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National Measures of Forest Productivity for Timber

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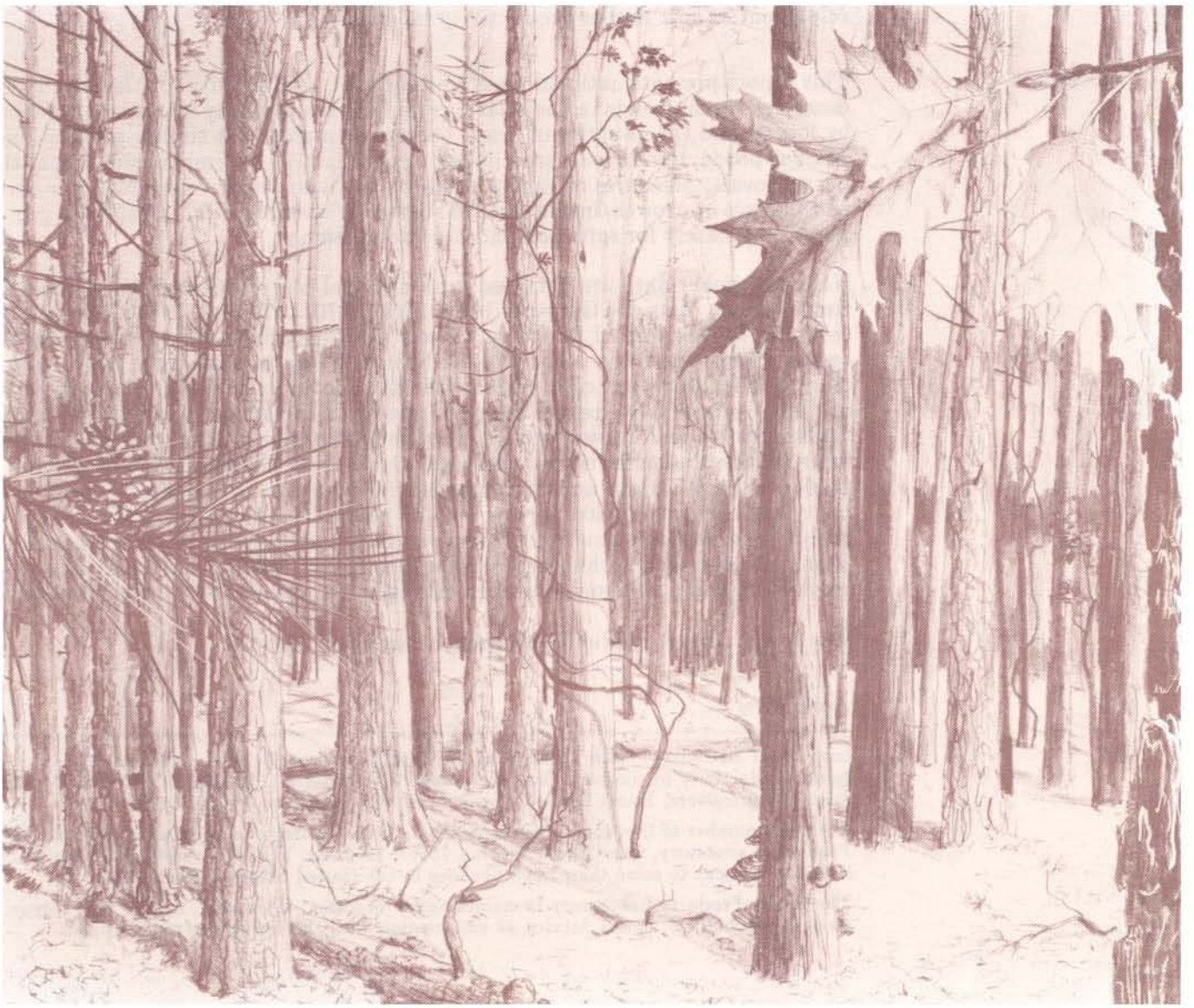

Preface

Forest productivity, and especially timber productivity, has been a longstanding topic of interest and study for John Fedkiw, coauthor of this paper. His public discussion of the topic has extended over several decades and is documented at least as far back as a joint U.S.–Canadian forestry meeting in Ottawa in 1967.

George Dunlop, USDA Assistant Secretary for Natural Resources and Environment, recognized the need for new forest productivity indexes while providing congressional testimony. For many years, the U.S. Department of Agriculture has had well-developed methodology and data for measuring crop and livestock productivity. These measures are very useful for explaining agricultural program progress and opportunities. However, Mr. Dunlop was concerned that no comparable measures of forest productivity were available, despite the now considerable compilation of forest statistics.

The insight and timing of Assistant Secretary Dunlop's interest in developing forest productivity indexes was extremely opportune. Data for the timber resources of the United States have been recently updated and are now available at approximately 10-year intervals back to 1952. Thus, the combination of need, interest, data availability, and strong direction provided the opportunity for development of new timber productivity indexes.

Abstract

This report presents national measures of forest productivity for timber. These measures reveal trends in the relationship between quantity of timber produced by forests and the quantity of forest resources employed in timber production. Timber production is measured by net annual growth of timber and annual timber removals. Measures of timber productivity include annual growth per acre and indexes of growth/inventory and removals/inventory. Information is presented separately for softwood and hardwood timber.

National timber data are obtained from national compilations of Forest Service timber survey data for the years 1952,1962,1970,1977, and 1987. The data are compiled for the United States as a whole, for four principal land ownership categories (forest industry, other private, National Forests, and other public agencies), and for three principal regions (North, South, and West). The measures of timber productivity reflect the performance of forests as measured by annual timber growth and harvest yields (the principal component of removals) in relation to the timber inventory and timberland area. These productivity measures provide a concise and comprehensive view of the overall timber productivity in the United States for the past 35 years. The measured productivity reflects amount and structure of the inventory and timberland area, trends in forest management, technology improvements, new investments, and various legal requirements influencing timber management, particularly on public lands.

Keywords: Forest productivity, timber, national indexes

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National Measures of Forest Productivity for Timber

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Introduction

Measures of productivity are important in characterizing the performance of the U.S. economy. Productivity indexes for the U.S. farm sector have been published for decades by the U.S. Department of Agriculture (USDA 1980, 1988a,b). Forests are an important national resource, and timber is one of the most economically important crops produced in the United States. Yet, no national productivity indexes have previously been reported for the forest resources of the United States. Timber is the basic raw material for an array of forest products industries that are vital to the U.S. economy and our international trade. The value of U.S. forest industries shipments (including logs, lumber, plywood, wood furniture, pulp, paper, and paperboard) was $134 billion in 1982 (U.S. Dept. of Commerce 1982). A basic challenge to foresters and forest resource managers is to increase productivity as the economy grows (Fedkiw 1967). For these reasons, we developed national indexes of forest productivity for timber and present them in this report.

The output of goods or services produced by a firm, industry, or nation depends generally on the inputs employed in production and the efficiency with which those inputs are employed (Kendrick and Grossman 1980). Productivity can be calculated most conveniently as the ratio of the physical or real quantity of output produced to the physical or real quantity of inputs employed in production. Productivity is increasing if the output/input ratio is increasing. Conversely, productivity is decreasing if the output/input ratio is decreasing.

Productivity ratios provide measures of technical performance, dealing with the quantitative relationship between output and inputs. As such, the concept of productivity is distinguished from simple production volume and from the more complex concept of economic efficiency.

Trends in productivity can behave differently than trends in production volume. Productivity can be increasing while production volume is decreasing, and conversely, productivity can be decreasing while production volume is increasing.

Also, trends in productivity do not directly reflect trends in prices, value, or quality of output or inputs. Therefore, productivity does not directly reflect economic efficiency (the relationship between real product value and real costs of production).

Forest Productivity for Timber

Measures of forest productivity for timber reveal trends in the relationship between quantity of timber output and the quantity of forest inputs employed in timber production. Two useful but different measures of timber output are net annual growth of timber and annual timber removals. The principal forest inputs employed in timber production are timber capital and forest land, as explained in the forestry economics literature (for example, see Duerr 1960, p. 102). The real quantity of timber capital employed in timber production is measured by the volume or inventory of timber growing stock on timberland. The real quantity of forest land employed in timber production is measured by timberland acreage.

Measures of forest productivity for timber presented in this report include net annual growth per acre and indexes of growth/inventory and removals/inventory. Net annual growth per acre reflects productive performance of forests for timber in relation to forest land input. Indexes of growth/inventory and removals/inventory reflect productive performance of forests for timber in relation to timber capital input.

Although we developed each productivity measure in relation to a single input (for example, capital or land), this does not mean that trends in each productivity measure are determined only by change in one input factor. Rather, single-input measures of productivity reflect the combined effects of numerous interrelated inputs (Kaiser 1975; USDA 1980). We present separate productivity measures for softwoods and hardwoods because of significant differences in productivity and utilization of hardwood timber and softwood timber.

Timber Data and Definitions

We used the most accurate national and regional timber data available. Data on timber inventory, timberland area, net annual growth, and annual timber removals were obtained from the USDA Forest Service, National Forest Resource Inventory. Data for the 1952 to 1977 productivity estimates were tabulated from previously published reference material (USDA Forest Service 1982); productivity estimates for 1987 were obtained from compilations pending publication in the 1989 Timber Analysis report (Haynes 1988). The data are compiled for the United States as a whole, for four principal land ownership categories (forest industry, other private, National Forests, and other public agencies) and for three principal regions (North, South, and West).

Timberland area refers to the acreage of all forest lands that are producing or capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. Areas qualifying as timberland have a potential capability of growing in excess of 20 ft^3 per acre per year of industrial wood in natural stands (USDA Forest Service 1982, 1988).

Timber growing-stock inventory is defined as the volume in live trees of commercial species at least 5.0 in. diameter at breast height and of good form and vigor, from stump to a minimum 4-in. diameter top (central stem). Growing stock inventory is measured in cubic feet.

Net annual growth of timber is defined as the increase in volume of growing stock inventory during a specified year. It takes into account the increment in volume of trees surviving from the beginning to the end of the year, plus net volume of trees reaching minimum size class during the year, minus the volume of trees that died during the year, and minus the net volume of trees that became rough or rotten trees during the year.

Timber removals are defined as the volume of growing stock trees removed from the inventory by harvesting, cultural operations (such as timber stand improvement), or changes in land use. Commercial timber harvest is by far the largest component of timber removals.

Table 1 shows timberland area and softwood and hardwood data for growing stock inventory, net annual growth, and timber removals in the United States and by ownership class and region for 1952,1962,1970, 1977, and 1987.

Net growth and removals are useful but different measures of timber output. Net annual growth reflects net biological output of the forest within a particular year. Annual growth may be stored for decades on the stump, accumulating as timber inventory. Growth depends directly on the current condition and structure of timber growing-stock inventory. Factors influencing growth include inventory age structure, stand density, forest health, and timber species mix. Current growth is only slightly influenced by current timber removals, because in any given year, removals are but a fraction of the total growing stock. Annual removals consist primarily of timber harvest, which is the market response to the economic supply and demand for timber and the legislative direction on public land harvests.

Calculation of Productivity Measures

Average annual growth per acre for softwoods is calculated by dividing net annual growth for softwoods by timberland acreage. Likewise, average annual growth per acre for hardwoods is calculated by dividing net annual growth for hardwoods by timberland acreage. Total timber growth per acre is calculated by dividing the sum of softwood and hardwood net annual growth by timberland acreage. Table 2 shows average annual growth per acre for softwoods, hardwoods, and total timber growing stock in the United States and by ownership class and region for 1952, 1962, 1970, 1977, and 1987.

The productivity index of growth/inventory is calculated by dividing an annual growth index by an inventory index for softwoods and hardwoods. The growth

Table 1–U.S. timberland area and timber growing-stock data

Year	Timberland area (× 10^3 acres)	Softwood data (× 10^6 ft^3) Inventory	Net annual growth	Timber removals	Hardwood data (× 10^6 ft^3) Inventory	Net annual growth	Timber removals
		UNITED STATES, ALL OWNERS AND REGIONS					
1952	508,205	430,079	7,735	7,770	180,083	6,175	4,092
1962	518,059	448,261	9,610	7,624	210,482	7,095	4,336
1970	505,058	458,153	11,321	9,365	234,446	8,466	4,729
1977	491,059	464,522	12,384	10,046	259,740	9,326	4,183
1987	480,760	449,391	12,722	11,864	302,893	9,593	5,176
		FOREST INDUSTRY					
1952	59,548	77,280	1,872	2,765	20,026	688	521
1962	61,558	76,239	2,326	2,301	25,089	830	657
1970	66,980	75,144	2,611	3,116	28,861	1,058	649
1977	68,782	74,317	2,867	3,633	32,139	1,207	596
1987	70,418	72,291	3,216	4,501	34,817	1,151	871
		OTHER PRIVATE					
1952	295,981	93,288	3,469	3,542	130,486	4,599	3,310
1962	304,190	102,553	4,325	3,007	147,971	5,125	3,399
1970	287,942	113,644	5,243	3,334	163,153	6,093	3,707
1977	278,146	123,465	5,876	3,569	180,147	6,640	3,233
1987	274,790	134,935	5,457	4,343	212,576	6,861	3,900
		NATIONAL FORESTS					
1952	94,744	204,354	1,663	1,032	13,253	396	117
1962	96,851	213,623	1,999	1,747	16,851	508	126
1970	94,651	211,808	2,361	2,162	18,690	570	160
1977	88,719	207,673	2,465	1,993	20,880	651	128
1987	84,975	186,366	2,680	2,042	24,362	617	168
		OTHER PUBLIC					
1952	57,933	55,163	730	431	16,324	492	144
1962	55,461	55,854	959	569	20,574	633	154
1970	55,457	57,564	1,106	752	23,748	745	214
1977	55,410	59,074	1,176	851	26,674	828	226
1987	50,579	55,799	1,370	978	31,138	963	238
		SOUTH					
1952	203,580	58,737	3,641	3,112	84,099	3,041	2,563
1962	211,557	73,470	4,699	2,812	94,621	3,394	2,713
1970	204,398	87,042	5,643	3,768	103,631	4,282	2,733
1977	199,947	99,011	6,315	4,471	118,554	5,009	2,100
1987	194,532	103,756	5,846	5,741	133,838	4,566	2,958
		WEST					
1952	150,350	344,201	3,120	4,023	19,280	391	50
1962	150,168	341,145	3,700	4,272	22,298	489	85
1970	146,645	332,333	4,358	5,001	25,555	604	121
1977	139,476	321,096	4,628	4,870	24,943	626	129
1987	132,906	298,800	5,594	5,398	31,069	852	236
		NORTH					
1952	154,275	27,051	973	635	76,605	2,743	1,479
1962	156,334	33,646	1,211	540	93,563	3,212	1,538
1970	154,016	38,778	1,336	596	105,260	3,593	1,876
1977	151,635	43,515	1,558	705	116,243	3,791	1,953
1987	153,323	46,837	1,283	726	137,987	4,174	1,983

Table 2–U.S. timber growth per acre for growing stock

Year	Annual growth per acre (ft^3)		
	Softwood	Hardwood	Total
	UNITED STATES, ALL OWNERS AND REGIONS		
1952	15.2	12.2	27.4
1962	18.5	13.7	32.2
1970	22.4	16.8	39.2
1977	25.2	19.0	44.2
1987	26.5	20.0	46.4
	FOREST INDUSTRY		
1952	31.4	11.6	43.0
1962	37.8	13.5	51.3
1970	39.0	15.8	54.8
1977	41.7	17.5	59.2
1987	45.7	16.3	62.0
	OTHER PRIVATE		
1952	11.7	15.5	27.3
1962	14.2	16.8	31.1
1970	18.2	21.2	39.4
1977	21.1	23.9	45.0
1987	19.9	25.0	44.8
	NATIONAL FORESTS		
1952	17.6	4.2	21.7
1962	20.6	5.2	25.9
1970	24.9	6.0	31.0
1977	27.8	7.3	35.1
1987	31.5	7.3	38.8
	OTHER PUBLIC		
1952	12.6	8.5	21.1
1962	17.3	11.4	28.7
1970	20.0	13.4	33.4
1977	21.2	14.9	36.2
1987	27.1	19.0	46.1
	SOUTH		
1952	17.9	14.9	32.8
1962	22.2	16.0	38.3
1970	27.6	21.0	48.6
1977	31.6	25.1	56.6
1987	30.1	23.5	53.5
	WEST		
1952	20.8	2.6	23.3
1962	24.6	3.3	27.9
1970	29.7	4.1	33.8
1977	33.2	4.5	37.7
1987	42.1	6.4	48.5
	NORTH		
1952	6.3	17.8	24.1
1962	7.7	20.5	28.3
1970	8.7	23.3	32.0
1977	10.3	25.0	35.3
1987	8.4	27.2	35.6

and inventory indexes are calculated by expressing the actual reported growth or inventory for a given year (Table 1) as a percentage of the growth and inventory in 1977 (all indexes are based on a 1977 index of 100). Table 3 shows the growth indexes, inventory indexes, and growth/inventory indexes in the United States for softwoods and hardwoods and by ownership class and region for 1952, 1962,1970, 1977, and 1987.

The productivity index of removals/inventory is calculated by dividing an annual removals index by an inventory index for softwoods and hardwoods.[1] Table 4 shows removals indexes, inventory indexes, and removals/inventory indexes in the United States for softwoods and hardwoods and by ownership class and region for 1952,1962,1970,1977, and 1987.

Table 5 summarizes the timber data and productivity measures (rounded for convenience) presented in Tables 1 to 4.

Discussion

Forest productivity depends on many factors, including natural conditions (such as climate, soils, elevation, and latitude) and timber management, which influences timber stocking levels, forest health, and species mix. Timberland investments and wider application of professional management, along with scientific and technological improvements, have helped to improve forest productivity. Changes in private land use and legal requirements influencing forest management, particularly on public lands, have affected the quantity and quality of timberland and timber resources employed in timber production.

All these factors have contributed to a fundamental change in the structure of timber growing-stock inventory in the past 35 years. The change in inventory reflects historical patterns of timber management and utilization. Over the past 35 years, market demands for softwood timber significantly exceeded those for hardwood timber. The higher demand for softwood timber contributed generally to more productive management of softwood timber resources than hardwood timber resources.

The structure of softwood growing-stock inventory in the United States changed as older and larger diameter softwood trees were harvested and replaced by more vigorous younger trees with more stems per acre. This trend is documented extensively in Forest Service timber reports (for example, see USDA Forest Service 1982, 1988). The inventory shift was accompanied by changes in softwood timber management, with more softwood timber being grown in managed sites and plantations. In the meantime, the total volume of softwood growing stock on timberland did not change substantially (see the trend in softwood

[1]Between the 1977 and 1987 national compilations of timber data, the definition of geographic regions was slightly changed. All timber inventory and growth data from 1952 to 1977 have been adjusted slightly to reflect a change in regional definition. No adjustment was made to the timber removals data. To have a consistent geographic base for removals/inventory indexes, the inventory index and removals index are calculated based on unadjusted timber removals and inventory data for the years 1952 to 1977, as published (USDA Forest Service, 1982).

Table 3–Timber growth, inventory, and growth/inventory indexes

Year	Softwood indexes			Hardwood indexes		
	Growth	Inventory	Growth/ inventory	Growth	Inventory	Growth/ inventory
	UNITED STATES, ALL OWNERS AND REGIONS					
1952	62	93	67	66	69	96
1962	78	96	80	76	81	94
1970	91	99	93	91	90	101
1977	100	100	100	100	100	100
1987	103	97	106	103	117	88
	FOREST INDUSTRY					
1952	65	104	63	57	62	92
1962	81	103	79	69	78	88
1970	91	101	90	88	90	98
1977	100	100	100	100	100	100
1987	112	97	115	95	108	88
	OTHER PRIVATE					
1952	59	76	78	69	72	96
1962	74	83	89	77	82	94
1970	89	92	97	92	91	101
1977	100	100	100	100	100	100
1987	93	109	85	103	118	88
	NATIONAL FORESTS					
1952	67	98	69	61	63	96
1962	81	103	79	78	81	97
1970	96	102	94	88	90	98
1977	100	100	100	100	100	100
1987	109	90	121	95	117	81
	OTHER PUBLIC					
1952	62	93	67	59	61	97
1962	82	95	86	76	77	99
1970	94	97	97	90	89	101
1977	100	100	100	100	100	100
1987	117	94	123	116	117	100
	SOUTH					
1952	58	59	97	61	71	86
1962	74	74	100	68	80	85
1970	89	88	102	86	87	98
1977	100	100	100	100	100	100
1987	93	105	88	91	113	81
	WEST					
1952	67	107	63	62	77	81
1962	80	106	75	78	89	87
1970	94	103	91	97	102	94
1977	100	100	100	100	100	100
1987	121	93	130	136	125	109
	NORTH					
1952	62	62	100	72	66	110
1962	78	77	101	85	80	105
1970	86	89	96	95	91	105
1977	100	100	100	100	100	100
1987	82	108	76	110	119	93

Table 4–Timber removals, inventory, and removals/inventory indexes

Year	Softwood indexes			Hardwood indexes		
	Removals	Inventory	Removals/ inventory	Removals	Inventory	Removals/ inventory
	UNITED STATES, ALL OWNERS AND REGIONS					
1952	77	93	83	98	70	140
1962	76	97	78	104	81	128
1970	93	99	94	113	90	125
1977	100	100	100	100	100	100
1987	118	97	122	124	117	106
	FOREST INDUSTRY					
1952	76	104	73	87	63	139
1962	63	102	62	110	78	142
1970	86	101	85	109	89	122
1977	100	100	100	100	100	100
1987	124	97	127	146	108	135
	OTHER PRIVATE					
1952	99	76	130	102	73	140
1962	84	83	102	105	82	128
1970	93	92	102	115	91	126
1977	100	100	100	100	100	100
1987	122	109	111	121	118	102
	NATIONAL FORESTS					
1952	52	98	53	91	64	143
1962	88	103	85	99	81	122
1970	109	102	106	125	90	140
1977	100	100	100	100	100	100
1987	102	90	114	131	117	112
	OTHER PUBLIC					
1952	51	98	52	64	60	107
1962	67	97	69	68	77	89
1970	88	99	89	94	89	106
1977	100	100	100	100	100	100
1987	115	94	122	105	117	90
	SOUTH					
1952	70	60	116	122	75	164
1962	63	74	85	129	81	160
1970	84	87	96	130	88	148
1977	100	100	100	100	100	100
1987	128	105	123	141	113	125
	WEST					
1952	83	108	77	39	76	51
1962	88	107	82	66	89	74
1970	103	104	99	93	104	90
1977	100	100	100	100	100	100
1987	111	93	119	182	125	146
	NORTH					
1952	90	62	145	76	65	116
1962	77	77	99	79	80	98
1970	85	89	95	96	90	106
1977	100	100	100	100	100	100
1987	103	108	96	101	119	86

Table 5–Timberland area, timber growing-stock data, growth per acre, and forest productivity indexes

Year	Timberland area ($\times 10^6$ acres)	Softwoods: Net annual growth ($\times 10^9$ ft³)	Softwoods: Annual removals ($\times 10^9$ ft³)	Softwoods: Total inventory ($\times 10^9$ ft³)	Softwoods: Annual growth per acre (ft³)	Softwoods: Productivity indexes: Growth/inventory	Softwoods: Productivity indexes: Removals/inventory	Hardwoods: Net annual growth ($\times 10^9$ ft³)	Hardwoods: Annual removals ($\times 10^9$ ft³)	Hardwoods: Total inventory ($\times 10^9$ ft³)	Hardwoods: Annual growth per acre (ft³)	Hardwoods: Productivity indexes: Growth/inventory	Hardwoods: Productivity indexes: Removals inventory
UNITED STATES, ALL OWNERS AND REGIONS													
1952	508	7.7	7.8	430	15.2	67	83	6.2	4.1	180	12.2	96	140
1962	518	9.6	7.6	448	18.5	80	78	7.1	4.3	210	13.7	94	128
1970	505	11.3	9.4	458	22.4	93	94	8.5	4.7	234	16.8	101	125
1977	491	12.4	10.0	465	25.2	100	100	9.3	4.2	260	19.0	100	100
1987	481	12.7	11.9	449	26.5	106	122	9.6	5.2	303	20.0	88	106
FOREST INDUSTRY													
1952	60	1.9	2.8	77	31.4	63	73	0.7	0.5	20	11.6	92	139
1962	62	2.3	2.3	76	37.8	79	62	0.8	0.7	25	13.5	88	142
1970	67	2.6	3.1	75	39.0	90	85	1.1	0.6	29	15.8	98	122
1977	69	2.9	3.6	74	41.7	100	100	1.2	0.6	32	17.5	100	100
1987	70	3.2	4.5	72	45.7	115	127	1.2	0.9	35	16.3	88	135
OTHER PRIVATE													
1952	296	3.5	3.5	93	11.7	78	130	4.6	3.3	130	15.5	96	140
1962	304	4.3	3.0	103	14.2	89	102	5.1	3.4	148	16.8	94	128
1970	288	5.2	3.3	114	18.2	97	102	6.1	3.7	163	21.2	101	126
1977	278	5.9	3.6	123	21.1	100	100	6.6	3.2	180	23.9	100	100
1987	275	5.5	4.3	135	19.9	85	111	6.9	3.9	213	25.0	88	102
NATIONAL FORESTS													
1952	95	1.7	1.0	204	17.6	69	53	0.4	0.1	13	4.2	96	143
1962	97	2.0	1.7	214	20.6	79	85	0.5	0.1	17	5.2	97	122
1970	95	2.4	2.2	212	24.9	94	106	0.6	0.2	19	6.0	98	140
1977	89	2.5	2.0	208	27.8	100	100	0.7	0.1	21	7.3	100	100
1987	85	2.7	2.0	186	31.5	121	114	0.6	0.2	24	7.3	81	112
OTHER PUBLIC													
1952	58	0.7	0.4	55	12.6	67	52	0.5	0.1	16	8.5	97	107
1962	55	1.0	0.6	56	17.3	86	69	0.6	0.2	21	11.4	99	89
1970	55	1.1	0.8	58	20.0	97	89	0.7	0.2	24	13.4	101	106
1977	55	1.2	0.9	59	21.2	100	100	0.8	0.2	27	14.9	100	100
1987	51	1.4	1.0	56	27.1	123	122	1.0	0.2	31	19.0	100	90
SOUTH													
1952	204	3.6	3.1	59	17.9	97	116	3.0	2.6	84	14.9	86	164
1962	212	4.7	2.8	73	22.2	100	85	3.4	2.7	95	16.0	85	160
1970	204	5.6	3.8	87	27.6	102	96	4.3	2.7	104	21.0	98	148
1977	200	6.3	4.5	99	31.6	100	100	5.0	2.1	119	25.1	100	100
1987	195	5.8	5.7	104	30.1	88	123	4.6	3.0	134	23.5	81	125
WEST													
1952	150	3.1	4.0	344	20.8	63	77	0.4	0.0	19	2.6	81	51
1962	150	3.7	4.3	341	24.6	75	82	0.5	0.1	22	3.3	87	74
1970	147	4.4	5.0	332	29.7	91	99	0.6	0.1	26	4.1	94	90
1977	139	4.6	4.9	322	33.2	100	100	0.6	0.1	25	4.5	100	100
1987	133	5.6	5.4	299	42.1	130	119	0.9	0.2	31	6.4	109	146
NORTH													
1952	154	1.0	0.6	27	6.3	100	145	2.7	1.5	77	17.8	110	116
1962	156	1.2	0.5	34	7.7	101	99	3.2	1.5	94	20.5	105	98
1970	154	1.3	0.6	39	8.7	96	95	3.6	1.9	105	23.3	105	106
1977	152	1.6	0.7	44	10.3	100	100	3.8	2.0	116	25.0	100	100
1987	153	1.3	0.7	47	8.4	76	96	4.2	2.0	138	27.2	93	86

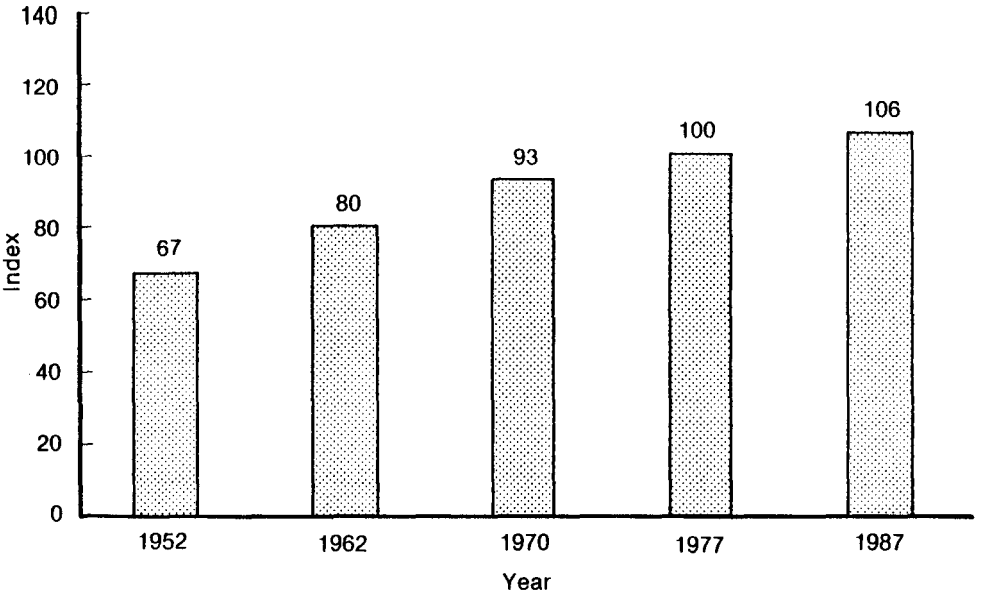

Figure 1–Timber productivity index trend for annual softwood growth relative to softwood growing-stock inventory for the United States.

total inventory, Table 1). Thus, the total quantity of softwood timber capital employed in timber production remained relatively constant, but the productive performance of softwood timber capital improved as the inventory structure shifted generally toward younger and more vigorous trees. Consequently, both timber capital and timberland have become significantly more productive for softwood timber. The historical improvements in forest productivity for softwood timber are reflected at the national level by increases in softwood annual growth per acre and indexes of softwood growth/inventory and softwood removals/inventory (see Tables 2 to 4).

By contrast, in the past 35 years, hardwood removals showed little change in volume, until the past decade. Consequently, hardwood timber capital underwent a large buildup, with little change in hardwood timber management. Overall hardwood growth per acre increased as more hardwood timber capital was accumulated (see Tables 1 and 2), but productivity of hardwood timber capital declined as hardwood timber stands became generally more dense and mature. The declines in forest productivity for hardwood timber capital are reflected in the indexes of hardwood growth/inventory and hardwood removals/inventory (see Tables 3 and 4). Declines in forest productivity for hardwoods are largely the result of the buildup in hardwood timber inventory while there have been slower gains in growth and removals. Trends in forest productivity in the United States for softwoods and hardwoods at the national level are compared in Figures 1 to 6.

Among ownership groups at the national level, the largest gains in forest productivity for softwoods, in terms of both growth and removals, occurred on forest industry lands and public forest lands (Table 5). Productivity on nonindustrial private forest lands has decreased since 1977 in terms of the

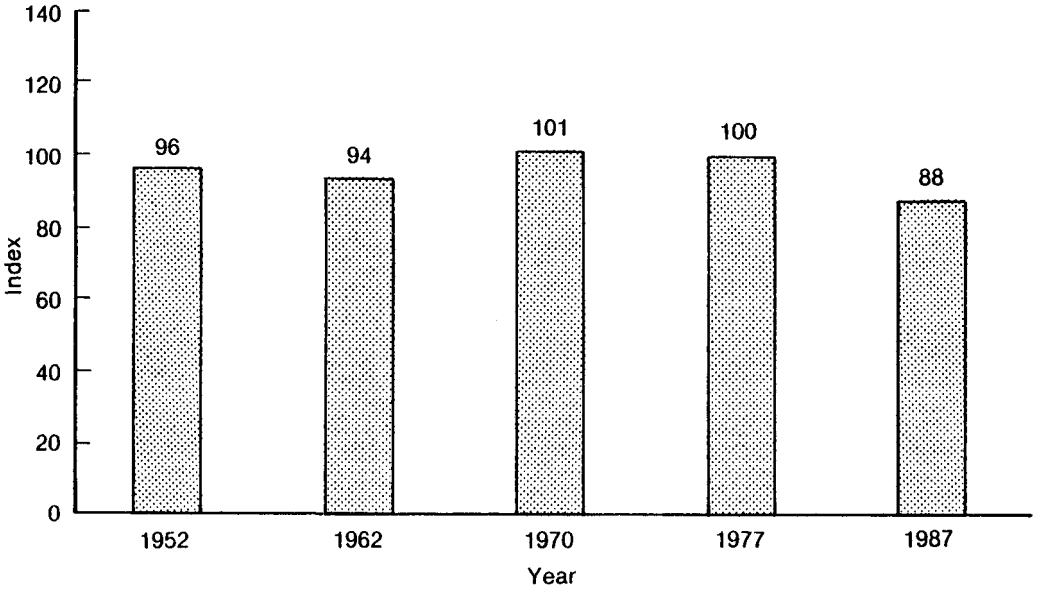

Figure 2–Timber productivity index trend for annual hardwood growth relative to hardwood growing-stock inventory for the United States.

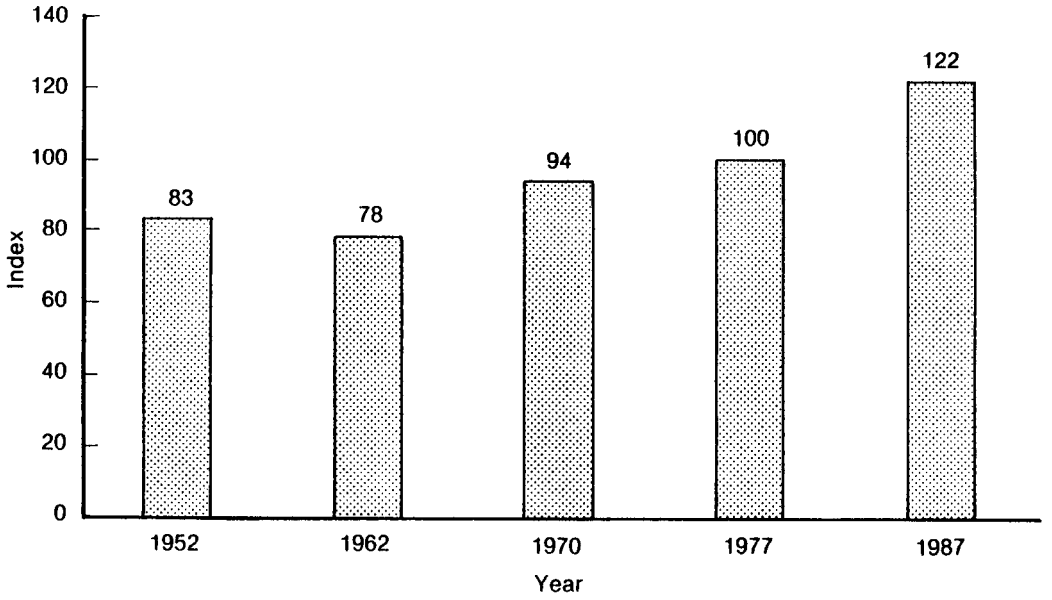

Figure 3–Timber productivity index trend for annual removals of softwood timber relative to softwood growing-stock inventory for the United States.

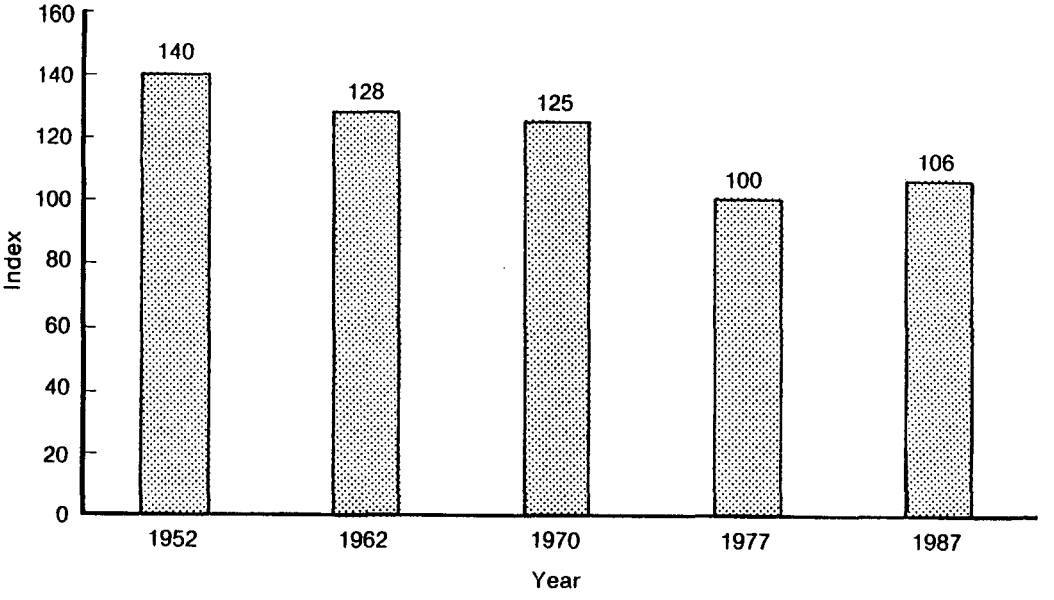

Figure 4–Timber productivity index trend for annual removals of hardwood timber relative to hardwood growing-stock inventory for the United States.

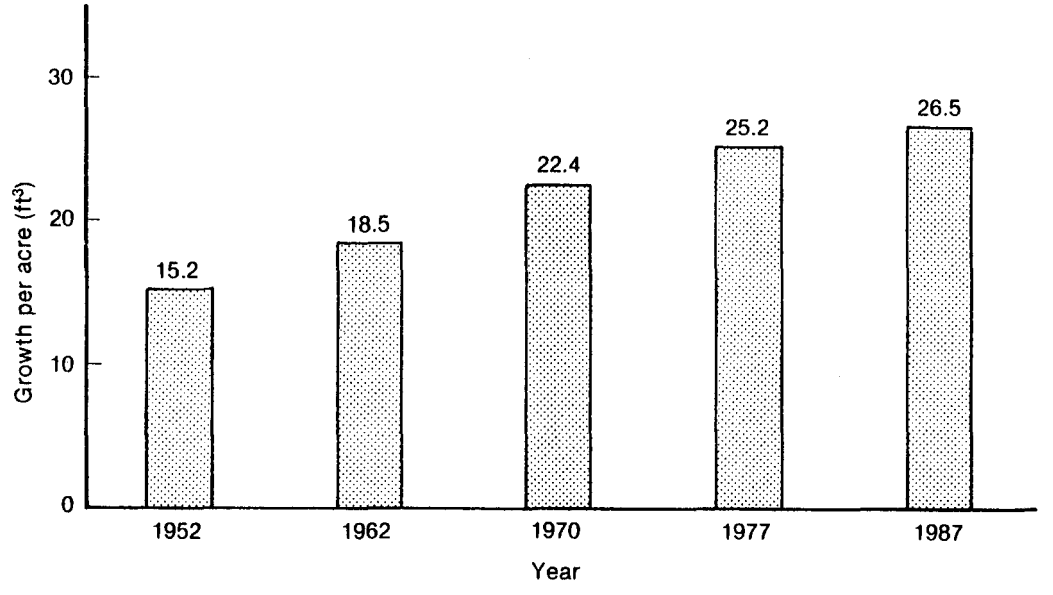

Figure 5–Softwood growth per acre for all regions and ownerships in the United States.

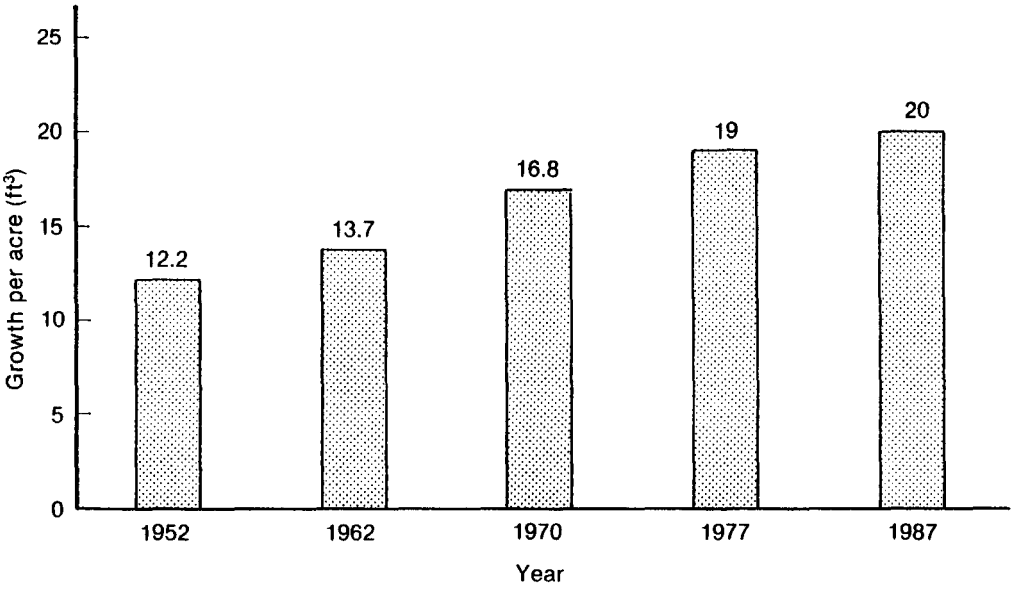

Figure 6–Hardwood growth per acre for all regions and ownerships in the United States.

growth/inventory index, although the removals/inventory index increased during the same period.

Regionally, the South and West experienced substantial productivity gains for softwoods, as indicated by the removals/inventory index, while the North experienced declines (Table 5). However, productivity, in terms of the growth/inventory index, for softwoods in the South has been relatively flat since 1952, and declined between 1977 and 1987, as the result of inadequate regeneration and increased timber mortality and cull trees (USDA Forest Service 1988). This pattern is the same for softwoods in the North.

Declines in forest productivity for hardwoods were experienced generally across all ownership groups and regions, as inventory rose more rapidly than growth and removals. However, some productivity gains for hardwoods have occurred in just the past decade as hardwood timber removals rose to higher levels in 1987.

In summary, these new indexes provide a tool for evaluating the performance of the United States timber resources over the past 35 years. The large data sets compiled from several forest resource inventories can now be more easily interpreted for significant productivity trends by ownership, geographic region, and major species group—softwoods and hardwoods. With this new insight into the performance of the timber resource, important management policy decisions may now be made with a more complete understanding of the existing resource and current major trends.

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