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RESOURCE INPUTS AND OUTPUT GROWTH: THE CONTRAST BETWEEN AGRICULTURE AND FORESTRY*

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The view is widely held by physical scientists, foresters, conservationists, economists and the general public that natural resources are scarce and becoming more so. It is frequently asserted that such scarcity is, or will in the near future, act as a serious restraint on the growth of output, not only in those industries which rely heavily on resource inputs, but in the general economy as well.1/

How does one bring evidence to bear on a hypothesis stated in such a broad context? The concept of "resources" or "natural resources" is notably difficult to define (Ciriacy-Wantrup, pp. 27-47). It is proposed, in this paper, to examine the issue posed above by analyzing relationships between resource inputs and output growth in agriculture and forestry - the two industries which together utilized almost 1.7 million of the nation's 1.9 million acres of land in 1954 (Table 1).

What kind of information does one look for in these two sectors as evidence regarding resource scarcity? Barnett (1958) suggests that evidence can be found in the areas of relative productivity and price movements.

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1/ An extensive review of the "scarcity" literature is presented in two excellent articles by Barnett (1958 and 1960).

Table 1. Land Utilization in Continental United States, 1954.

Major Land Use	Acres (in millions)	
Agriculture		
Crops	409	
Pasture	69	
Other	45	
		523
Grazing		700
Commercial Forestry		
Continuous Management	359	
Little or No Management	125	
		484
Total in Agriculture and Forest		1,707
Other		197
Total Land Area		1,904

Source: Clawson, Marion, R. Burnell Held, Charles H. Stoddard, 1960, Land For the Future, Johns Hopkins Press (for Resources for the Future), Baltimore, p. 442.

Productivity. Resource scarcity, if it exists, should be accompanied by the utilization of lower quality or less accessible resources. The result should be a lag in total productivity relative to productivity in other sectors of the economy. By total productivity we mean output per unit of total input, including capital, land and other resource inputs and not simply labor productivity.2/ A relative lag in total productivity in an industry can be taken as an indication that technological change has been less effective in overcoming the effects of declining resource productivity than in other sectors of the economy.

Prices. A productivity lag by itself is not sufficient to indicate resource scarcity. Only if productivity growth lags relative to growth in demand can resource scarcity be said to exist. A lag in productivity relative to growth in demand can be expected to reveal itself in terms of a rise in the price of the resource-based products relative to other products. If total productivity rises more rapidly than growth in demand the result should be declining relative prices.

2/ Barnett (1958) couches his discussion in terms of labor productivity. The advantages of the total productivity measure are outlined by Ruttan (1954), pp. 15-28.

I. Relative Price Movements in Agriculture and Forestry

Evidence with respect to changes in the prices of agricultural and forest products relative to the general price level is presented in Table 2. The price series were obtained by dividing the index of prices received by farmers for farm products and the wholesale forest product price indexes by the Bureau of Labor Statistics wholesale price index. Thus the indexes in Table 2 indicate changes in the prices of agricultural, forest product, and stumpage prices relative to the index of wholesale prices rather than absolute price changes. A rise in the index for a particular item indicates that its prices rose faster (or fell more slowly) than the average of all wholesale prices. A decline indicates that its prices did not rise as fast (or fell faster).

Primary emphasis is focused on the forest product (lumber and pulpwood) prices rather than the stumpage prices as evidence of resource scarcity in the forest industries. There are two reasons for this: (1) Prices at a comparable stage in the production process are not available in the agricultural sector. Comparable prices would imply a series constructed from such items as the price of unharvested wheat standing in the field and unharvested fruit on the tree. (2) Both farm products and forest products are raw materials whose value is derived primarily from a demand for more highly processed final products. The effect of resource scarcity on prices of agricultural and forest products should be defined, therefore, at the wholesale level.

A review of the relative changes in agricultural and forest product prices since 1870 reveals a sharp contrast between the two sectors.

The only long term secular increase in agricultural prices relative to the general price level during the entire period since 1870 occurred between the late 1890's and the early 1920's. Except for this period agricultural product prices have remained stable or have tended to decline relative to the general price level. Even the relatively heavy demands placed on agriculture during World War II and

the Korean incident did not move agricultural prices upward more rapidly than the general price level for more than a few years. By the late 1950's prices of farm products had declined sufficiently relative to the general price level to wipe out most of the increase that occurred during the secular rise in the early part of the century. It seems reasonable to hypothesize, therefore, that resource scarcity, if it has existed at all in the agricultural sector since 1870, exerted its influence primarily in the first two decades of the twentieth century.

In the forestry sector the relative price movements support the opposite hypothesis. Forest product prices have risen almost continuously since 1870. When forest product prices are analyzed separately for lumber and pulpwood, however, it would appear that the lumber component has been the major contributor to the rise in prices. The relative price data clearly suggests the hypothesis that in the forest industries, particularly the lumber industry, resource scarcity has and continues to limit output growth.

Table 2. Indexes of Agricultural and Forest Product Prices Relative to the BLS Wholesale Price Index, 1870-1959.

	Agriculture	Forest Products			Stumpage	
		All	Lumber	Pulpwood	Douglas Fir	Southern Pine
		(1947-49 = 100)				
1870	69	27	22			
1879	65	30	24			
1889	67	35	28			
1899	68	40	32			
1909	82	43	38	76	35	22
1919	89	44	42	60	20	27
1929	89	53	50	65	32	36
1939	70	63	62	67	35	74
1949	93	99	99	98	82	127
1954	82	104	106	94	108	172
1959	74	99	109	88	237	190

Sources:

Agricultural and Forest Products:

(a) 1870-1949. Indexes are from Harold J. Barnett, October 1958. "Measurement of National Resource Scarcity and Its Economic Effects", Paper presented at the Annual Conference on Research in Income and Wealth, National Bureau of Economic Research, (Tables 1 and Appendix). The Barnett data are from a study by N. Potter and F. T. Christy, Jr; U. S. National Resource Statistics, 1870-1956 to be published by Resources for the Future, Inc; Washington, D. C.

(b) 1954-1959. Forest product price indexes are from D. Hair and H. B. Wagner, November 1959. The Demand and Price Situation for Forest Products, U. S. Department of Agriculture, Forest Service and Commodity Stabilization Service, Washington. Agricultural price indexes are computed from the wholesale price indexes presented in The Demand and Price Situation for Forest Products, op. cit. and the index of prices received by farmers presented in U. S. Department of Agriculture, November 1959, Agricultural Outlook Charts, 1960.

Stumpage: Price indexes are computed from the wholesale price indexes and stumpage price data presented in The Demand and Price Situation for Forest Products, op. cit.

II. Productivity and Output Growth in Agriculture

The contribution of technological change to the output explosion in American agriculture since the end of World War II is well known. At this point it is only necessary to repeat a few facts with respect to this output explosion and then attempt to provide some historical perspective to the very rapid progress of recent years.

The dramatic nature of the change that has occurred in American agriculture during the last decade is emphasized when one recalls the discussion of the early 1950's which centered around the problem of meeting farm output requirements during the period 1950-75. The President's Water Resources Policy Commission (1952, pp. 156-159) warned that the equivalent of almost 100 million acres of cropland would have to be added to meet 1975 farm output requirements and that two-thirds of this would have to come from resource development activities such as irrigation, flood protection, drainage, and land clearing if in the terminology of the Department of Agriculture (1952), the "fifth plate" resulting from population growth was to be filled. By 1958 farm output had risen almost 25 percent above the 1950 level (Table A2). When the 1960 farm output figures become available they will indicate that the "fifth plate" has been filled and a start has been made toward filling the sixth.

Even more dramatic than the increase in output itself has been the change in resource combinations used to produce this increase in output.

- Between 1953 and 1958 crop acreage--mainly wheat, cotton, corn, and rice acreage--was reduced by approximately 29 million acres by the acreage allotment and soil bank programs. Agriculture was using approximately 5 percent fewer land inputs in 1958 than in 1950.

- Labor inputs declined by more than one-fourth.

- Inputs of capital and current operating expenses rose sufficiently to approximately offset the decline in land and labor inputs.

During the decade of the 1950's then, the nation has experienced an increase in agricultural output of at least one-fourth while the total inputs devoted to agricultural production have remained approximately unchanged. During the decade it has been possible to substitute new technology for resources at a sufficiently rapid rate to account for the entire increase in output.

The experience of the 1950's is in sharp contrast to the period prior to the mid 1920's (Table A1). Prior to the mid 1920's most of the year-to-year increases in farm output came from using more inputs. In the period prior to 1899 land and labor accounted for a major share of these increased inputs. Between 1899 and 1929 increased capital inputs accounted for a major share of output growth. Since the mid 1920's, however, technological change --in the form of more productive capital inputs and current operating expense items-- has been adopted at an increasingly rapid rate until by the end of 1950 technological change was occurring at a sufficiently rapid rate to hold total inputs unchanged.

The relative price movements outlined in the previous section can now be interpreted in terms of the productivity movements discussed above:

-Between 1870 and 1899 new land resources were brought into agriculture at a sufficiently rapid rate to hold prices at the end of the period at approximately the same level as at the beginning. Resource scarcity did not act as a limiting factor on output growth in this period.

-Between 1899 and the middle or late 1920's resource scarcity did apparently act to limit the growth of output in agriculture. Higher farm prices were required to attract capital into agriculture.

-Since the middle or late 1930's, resource scarcity has not acted as a limiting factor on the growth of farm output. Technological change has progressively reduced the importance of resource inputs and in recent years an absolute decline in both land and labor inputs has taken place.

It is of interest to note that the period 1899-1925, when resources did act to limit output growth in agriculture, is also associated with vigorous growth of the conservation movement (Griffith, 1958). The earlier period, 1780-1899, was characterized by vigorous farmer movements designed to protect farmers from the exploitation of the "trusts" (Hicks, 1931). And the last period, 1925-1960, has been characterized by farmer efforts to obtain direct government support for agricultural prices and income (Cochrane, 1958).

III. Productivity and Output Growth in Forest Industries

From the output series (Table A3) four distinct periods in the historical development of timber production can be distainguished: (a) A period of rapid and continuous output growth from 1870 until shortly after the turn of the century; (b) A period of relative stability to 1929 with output during the 1920's somewhat below the levels reached before and during World War I; (c) A period of sharp decline and partial recovery during the depression of the 1930's; (d) A period of slowly increasing output from the early 1940's to the present. Unfortunately, information is not available on factor inputs and outputs to permit the presentation of as clear a picture of the interaction between technological change and resource utilization in forestry as in agriculture. Nevertheless, the available data on timber output, labor inputs, and labor productivity do permit us to draw a few rather clear-cut implications. Inconsistencies in the several measures of forest land noted in the footnotes to Table A3 limit the usefulness of aggregate yield indexes.

It is clear (Table 3) that the logging industry has swept through the several forested regions in the country harvesting the fund of timber on the land using priority system based on accessibility and availability to markets. It was not until about 1940 that the lumber industry gave serious consideration to the systematic management of forest lands and the continuous production of forest crops from given areas.

Due to the location and size of the forested areas cut during the rapid initial growth of eastern United States, limitation of the forest resource was not a serious restraint on output between 1870 and the early 1900's. Productive capacity during this period was rapidly multiplied by the prompt adoption of steam power to operate sawmilling machinery and locomotives in harvesting operations. Although, wholesale lumber price indexes, when related to the Bureau of Labor

Statistics Wholesale Price Index, increased (Table 1) during this period the increases were apparently not sufficient to prevent consumption from expanding rapidly.

Declining output between the early 1900's and the late 1920's reflected the introduction of a number of new factors which are difficult to analyze quantatively. Increasing use of substitute building materials in this period was a critical factor. Aggravating the over-all decrease in consumption was the trend toward smaller homes and multi-unit dwellings which required less lumber in their construction. Production, nevertheless, was quite responsive to changes in lumber price. Evidence presented by Holland (1960) indicated a supply response coefficient[3/] of about 2.0 during the 1920's. Lumber production shifted rapidly from Eastern to Western United States in this period and lumber prices began to increase relative to those of competing materials by the early 1930's (Eighty-Fifth Congress, 1957). Decreasing labor productivity trends established in the earlier period continued as it became necessary to pursue more distant and often times inferior timber resources. The rate of decline, however, was apparently at slower rate after 1910 than before this time.

Although gasoline and diesel power units for mills and woods machinery were introduced after 1910, adoption of the new types of mechanical equipment lagged. In the 1930's most log skidding was still done by animals or steam-powered devices and the steam locomotive was still the principal method of moving large volumes of logs from the forest to the mill.

Virtual cessation of new residential and industrial construction activity during the early 1930's was the major factor in the sharp decline of output in the years immediately following 1929. By the beginning of World War II output had risen almost to the predepression level. Since the early 1940's output has

3/ Ratio of percent change in output to percent change in price.

Table 3. Percent of Total United States Lumber Production Accounted for by Major Regions, 1869-1954.

	North-east	Lake	Central	South	West	Total
	(Percent of United States' Total)					
1869	35.7	28.2	21.2	10.0	4.9	100.0
1879	25.8	34.7	21.1	13.8	4.6	100.0
1889	20.0	36.9	15.3	18.7	9.1	100.0
1899	16.3	24.9	17.1	31.7	10.0	100.0
1909	11.7	12.3	12.6	44.8	18.6	100.0
1919	7.5	7.8	8.8	46.5	29.4	100.0
1929	4.5	4.9	7.0	42.2	41.4	100.0
1939	6.5	3.3	8.6	39.7	41.9	100.0
1949	5.9	2.7	6.2	34.0	51.2	100.0
1954	5.9	2.4	6.3	30.5	54.9	100.0

Source: U. S. Department of Agriculture, October 1958. Historical Forestry Statistics of the United States, Stat. Bul. 228.

expanded slowly and currently approaches the levels reached 50 to 60 years ago.

Between the early 1940's and the mid 1950's substantial price increases relative to the general price level were required to obtain relatively modest increases in the output of forest products. Holland's (1960) estimates imply a decline in the supply response coefficient for lumber during this period (from around 2.0 to around 1.0). There are some indicators that the coefficient has been rising in recent years, however. In spite of sharply higher stumpage prices since 1954 increases in timber output have been achieved with only modest increases in lumber prices relative to the general price level. Pulpwood prices have declined during most of the 1950 decade while output has continued to rise. Indications are that labor productivity in timber harvesting and processing which experienced it's first significant rise during the 1940's is continuing at an increasing rate with the greatest progress being made in the pulp industry.

Since labor productivity is a function of technological advance and the relative prices of labor and capital equipment, it is reasonable to expect that capital inputs have increased over time. Historically, this appears to be the case. Power saws used to fell and cut trees into logs were commercially developed about 1920 and widely adopted by 1940 (Miller, 1949). Wheeled and track-type tractors introduced into the woods by about 1930, had proved themselves for most types of logging operation by 1935. Combustion-engine powered yarding equipment, mechanical loaders, truck transportation of logs, and increased electrification of mill operations are other innovations adopted almost exclusively after 1932. Innovation resulting in increased utilization of felled trees, integrated production, automated processes, and specialized machinery have occurred more recently in logging and milling operations (Holbrook, 1959). Mergers in the forest product industry in the last few years (Dealey, 1958) have complemented these innovative features by increasing the economic stability of firms resulting from consoli-

dation of timber holdings and permitting the realization of significant scale economics.

No precise information is available on the increase of capital investment in the various segments of the timber industry. Nevertheless, some insight may be gained from Tables 4 and 5. Horse power per wage earner has had a respectable increase since 1919 in the lumber and wood-products industry, although the rate of increase has been less than in its principal competitor, metal products. Capital invested per production worker has increased at a relative rate exceeding those of both paper and metal products.

A limitation of the aggregate labor productivity statistics used in this paper is that significant regional differences may be obscured. This appears to be particularly true in the case of lumber (Table 6). The South and the West together produce about 85 percent of present lumber production. The data in Table 6 refer specifically to the more productive areas within these regions. With smaller trees, relatively low volumes of timber per acre, and lighter equipment twice as much labor was required to produce 1,000 board feet of logs and lumber in the South than in the Douglas Fir country during the last several decades. Interestingly enough, wage rates are and have been twice as high in the mills of the West (Table 7). Assuming the same wage relationship also holds true for woods labor in the two regions, the product of hourly wage and hours per 1,000 board feet gives a similar labor cost per unit of volume and explains to a large degree the often observed fact that Douglas Fir lumber is price competitive with southern pine lumber in many areas of the southern pine region.

Dynamic changes which also should be mentioned are the technological breakthroughs made in the wood pulp and paper industry. Although, wood pulp has been manufactured for about 100 years in this country, it was the rapid advances in sulphate pulping technology in the 1920's that released the industry from its dependence on spruce and fir of the Northeast and made it possible to utilize south-

Table 4. Horsepower of prime movers and motors per wage earner in the lumber and wood products and metal products industries for selected years.

Year	Lumber and wood products		Metal products	
	Horsepower per wage earner	Index (1919 = 100)	Horsepower per wage earner	Index (1919 = 100)
1899	3.3	67		
1904	3.7	76		
1909	4.2	86		
1919	4.9	100	7.4	100
1929	4.7	96	10.4	140
1939	7.1	145	19.5	264
1954	8.8 1/	180	26.1	353

1/ Includes loggers which accounted for 11.7 percent of employment in this group in 1954.

Source: U. S. Bureau of Census, Census of Manufactures, USGPO, Washington, various years.

Table 5. Capital invested 1/ per production worker for selected industries and years.

Year	Lumber and wood products		Paper and allied products		Metal Products	
	Dollars per worker	Index (1939 = 100)	Dollars per worker	Index 1/ (1939 = 100)	Dollars per worker	Index 1/ (1939 = 100)
1939	3,058	100	6,675	100	6,627	100
1942	2,577	84	6,362	95	5,595	84
1947	2,959	97	7,926	119	7,321	110
1952	5,688	186	12,405	186	11,121	168
1956	8,025	262	15,841	237	13,834	209

1/ Total assets less investments in Government obligations and securities of other corporations.

Source: National Industrial Conference Board, Inc., 1956 and 1960, The Economic Almanac, New York.

Table 6. Man hours required to log and manufacture 1,000 board feet of yard lumber for specified years.

Year	Logging		Manufacturing Lumber	
	Southern Pine Region	Douglas Fir Region	Southern Pine Region	Douglas Fir Region
	(hours)		(hours)	
1921	-	-	-	9.3
1929	-	-	-	7.7
1935	9.9	4.9	13.0	6.5
1945-46	14.6	-	18.2	-
1949	-	5.1	-	9.0

Sources: U. S. Bureau of Labor Statistics, 1923, 1932, 1937 and 1946. Monthly Labor Reviews 16:1-21 (1921); 35:818-825 (1929); 44:1136-1152 (1935); 63:941-953 (1945-46). 1949 data are adapted from Holland (1960) whose source was West Coast Lumbermen's Assn., 1949. Employment Stat. Dept. Release.

Table 7. Hourly wages for production workers in sawmills and planing mills in the South and West for specified years.

Year	Hourly Wage Rates	
	South	West
	(dollars)	
1921	0.21	0.47
1944	.52	1.18
1949	.92	1.82
1954	1.04	2.17
1959	1.27	2.44

Sources: U. S. Bureau of Labor Statistics, 1923. Monthly Labor Review 16:1-21 (1921); U. S. Bureau of Labor Statistics, 1954 and 1960. Employment and Earnings Annual Supplement Issues for May, 1954 (1949) and May, 1960 (Vol. 6, No. 11) (1954 and 1959). 1944 data from Brown, Nelson Courtland, 1949. Logging, John Wiley and Sons, New York, pp. 418.

ern pine for pulp. This led to the "sulphate revolution" of the South and was instrumental in increasing national consumption from 6.8 million cords in 1926 to 33.4 million in 1955. The South's share of production rose from 1.1 million cords to 19.2 million cords in this period while pulpwood consumption in the West was increasing from 0.5 to 6.4 million cords (Zivnuska, 1957). By the mid-1950's the South's share of woodpulping capacity had risen to over 55 percent of the national total (Pikl, 1960). Semi-chemical pulping innovations of the 1940's promise to perform similar spectacular results in the hardwood regions of the country. Pulp and paper technology and efficient use of labor (Table 8) have made it possible for wood-cellulose products to aggressively compete against products made traditionally from lumber, metal, and glass. Increasingly, pulpwood has become a larger proportion of the total timber harvest (Table 9).

The above discussion has led to the following tentative judgments with respect to resource scarcity and output growth in the timber-based industries:

-Labor productivity in the timber industries declined almost continuously between 1870 and 1920; remained almost constant throughout the 1920's and 1930's and has risen moderately since 1940.

-Between 1870 and the early 1900's resource scarcity apparently acted as only a minor brake on output growth in the forest industries in spite of the fact that higher prices were required to compensate for declining labor productivity.

-Between the early 1900's and the late 1920's resource scarcity acted as a somewhat stronger restraint on output growth in the forest industries. In spite of the fact that labor productivity was no longer declining, continued price increases failed to maintain output at the levels reached in the early 1900's.

-Following the depression of the 1930's resource scarcity acted as a serious brake on output expansion in the timber industries during the decade of the 1940's. Technological change was not sufficient to offset the effect of lower-quality and less-accessible timber. Sharply increased timber prices relative to

Table 8. Indexes of output per man hour for paper and pulp and basic steel industries, 1919-1958.

Year	Industry	
	Paper and pulp	Basic steel
	(1947 = 100)	
1919	49.0	29.5
1929	80.8	57.8
1939	109.2	79.3
1947	100.0	100.0
1949	106.7	102.8
1954	129.1	115.9
1957	146.4	128.9

Source: U. S. Bureau of Labor Statistics, April 1959. Indexes of Output per Man Hour for Selected Industries, 1919 to 1958, unnumbered, p. 6.

Table 9. Sawlogs and pulpwood harvested relative to total harvest round timber products for selected years.

Year	Product	
	Sawlogs	Pulpwood
	(percent of total harvest)	
1900	78.0	1.9
1929	74.4	6.1
1954	64.2	21.8

Source: U. S. Department of Agriculture, 1958. Historical Forestry Statistics of the United States, Stat. Bul. 228.

the wholesale price index were required to attract increased amounts of capital into the industry.

-Resource scarcity has continued to act as a restraint on output growth during the decade of the 1950's. There is one sign - modest increases in labor productivity and output and slower increases in relative prices - that this limitation may be becoming less serious than in the past.

- Technological change clearly seems to have been a major factor in permitting utilization of wood pulp and paper to expand rapidly and at the same time avoid the relative price increases imposed by resource scarcity. Technological changes at the harvesting and processing stages in the lumber industry, although not as dramatic, have been effective in limiting increases in the relative price of lumber.

IV. What About the Future?

Agriculture

Current population and per capita income projections imply a growth in the demand for farm products of slightly more than 30 percent between 1960 and 1975. If technological change continues at the level maintained during the decade of the 1950's it seems likely that the 1975 farm output will be produced with approximately 25-30 percent less labor, around 10-15 percent more capital, a 25-30 percent increase in current operating expenses, and a decline in land inputs of 5-10 percent.[4/] Furthermore, these output and input changes are expected to occur with no rise in farm prices relative to the general price level.

It seems clear then that in the case of agriculture resource scarcity cannot be expected to act as a serious brake on the growth of output during at least the next decade and a half. The momentum of the current technical revolution is such that it is reasonable to expect the production of 1975 farm output requirements with little or no rise in total inputs and with less land than at present.

Beyond 1975 or 1980 the picture becomes less clear. Some recent Department of Agriculture (1960) projections based on very rapid increases in population imply the necessity of shifting some land from forestry to agriculture by the end of the century. Aside from the failure of similar projections made in the early 1950's there is some basis for not letting the weight of these projections impinge too heavily on current resource policy decisions. It will be possible to view the prospects for the period 1975-2000 much more clearly after another decade than at present. In particular it should be more apparent whether the rate of technological change achieved during the 1950's will become a permanent feature of the agricultural landscape.

4/ These projections are modifications of data presented by Ruttan (1956). For a review of how these projections stand up in the light of the experience of the past five years, see Ruttan (1960).

Forestry

Because of the long growth cycle for timber, policy decisions affecting the future supply of timber cannot be delayed to the same extent as in the case of agriculture. Decisions made within the next decade will to a great extent determine the timber supply in the year 2000.

Rettie and Hair (1958, p. 471) in the Forest Service Report on Future Demand for Timber project annual timber cuts 13-28 percent above the level of the early 1950's for 1975 and 45-117 percent above the level of the early 1950's for 2000. Stoddard (1958) indicates that if the upper level Forest Service projections are met, an increase of about 11 percent in commercial timber acreage (from 489 million acres to around 541 million acres) plus substantial stand improvement will be required. He estimates that additional capital inputs over and above land costs of around $4.0 billion would be required for planting and for putting the improved management practices into effect. No estimate of changes in labor inputs, current operating expenses or other capital inputs is available for the timber industries. It seems clear, however, that an assumption of continued resource scarcity, is clearly implicit in the above projections. The Forest Service projections assume that prices of most timber products other than pulpwood will continue to rise relative to the general price level. (Rettie and Hair, p. 421, 438, 446).

Is it possible to anticipate a time when technological change will reverse the effects of resource scarcity on output growth in the timber industry and thereby, actually make certain resources now devoted to commercial timber production marginal for anything but recreational use? Another way of stating this question is to ask whether the changes in output and productivity that can be seen emerging in the forestry industry during the 1950's stem from the same factors that led to similar changes in agriculture during the period 1900-1925? If this is the case, is it reasonable to anticipate a build up in the rate at which tech-

nology is substituted for resources in forestry similar to the rate which has occurred in agriculture?

In asking this question no attempt is made to minimize the difficulty of obtaining a clear-cut answer. The full implications of the technological revolution in agriculture were not realized until more than a quarter century after agriculture's rising productivity began to manifest itself. Lack of recognition of the technological basis of agriculture's growing output potential has led to unsuccessful attempts to deal with agricultural surplus on a temporary or emergency basis while at the same time continuing to implement programs designed to draw additional land and capital resources into agriculture.

If technological change in timber production, harvesting, and utilization should in the future move ahead at a sufficiently rapid rate to overcome the effects of resource scarcity, equally drastic revisions may be required in our thinking in regard to forest resource policy. Instead of talking about the increasing timber acreage required to meet output requirements, discussion may have to shift to the number of timber acres that can be shifted to recreational use in order to obtain favorable timber prices.

A1. Total and Partial Productivity Indexes for Agriculture and Forestry.

	Agriculture Output per unit of:					Forest industries Output per unit of:		
	Gross inputs (1)	Operating expenses (2)	Non-land capital (3)	Land (4)	Labor (5)	Land (6-A)	Land (6-B)	Labor (7)
	(1929 = 100)							
1869	69.0				53.9			209
1879	80.1				64.2	30		183
1889	85.5				69.2	48		135
1899	95.8				79.8			
1900	95.8				80.0	77	103	175
1901	94.7				79.2			
1902	93.1				78.1			
1903	94.9				80.1			
1904	96.8				81.9			
1905	97.1				82.4			
1906	101.5				86.4			
1907	96.4				82.2			
1908	97.8				83.5			
1909	95.2				81.4			
1910	98.4	129.4	101.4	85.0	84.2	117	113	150
1911	93.0	127.5	95.6	81.2	80.3			
1912	101.6	136.6	105.7	89.6	88.6			
1913	92.4	117.5	95.4	80.0	81.1			
1914	98.2	129.3	106.4	86.0	86.7			
1915	102.3	134.8	102.7	88.5	91.3			
1916	92.3	116.6	91.1	81.8	83.8			
1917	96.7	133.8	99.1	86.5	85.3			
1918	96.1	119.9	90.9	89.3	85.5			
1919	96.1	118.6	85.8	90.1	87.3			
1920	99.7	115.4	85.8	94.2	91.3	105	105	98
1921	91.3	92.1	63.3	80.7	87.6			
1922	97.9	99.2	77.0	90.3	92.5			
1923	99.2	102.2	81.3	92.7	93.2			
1924	95.8	94.2	88.2	92.8	91.3			
1925	97.6	99.3	89.6	96.7	91.9	104		
1926	99.6	100.5	92.8	100.5	95.2			
1927	100.4	98.7	92.7	98.2	98.0			
1928	102.3	100.3	99.9	102.0	100.6			
1929	100.0	100.0	100.0	100.0	100.0	100		100
1930	98.3	100.7	93.7	96.5	98.0	77		100

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A1. Total and Partial Productivity Indexes for Agriculture and Forestry, (Con't)

	Agriculture Output per unit of:					Forest industries Output per unit of:		
	Gross inputs (1)	Operating expenses (2)	Non-land capital (3)	Land (4)	Labor (5)	Land (6-A)	Land (6-B)	Labor (7)
				(1929 = 100)				
1931	109.0	118.1	101.4	103.4	105.3			
1932	108.2	123.1	98.8	99.2	105.0			
1933	101.9	115.1	94.3	93.9	96.7			
1934	92.4	103.6	85.9	80.8	92.5			
1935	108.4	122.8	109.1	95.4	106.6	62		
1936	96.7	98.8	92.2	87.3	99.3			
1937	115.5	121.1	116.3	109.5	115.9			
1938	115.1	114.7	104.5	106.3	119.9			
1939	111.4	103.8	112.8	104.3	119.9			
1940	111.9	97.1	117.0	108.8	125.3	80	81	98
1941	116.1	97.0	118.1	113.1	132.1			
1942	125.8	98.8	125.0	127.8	145.6			
1943	123.2	91.6	109.2	125.6	144.8			
1944	127.2	90.9	114.0	129.8	150.7			
1945	127.1	84.1	117.8	127.8	156.8	77		
1946	131.1	83.8	125.1	130.0	169.3			
1947	127.1	79.4	124.2	125.0	172.1			
1948	137.7	86.9	128.9	134.6	193.8			
1949	132.4	85.7	113.3	131.6	194.2			
1950	132.4	81.0	115.5	131.4	209.4	82	98	110
1951	132.4	78.8	115.5	133.7	213.2			
1952	137.5	82.2	109.6	138.8	234.2			
1953	140.2	83.1	112.3	140.8	245.1			
1954	141.5	81.6	118.8	139.8	260.7	113		
1955	146.7	83.0	122.7	145.0	277.1			
1956	147.9				295.0			
1957	151.0				312.4			
1958	162.6				350.6			
1959								
1960								

Source:
(1) - (5) Computed from data presented in Table A2
(6) and (7) Computed from data presented in Table A3

42. Indexes of Gross Output and Factor Inputs in U. S. Agriculture, 1870-1958.

	Gross output (1)	Gross inputs (2)	Current operating expense (3)	Non-land capital (4)	Land (5)	Labor (6)
			(1929 = 100)			
1869	28.9	41.9				53.6
1879	45.2	56.4				70.4
1889	57.2	66.9				82.6
1899	72.5	75.7				90.8
1900	73.3	76.5				91.6
1901	73.0	77.0				92.2
1902	72.5	77.9				92.8
1903	74.8	78.8				93.4
1904	76.9	79.4				93.9
1905	77.9	80.2				94.5
1906	82.2	81.0				95.1
1907	78.6	81.5				95.6
1908	80.3	82.1				96.2
1909	78.8	82.8				96.8
1910	82.4	83.7	63.7	81.3	96.9	97.8
1911	79.7	85.7	62.5	83.4	98.2	99.3
1912	89.2	87.8	65.3	84.4	99.6	100.7
1913	81.1	87.8	69.0	85.0	101.3	100.0
1914	89.2	90.8	69.0	83.8	103.7	102.9
1915	91.9	89.8	68.2	89.5	103.8	100.7
1916	83.8	90.8	71.9	92.0	102.5	100.0
1917	87.8	90.8	65.6	88.6	101.5	102.9
1918	89.2	92.8	74.4	98.1	99.9	104.3
1919	89.2	92.8	75.2	104.0	99.0	102.2
1920	94.6	94.9	82.0	110.2	100.4	103.6
1921	83.8	91.8	91.0	132.3	103.8	95.6
1922	91.9	93.9	92.6	119.4	101.8	99.3
1923	93.2	93.9	91.2	114.6	100.5	100.0
1924	91.9	95.9	97.6	104.2	99.0	100.7
1925	94.6	96.9	95.3	105.6	97.8	102.9
1926	98.6	99.0	98.1	102.6	98.1	103.6
1927	97.3	96.9	98.6	105.0	99.1	99.3
1928	101.3	99.0	101.0	101.4	99.3	100.7
1929	100	100.0	100.0	100.0	100.0	100.0
1930	97.3	99.0	96.6	103.8	100.8	99.3

(Continued on next page)

Table A2 (Continued)

	Gross output (1)	Gross inputs (2)	Current operating expense (3)	Non-land capital (4)	Land (5)	Labor (6)
			(1929 = 100)			
1931	106.8	98.0	90.4	105.3	103.3	101.4
1932	102.7	94.9	83.4	104.0	103.5	97.8
1933	94.6	92.8	82.2	100.3	100.7	97.8
1934	81.1	87.8	78.3	94.4	100.4	87.7
1935	97.3	89.8	79.2	89.2	102.0	91.3
1936	87.8	90.8	88.9	95.2	100.6	88.4
1937	110.8	95.9	91.5	95.3	101.2	95.6
1938	106.8	92.8	93.1	102.2	100.5	89.1
1939	106.8	95.9	102.9	94.7	102.4	89.1
1940	110.8	99.0	114.1	94.7	101.8	88.4
1941	114.9	99.0	118.5	97.3	101.6	87.0
1942	129.7	103.1	131.2	103.8	101.5	89.1
1943	127.0	103.1	138.6	116.3	101.1	87.7
1944	131.1	103.1	144.2	115.0	101.0	87.0
1945	128.4	101.0	152.6	109.0	100.5	81.9
1946	132.4	101.0	157.9	105.8	101.8	78.2
1947	128.4	101.0	161.6	103.4	102.7	74.6
1948	140.5	102.0	161.6	109.0	104.4	72.5
1949	136.5	103.1	159.2	120.5	103.7	70.3
1950	136.5	103.1	168.5	118.2	103.9	65.2
1951	140.5	106.1	178.4	121.6	105.1	65.9
1952	145.9	106.1	177.6	133.1	105.0	62.3
1953	147.3	105.1	177.3	131.2	105.0	60.1
1954	147.3	104.1	180.5	124.0	105.0	56.5
1955	152.7	104.1	183.9	124.4	104.2	55.1
1956	154.0	104.1			102.0*	52.2
1957	154.0	102.0			99.1*	49.3
1958	167.6*	103.1*			98.7*	47.8*
1959						
1960						

* Preliminary

Sources: (1) 1910-58 indexes are from Farm Economics Research Division, Agricultural Research Service, Changes in Farm Productivity and Efficiency, U. S. Department of Agriculture Statistical Bulletin No. 233, Washington, Sept. 1959, Table 1.

1869-1909 indexes are from J. W. Kendrick, Productivity Trends on the United States, National Bureau of Economic Research, forthcoming, Appendix B, Table B-II.

(2) 1910-58 indexes are from U. S. Department of Agriculture, Agricultural Outlook Chart, '60, U. S. Department of Agriculture, Washington, November 1958, Table 1, p. 50.

1869-09 indexes are based on J. W. Kendrick, op.cit., Appendix B, Table B-I. The Kendrick indexes do not include current operating expense.

(3,4,5) indexes are computed from data supplied by the U.S.D.A. See T.T. Stout and V.W. Ruttan, "Regional Differences in Technological Change in American Agriculture," Journal of Farm Economics, Vol. 40, No.2, May 1958, pp. 196-207.

(6) 1910-58 indexes are from Changes in Farm Production and Efficiency, op. cit. Table 15. 1869-1909 indexes are from J. W. Kendrick, op. cit. Appendix B, Table B-I.

A3. Indexes of Gross Output and Factor Inputs in Forest Product Industries in the United States, 1870-1958, (1929 = 100).

	Gross output (1)	Land (2-A)	Land (2-B)	Labor (3)
1869	33.0			15.8*
1879	46.4	155*		25.4*
1889	69.6	146*		51.7*
1899	91.1			
1900	108.9	142	106*	62.3
1901	111.6			
1902	111.6			
1903	112.5			
1904	111.6			
1905	112.5			
1906	117.8			
1907	119.6			
1908	109.8			
1909	117.0			
1910	116.1	99	103	77.2
1911	111.6			
1912	116.1			
1913	115.2			
1914	107.1			
1915	100.9			
1916	106.2			
1917	98.2			
1918	90.2			
1919	94.6			
1920	96.4	92	101	98.2
1921	82.1			
1922	92.8			
1923	103.6			
1924	100.0			
1925	101.8	97		
1926	99.1			
1927	95.5			
1928	94.6			
1929	100.0	100	100	100.0
1930	76.8	100	100	77.2

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A3. Indexes of Gross Output and Factor Inputs in Forest Products Industries in the United States, 1870-1958, (1929 = 100). (Continued)

	Gross output (1)	Land (2-A)	Land (2-B)	Labor (3)
1931	57.1			
1932	42.0			
1933	49.1			
1934	52.7			
1935	63.4	103		
1936	73.2			
1937	76.8			
1938	67.8			
1939	75.9			
1940	80.4	101	99	82.4
1941	91.1			
1942	92.0			
1943	87.5			
1944	84.8			
1945	75.0	98		
1946	86.6			
1947	91.1			
1948	93.7			
1949	83.0			
1950	96.4	118	98	87.7
1951	98.2			
1952	98.2			
1953	98.2			
1954	98.2			
1955	106.2	94		
1956	108.9			
1957	100.9			
1958	97.3			
1959	106.2			

* Data is for 1870, 1880 and 1890

Footnotes for Table A3 on next page.

Footnotes for Table A3.

(1) Indexes for 1869-1955 are from Neal Potter and Francis T. Christy, Jr., "Employment and Output in the Natural Resource Industries 1870-1955", Paper presented at the Annual Conference on Research in Income and Wealth, National Bureau of Economic Research, October 17-18, 1957, Table 1A. Indexes are extended to 1959 on the basis of total domestic production estimates presented in Dwight Hair and H. B. Wagner, The Demand and Price Situation for Forest Products, U. S. Department of Agriculture, Washington, November 1959, Table 2.

(2A) Indexes are based on data presented in Hugh H. Wooten and James R. Anderson 1957, Major Uses of Land in the United States, Summary for 1951, Agricultural Information Bulletin 168, Washington, U. S. Department of Agriculture, pp. 36, 37.

(2B) Indexes based on data presented in Marion Clawson, et. al., 1960, Land for the Future, Johns Hopkins, Baltimore, pp. 442.

In both 2A and 2B it is assumed, for purposes of index construction, that acres of forest land was the same in 1929 and 1930. Estimate (2B) were constructed by Clawson (1960) in an attempt to adjust the Wooten and Anderson (1957) data to the levels indicated by Crafts (1958, p. 30) in his summary of the Timber Resource Review. It appears that an important element in the difference between the two series is the treatment of forest grazing land.

(3) Indexes are from Neal Potter and Francis T. Christy, Jr., op. cit., Table A2. For purposes of index construction, 1929 employment estimate was constructed on the assumption that labor productivity in forestry was the same in 1929 as in 1930.

Note: Gross Output Indexes differing somewhat in detail may be found in Historical Forestry Statistics, 1958; U.S.D.A. Stat. Bul. No. 228, and in Solomon Fabricant's book (1942), Employment in Manufacturing, 1899-1939, National Bureau of Economic Research, New York, 685pp. The Potter-Christy output measure includes the value of timber and labor used in the logging operation while the Fabricant measure includes value added during manufacturing.

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