60	35.00	7.65	4.20
1960	31.80	34.30	7.20	4.35
1961	27.50	26.70	8.00	4.25
1962	24.70	25.80	8.20	4.20
1963	27.80	25.00	8.00	4.30
1964	37.90	27.70		4.30
1965	41.60	30.90		4.30
1966	47.20	36.40		4.30
1967	39.30	36.10	6.80	4.35
1968	56.30	38.80	7.40	4.25
1969	72.70	45.80	6.65	4.10
1970	35.80	37.60	6.10	4.00
1971	40.60	43.20	4.34	3.90

Sources: Sawtimber: Hair & Ulrich, 1972, p. 44, and Hair & Ulrich, 1964, p.33.
Pulpwood: US Congress, House Doc. 195, 1958; Hair & Ulrich, 1972. 1955-1972 southern pine covers Louisiana only; previously, refers to all southern national forests. Spruce-Wisconsin.
Series deflated by all commodity price index, 1957-59 = 100.

TABLE 4. Estimated Domestic Production of Round Timber Products, 1900–1970, Million Cubic Feet.

Year	Total	Sawlogs	Veneer logs	Pulpwood	Fuelwood
1900	12,085	5,680	5	135	4,800
1910	13,205	6,910	90	220	3,910
1920	11,835	5,440	80	360	4,065
1930	10,095	4,560	155	395	3,790
1940	10,865	4,845	235	930	3,890
1950	10,790	5,905	345	1,500	2,270
1960	10,210	5,080	705	2,565	1,300
1970	11,825	5,285	960	3,925	700

Source: Hair & Ulrich, 1964, 1971.

TABLE 6. Estimated Net Imports as a Percentage of Apparent Consumption, Major Timber Products, 1900–1970.

Year	Total	Sawlogs	Pulpwood
1900	-2	-3	20
1905	-1	-2	25
1910	-1	-3	38
1915	2	...	36
1920	2	-1	42
1925	4	-2	58
1930	6	-4	59
1935	8	-4	53
1940	5	...	32
1945	9	2	33
1950	14	7	36
1955	12	7	27
1960	13	9	23
1965	12	10	20
1970	8	12	12

Sources: Calculated from data in Hair & Ulrich, 1964, 1971.

TABLE 5. Trends in Labor Productivity, 1869–1968.

year	Sawmills, real value added per man-year	Sawmills, Employment per million bd. ft.	Kendrick output per man-hour		Logging Employment per unit of output
			Lumber & wood	Paper & allied	
	1957–59 Dollars	*Man-years*	*1929 = 100*		*1947–49 = 100*
1869	3.4	11.7	...	...	48
1879	2.4	8.3	...	...	58
1889	2.3	11.5	...	...	85
1899	2.3	11.7	84.0	43.1	63
1909	2.5	12.4	82.6	57.9	73
1919	4.7	13.6	74.6	61.0	112
1929	4.5	10.9	100.0	100.0	111
1939	2.8	10.4	98.3	141.7	114
1949	4.1	12.1	127.3	152.2	— 100
1954	3.7	10.4	158.1	172.0	...
1957	...	10.4	...	...	...
1958	5.0	...	177.8	198.5	...
1963	6.6	...	...	...	...
1967	8.6	...	...	...	...

Sources: Sawmills: Real value added: Author's estimates based on Census value added and employment data for sawmills and planing mills. Convenient sources are the 1914 *Census Handbook*, NFPA, *Lumber Industry Facts*, 1966, and the 1967 *Census of Manufacturers*.
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Logging: Potter & Christy, 1961, p. 128, 129.

FOOTNOTES
Abbreviations used

AER	American Economic Review
AJAE, JFE	American Journal of Agricultural Economics-formerly Journal of Farm Economics
FPJ	Forest Products Journal
GPO	Government Printing Office
JFor.	Journal of Forestry
JPE	Journal of Political Economy
QJE	Quarterly Journal of Economics
RE Stat	Review of Economics and Statistics

INTRODUCTION

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