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Incidence and Impact of Damage to East Oklahoma's Timber, 1986

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SUMMARY

An average of 57.4 million cubic feet of timber was lost annually to mortality and cull from 1976 to 1986 in east Oklahoma's 4.75 million acres of commercial forest land, resulting in a monetary loss of $7.2 million per year. Hardwoods generally had more damage than softwoods, with upland hardwoods accounting for 63 percent of cull volume loss. Of the ownership classes, nonindustrial private forests sustained the most damage. Disease caused the greatest damage to the forests, but weather, stem and shoot borers, and inhibiting vegetation also contributed significantly to volume losses.

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INTRODUCTION

The periodic inventory of eastern Oklahoma's forests was conducted by the Forest Inventory and Analysis Unit (FIA) of the USDA Forest Service, Southern Forest Experiment Station, Starkville, MS, in 1986. In this survey, established forest plots measured during the previous inventory in 1976 were remeasured.

One of the many functions of the inventory is to provide information on the extent of tree damage and mortality in the State and the factors contributing to these losses in forest productivity. The authors utilized inventory results to summarize the percentage of and the average annual number of damaged and dead trees in eastern Oklahoma, and to estimate the associated volume and economic losses.

PROCEDURES

Sampling

The inventory procedures followed are outlined in "Forest Survey Inventory Work Plan, Texas/Oklahoma 1985" (USDA FS 1984). These sampling methods were designed to provide reliable Statewide estimates of forest area and volume for large groups of counties and for tree species with large total volumes. Consequently, there should be fewer sampling errors for major species such as loblolly pine than for minor species.

Before starting the inventory, field crews were trained in damage assessment by Forest Pest Management personnel from the Southern Region. During the inventory, the field crews recorded damaged (injured but still living) and dead trees and, when possible, identified the causal agents. Damaging agents and associated symptoms are described in the appendix. Cull volume loss associated with the damage was also estimated for each tree. Only trees at least 1 inch in diameter at breast height (d.b.h.) were tallied.

Because plots were visited only once, damaging agents that produce recognizable signs and symptoms year-round were more likely to be recorded than ephemeral damage such as hardwood defoliation, which cannot be detected in winter. Only the most damaging agent in terms of volume loss was recorded. Designation of causal agents was often hindered because the damage produced by factors such as root decay organisms is not easily identifiable, and because some agents cause rapid tree mortality, making determination of cause of death difficult. Damage or mortality that could be attributed to a particular causal group, but not to a specific agent, was placed in a more general category (i.e., other insects, other diseases).

These limitations lead to an understatement of the incidence and impact of damage to Oklahoma's timber. However, although tree deaths attributable to specific agents are underestimated, the mortality estimates are accurate, and the results should give forest managers the relative incidence of certain damaging agents and enable them to plan prevention and protection measures.

Data Analysis

Trees were grouped into the following size classes: saplings, 1.0 to 4.9 inches in d.b.h.; poletimber—softwoods, 5.0 to 8.9 inches in d.b.h. and hardwoods, 5.0 to 10.9 inches in d.b.h.; sawtimber-softwoods, 9.0 inches and larger in d.b.h. and hardwoods, 11.0 inches and larger in d.b.h. The tree data were also analyzed by management class: natural pine, planted pine, hardwood-pine, upland hardwood, and bottomland hardwood. Percentage of trees damaged was calculated for the three tree size classes within each management class, and the associated current cull volume was calculated for the poletimber and sawtimber classes. These data were further subdivided by the damaging agent or defect for the major species components in each management class. Only those agents causing at least 3 percent damage in one of the size classes in these subgroups were tabulated. All cubic volumes were computed using volume prediction equations derived from measurements of standing and felled trees in Oklahoma.

Damage ascribed to suppression and stagnation, form, and forking was omitted from our tables. These categories consistently had the most damaged trees,

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but the difficulty of drawing conclusions and planning prevention procedures from these data precipitated their exclusion in accordance with the stated purpose of thisbulletin.

Estimates of volume losses due to mortality and removal were calculated using all survey trees, including those in the above three categories, regardless of whether damage or death was attributed to a specific cause. These volume losses were derived from the 1986 and 1976 inventory data and then converted to average annual removal and mortality losses by dividing by the timespan between surveys for each inventory plot. Volume loss from tree removal was included for comparison with mortality volume loss.

Unlike mortality, which is assumed to have occurred between surveys, cull loss is often a cumulative volume, and incremental loss between survey periods cannot be estimated until two survey periods are compared. For Oklahoma, the methods used for the current and previous survey periods did not permit direct comparisons between the two surveys, so the results in this bulletin are based upon annual averages.

Economic Losses

Present values for losses were calculated using the average annual loss estimates for mortality and cull described previously. Professional foresters in the State were consulted to obtain estimates of the average age of trees at harvest for each ownership-management class combination. For trees in each age class, estimates of mortality and cull loss in thousands of cubic feet were converted to volume per acre and projected to a final rotation age using growth factors described in "The South's Fourth Forest: Alternatives for the Future" (USDA FS 1988). This process treated each age class as a group of acres in that class. Mortality was incorporated into each of the specific factors employed for age class, species, and ownership growth. Because these estimates cover large areas, estimation of volume growth may be quite variable. The authors assumed that overestimates of volume due to slow growth of trees in fully stocked stands were canceled out by underestimates of volume in trees of a particular age class in understocked stands.

If the age class for volume loss was greater than the estimated rotation age, no growth was calculated; the authors assumed that the damaged trees would be harvested immediately. The resulting future volumes at harvest were converted to thousand board feet (bf) and cords using divisor factors of 200 ft^3/1,000 bf and 90 ft^3/cord.

Average Statewide stumpage prices for the species in the year of the FIA survey were taken from Norris (1986) and increased from that year to 2030 by the real rates of increase for hardwood and softwood stumpage estimated in USDA Forest Service (1988). Further real increase in stumpage was assumed not to occur after 2030. The resulting future stumpage values were multiplied by the estimated harvest volumes at rotation age.

All ownership categories except forest industry were assumed to have a sawtimber product at rotation. For forest industry, a proportion of the softwood volume less than 25 years old was calculated as a cordwood product. The future value of trees in each class was discounted to the present (1986) at a 4 percent real rate of interest and by a time factor that was equal to the difference between the assumed rotation age and the age class. The authors assumed that there would be a market available for the lost timber, so the values of loss were calculated under the assumption that there would be no demand-supply adjustments in price.

Timber was considered to have value only in those areas where logging was economically feasible, and the analysis was restricted to exclude affected timber where the cost of logging might be extreme or prohibitive. Thus, expected volume loss is understated in all ownership categories because of the location restriction. Furthermore, the possibilities that mortality would increase the growth rate of residual stems or result in ingrowth were ignored.

RESULTS

Oklahoma had 4.75 million acres of commercial forest land in 1986 (table 1). Only 5 percent of this total was planted pine, with loblolly pine being the preferred species. Shortleaf pine was the predominant softwood in natural stands. Upland hardwoods accounted for over half the commercial forest area, and oaks were the major species components. Oak-gum-cypress and sugarberry-American elm-green ash were the primary species components in the bottomlands. Classified by stand size, 1.8 million acres were seedlings and saplings, with 1.66 and 1.29 million acres in poletimber and sawtimber, respectively. No understocked stands were reported.

Damage Losses

Percentage of trees damaged ranged from 31 to 85, with saplings generally having the highest rates and poletimber having the lowest (table 2). Hardwood volumes were higher than softwood volumes, and the percentage of trees damaged was generally higher for hardwoods. Softwoods had very little associated cull volume. Sawtimber had greater associated cull volumes than poletimber, and 63 percent of the cull volume for sawtimber was in the upland hardwoods.

Disease caused the greatest incidence of damage in the forest, and large percentages of sawtimber-sized trees were often affected (table 3). Most disease

damage could not be attributed to a specific agent, although fusiform rust was occasionally identified on loblolly pines. Feeding by shoot and stem borers was prevalent on hickory saplings and shortleaf pine poles, and damage from logging or other human activities was evident in pine stands. One hundred percent of the bottomland baldcypress poletimber and sawtimber was damaged: the poletimber by weather and the sawtimber by some type of disease.

A large volume of shortleaf pine had been harvested since the previous inventory (table 4). Some hardwood removal had occurred, particularly from the white oak-red oak-hickory species component in the uplands. Mortality losses were higher for hardwood types than for softwood types, and, in the bottomlands, mortality volumes exceeded removal volumes.

Economic Losses

From 1976 to 1986, the average annual loss to cull and mortality was 57.4 million cubic feet of timber (table 5). The estimated value of the loss was $7.2 million (in 1936 dollars) per year over the 9.8 year remeasurement period. Averaged over the State's 4.75 million acres of commercial timberland, the loss was about $1.52 per acre per year. About 75 percent of the volume and 50 percent of the present value loss occurred in nonindustrial private forests (fig. 1). Forest industry land sustained 10 percent of the volume loss and 27 percent of the present value loss.

Among management classes, losses were greatest in the upland hardwoods (fig. 2). These stands sustained 54 percent of the volume loss and 36 percent of the present value loss. Bottomland hardwoods accounted for about 29 percent of the volume loss and 21 percent of the present value loss. Significant losses also occurred for natural pines, representing 33 percent of the present value loss, but only 9 percent of the volume loss. Monetary losses due to cull were generally higher than losses. caused by mortality for hardwoods, whereas the reverse was true for softwoods (table 5).

Figures 3 through 6 illustrate losses by management class within each ownership category. Upland hardwoods in the nonindustrial private forests sustained the greatest percentage of volume loss across all ownership categories. Bottomland hardwoods on other public lands had slightly less than 60 percent of the volume loss in that ownership category. Natural pine had about 52 and 66 percent of the present value losses for the forest industry and the national forest ownership, respectively. Other significant present value losses occurred in upland hardwoods on nonindustrial private forests and in bottomland hardwoods on other public lands.

Table 1. -Area *of commercial forest land in east Oklahoma in 1986 by management class and species component*

Management class and species component	Area
	Thousands of acres
Planted pine	
Loblolly pine	218
Shortleaf pine	29
Total	247
Natural softwoods	
Loblolly pine	*39*
Shortleaf pine	664
Eastern redcedar	6
Total	709
Hardwood-pine	
Eastern redcedar-hardwood	*39*
Shortleaf pine–oak	*539*
Loblolly pine-hardwood	167
Total	745
Upland hardwoods	
Oak-hickory	355
Post oak-black oak-bear oak	744
White oak-red oak-hickory	1,433
White oak	12
Southern scrub oak	47
Mixed hardwoods	19
Total	2,610
Bottomland hardwoods	
Oak–gum–cypress	142
Sweetgum-nuttal oak-willow oak	18
Sugarberry-American elm-green ash	160
Overcup oak-water hickory	39
Cottonwood	17
Willow	11
Sycamore-pecan-American elm	50
Total	437
Grand total	4,747

Table 2. — *Number and volume of live trees, percentage of trees damaged, and associated cull by management class, species component, and tree size on all survey sites in east Oklahoma, 1986*

Management class and selected species components	Population	Volume	Percentage of trees damaged			Associated cull damage	
			Sapling	Poletimber	Sawtimber	Poletimber	Sawtimber
	Thousands	*Thousand cubic feet*				*Thousand cubic feet*	
Planted pine	149,608	.....*	50	31	36	88	665
Loblolly	91,465	36,812				0	130
Shortleaf	16,433	4,388				0	0
All hardwoods	41,710	3,702				88	535
Natural pine	611,226	.....	67	43	43	3,849	16,165
Loblolly	13,122	58,797				0	65
Other softwoods	8,479	2,879				0	12
All hardwoods	262,163	122,590				2,891	9,286
Hardwood-pine	485,566	....	67	51	52	5,466	15,910
Red oak	37,075	35,147				464	3,026
White oak	105,873	97,642				2,218	7,820
Hickory	50,436	22,538				1,553	694
Loblolly	16,579	14,385				0	113
Other softwoods	15,627	5,935				0	214
Other hardwoods	128,716	41,127				799	2,327
Upland hardwoods	1,435,759	.....	71	61	79	26,429	98,113
Red oak	161,348	366,725				6,617	36,553
White oak	357,907	473,465				7,678	37,645
Hickory	216,848	181,139				5,705	8,341
All softwoods	77,685	85,410				173	1,218
Other hardwoods	621,949	301,130				6,256	14,357
Bottomland hardwoods	193,331	.....	82	72	85	5,293	25,374
Bed oak	18,811	83,583				224	5,928
White oak	9,453	35,443				168	2,247
Ash	28,605	53,985				1,211	2,788
Sweetgum	2,190	7,831				0	805
Baldcypress	89	393				0	0
Cottonwood	10,093	41,663				34	994
Pecan	4,582	13,455				149	1,016
All other hardwoods	114,774	147,891				3,507	11,560
Total	**2,874,989**		*69*	56	64	41,125	156,228

*Not measured.

Table 3. -Incidence *of* damage ***by management class, host species, and tree size in east Oklahoma, 1986***

Management class, host species, and, damaging agent or defect	Trees damaged		
	Sapling	Poletimber	Sawtimber
Planted pine	..... *Percent*		
Loblolly			
Pusiform rust	1	1	7
Inhibiting vegetation	1	2	3
Shortleaf			
Terminal shoot and stem borers	0	14	0
Other diseases*	4	0	0
People	3	0	0
Logging damage	3	0	0
All hardwoods			
Other insects*	5	0	0
Other diseases	0	14	22
Inhibiting vegetation	3	18	0
People	0	0	13
Natural pine			
Loblolly			
Pusiform rust	0	3	2
Logging damage	6	4	3
All other softwoods			
Other diseases	0	0	17
All hardwoods			
Other diseases	2	7	31
Hardwood-pine			
Bed oak			
Other diseases	0	5	31
White oak			
Other diseases	1	9	30
Hickory			
Terminal shoot and stem borers	14	3	0
Other diseases	3	14	19
Basal defects	0	3	0
Branch stubs	0	0	4
Loblolly			
Terminal shoot and stem borers	4	0	0
Other diseases	0	0	5
Pusiform rust	4	6	0
All other softwoods			
Other diseases	0	0	12
Logging damage	4	0	0
All other hardwoods			
Other diseases	0	2	22
Upland hardwoods			
Red oak			
Other diseases	2	12	38
White oak			
Other diseases	2	6	33
Hickory			
Other diseases	2	10	23
Terminal shoot and stem borers	3	0	0
All softwoods			
Other diseases	1	0	5
All other hardwoods			
Other diseases	1	6	15

Table 3. -*Incidence of damage by management class, host species, and tree size in east Oklahoma, 1986 – Continued*

Management class, host species, and damaging agent or defect	Trees damaged		
	Sapling	Poletimber	Sawtimber
	..... *Percent*		
Bottomland hardwoods			
Red oak			
Other diseases	0	5	20
Other weather	4	11	1
White oak			
Other diseases	0	4	15
Inhibiting vegetation	0	3	0
Ash			
Other diseases	0	5	15
Fire	0	5	0
Beaver	0	5	9
Sweetgum			
Other diseases	0	0	13
Beaver	0	0	8
Baldcypress			
Other diseases	0	0	100
Other weather	0	100	0
Cottonwood			
Other diseases	0	6	2
Pecan			
Other diseases	0	0	35
All other hardwoods			
Other diseases	1	8	25

*Defined in appendix.

Table 4. -*Annual removals and mortality of poletimber and sawtimber by management class and species component in east Oklahoma, 1986*

Management class and species component	Annual removals		Annual mortality	
	Poletimber	Sawtimber	Poletimber	Sawtimber
	..... *Thousand cubic feet*			
Planted pine				
Loblolly pine	0	0	0	0
Shortleaf pine	0	0	55	0
Total	0	0	55	0
Natural softwoods				
Loblolly pine	781	1,467	149	217
Shortleaf pine	12,931	29,121	1,423	1,489
Eastern redcedar	0	0	0	0
Total	13,712	30,588	1,572	1,706
Hardwood-pine				
Eastern redcedar-hardwood	0	0	0	0
Shortleaf pine-oak	5,604	13,076	1,000	1,810
Loblolly pine-hardwood	0	0	0	0
Total	5,604	13,076	1,000	1,810
Upland hardwoods				
Oak-hickory	499	449	566	241
Post oak–black oak–bear oak	4,505	4,512	4,221	3,984
White oak-red oak-hickory	5,819	11,702	4,369	6,383
White oak	515	643	37	105
Southern scrub oak	252	133	498	177
Mixed hardwoods	0	0	0	0
Total	11,590	17,439	9,691	10,890

Table 4. -Annual removals and mortality ofpoletimber and sawtimber by management class and species component in east Oklahoma, 1986 – Continued

Management class and species component	Annual removals		Annual mortality	
	Poletimber	Sawtimber	Poletimber	Sawtimber
	Thousand cubic feet			
Bottomland hardwoods				
Oak-gum-cypress	505	1,843	501	1,252
Sweetgum-nuttaloak-willow oak	580	3,088	71	29
Sugarberry-American elm–greenash	522	1,413	1,701	5,704
Overcup oak-water hickory	0	0	388	485
Cottonwood	0	0	308	472
Willow	638	784	0	0
Sycamore-pecan-American elm	41	1,157	784	1,495
Total	2,286	8,285	3,753	9,437

Table 5. -*Average annual volume* and value *(in 1986 dollars) of timber damaged or killed on loggable sites, by ownership and management class, in east Oklahoma, 1976-86*

Ownership and management class	Average annual volume	Average annual value		
		Mortality	Cull	Total
	Thousand cubic feet	*1986 Dollars*		
Natural forest				
Planted pine	51	0	25,743	25,743
Natural pine	802	191,970	112,491	304,461
Hardwood-pine	421	7,524	27,719	35,243
Upland hardwoods	1,230	37,921	48,889	86,810
Bottomland hardwoods	123	0	7,447	7,447
Total	2,627	237,415	222,289	459,704
Other public				
Planted pine	0	0	0	0
Natural pine	180	33,630	106,738	140,368
Hardwood-pine	178	7,134	17,395	24,529
Upland hardwoods	1,806	149,677	205,741	355,418
Bottomland hardwoods	3,031	392,660	216,863	609,523
Total	5,195	583,101	546,737	1,129,838
Nonindustrial private				
Planted pine	68	14,237	4,016	18,253
Natural pine	1,841	408,617	434,075	842,692
Hardwood-pine	2,662	74,591	112,996	187,587
Upland hardwoods	25,780	718,962	1,064,899	1,783,861
Bottomland hardwoods	11,984	486,690	257,163	743,853
Total	42,335	1,703,097	1,873,149	3,576,246
Forest industry				
Planted pine	12	0	67,529	67,529
Natural pine	2,178	738,156	337,577	1,075,733
Hardwood-pine	1,606	196,796	137,449	334,245
Upland hardwoods	2,317	262,485	151,464	413,949
Bottomland hardwoods	1,174	118,429	54,806	173,235
Total	7,287	1,315,866	748,825	2,064,691
All ownerships				
Planted pine	131	14,237	97,288	111,525
Natural pine	5,001	1,372,373	990,881	2,363,254
Hardwood-pine	4,867	248,045	295,559	581,604
Upland hardwoods	31,133	1,169,045	1,470,993	2,640,038
Bottomland hardwoods	16,312	997,779	536,279	1,534,058
Grand total	57,444	3,839,479	3,391,000	7,230,479

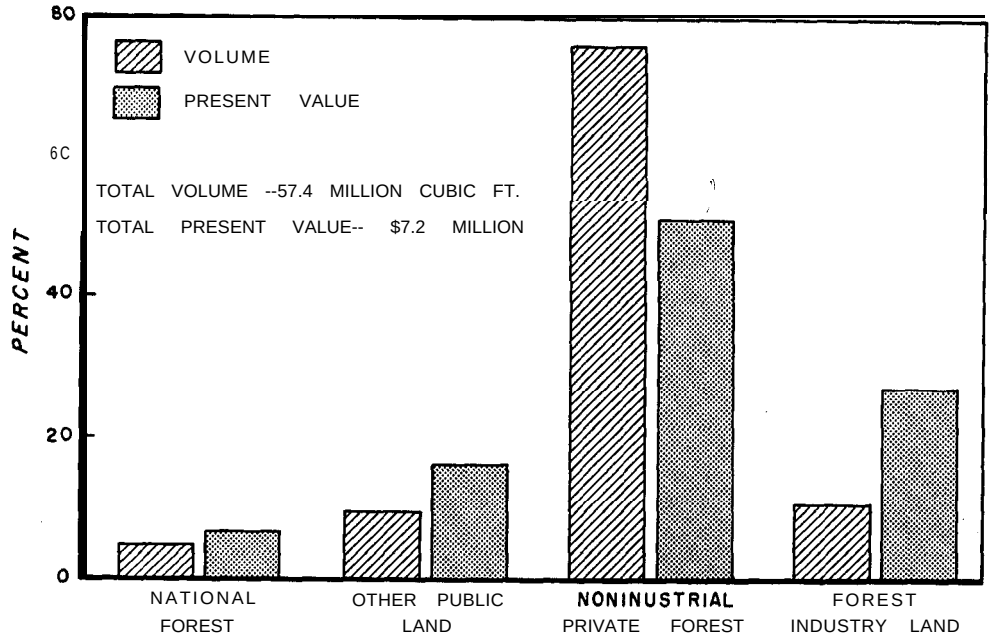


Figure 1. *-Percentage of total annual affected volume* and *present* value *of loss in 1986 dollars, by ownership, in east Oklahoma, 1976-86.*

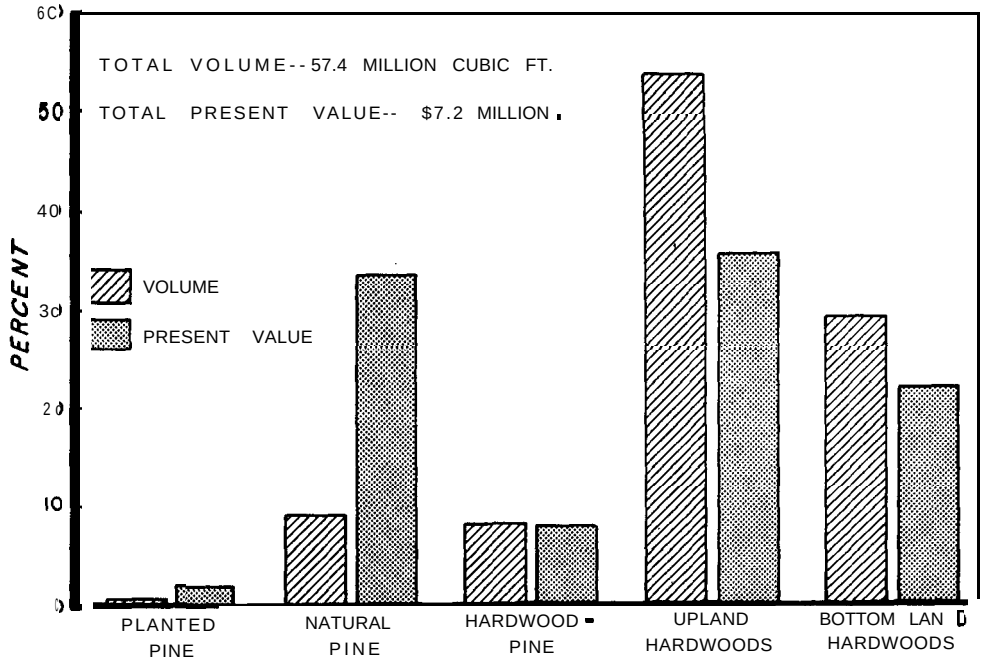
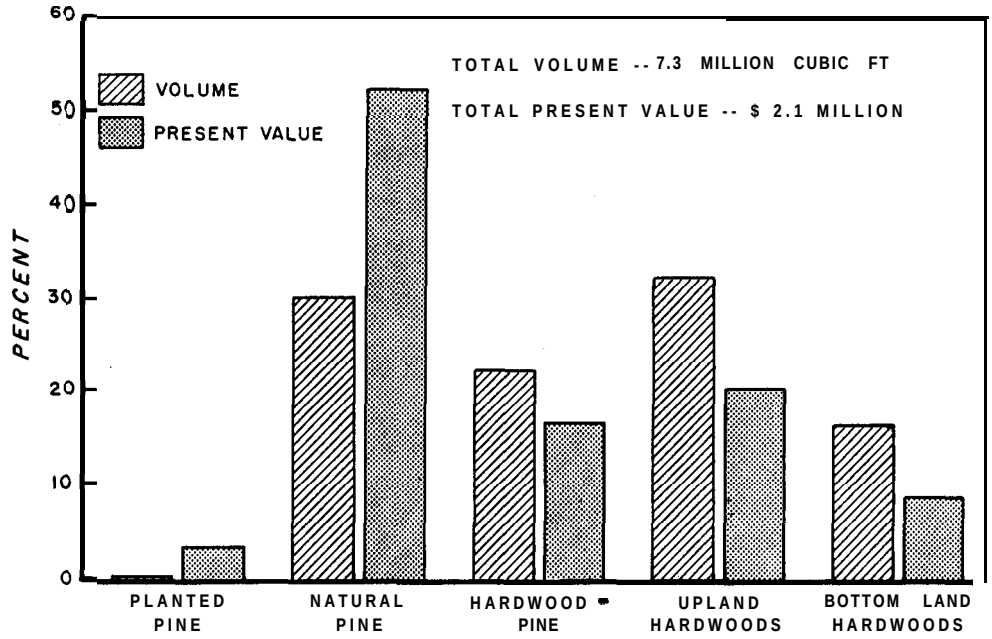


Figure 2. -Percentage of total annual affected volume and present value of loss in 1986 dollars, by management class, in east Oklahoma, 197686.



of total annual affected volume and present value of loss in 1986 dollars on forest industry lands by management class, in east Oklahoma, 1976-86.

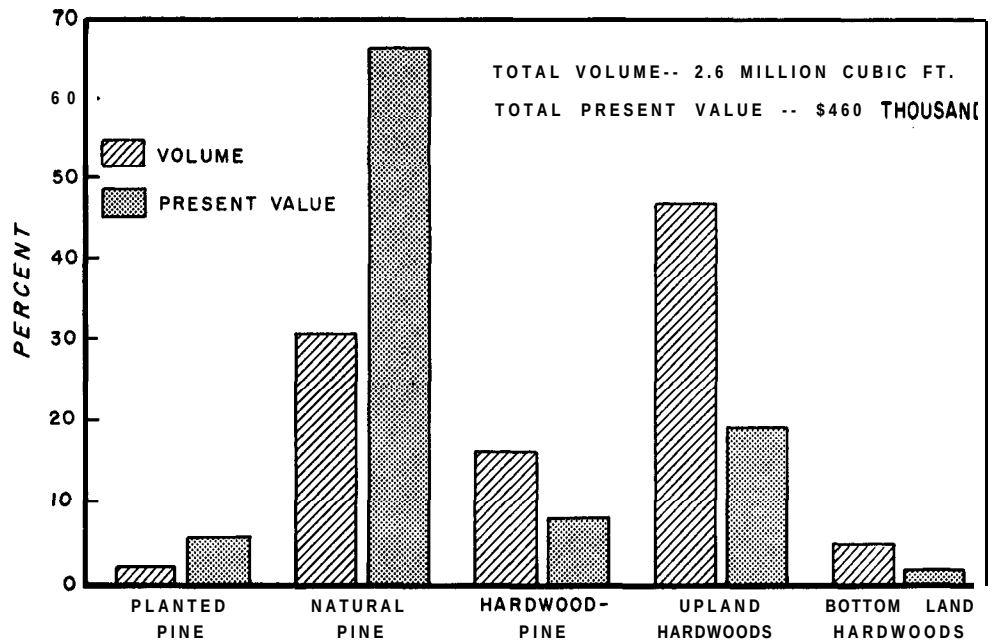
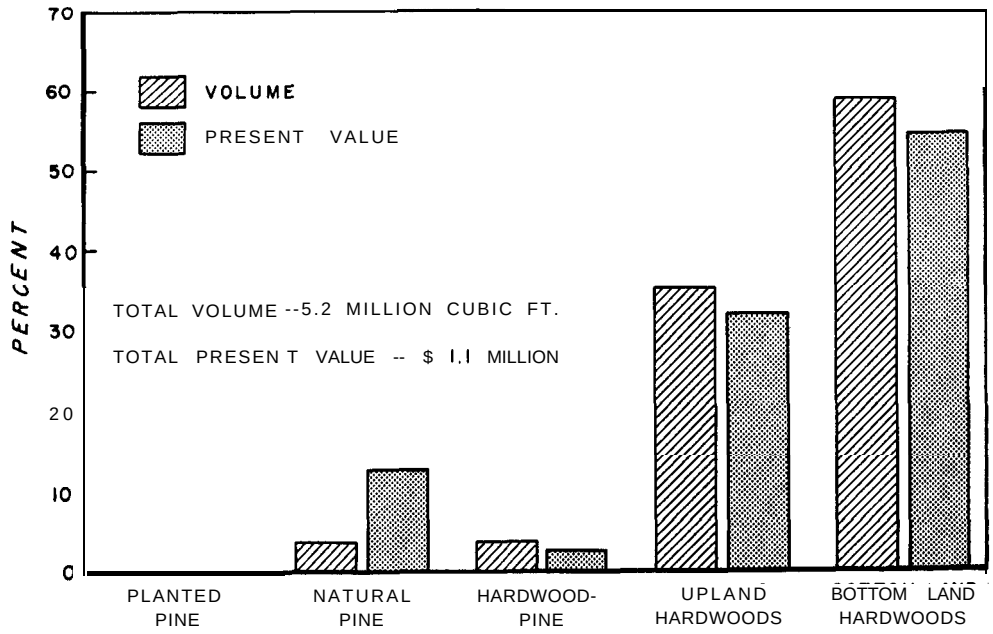


Figure 4. - Percentage of total annual affected volume and present value of loss in 1986 dollars on National Forests, by management class in east Oklahoma, 1976-86.



dollars on other public lands, by management class, in east Oklahoma, 1976-86.

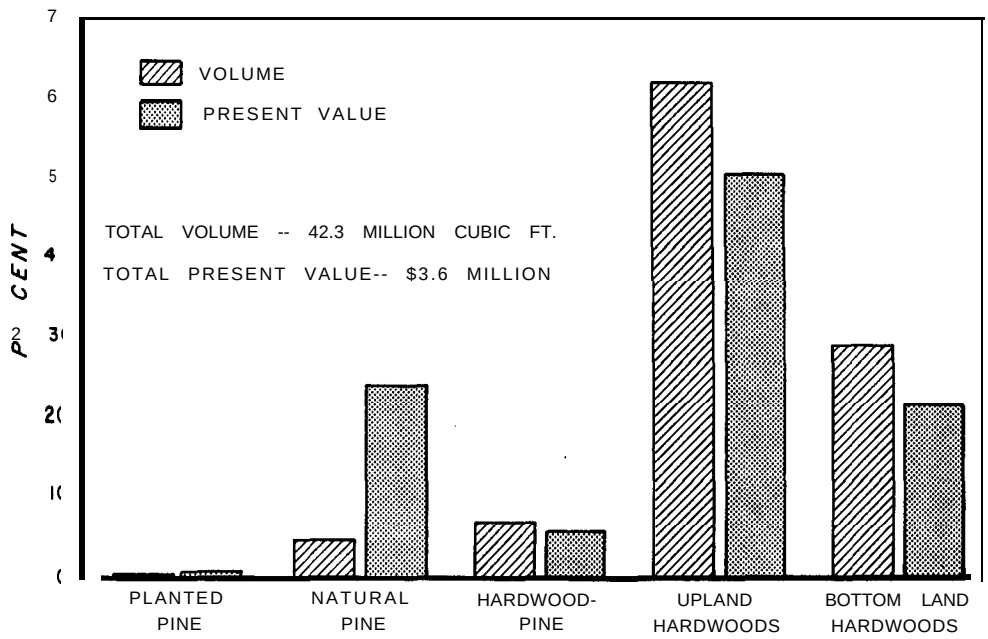


Figure *6.-Percentage of total annual affected volume and present value of loss in 1985 dollars on nonindustrial private forests, by management class, in east Oklahoma, 1976-86.*

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Appendix: — Damaging Agents, Species Affected, and Indicator Symptoms

Animals

Animals-All tree species: branches clipped off or broken, bark removed, holes in stems, tears and toothmarks in the wood.

Beaver-All tree species: toothmarks and bark removed from bole. Trees are flooded.

Sapsucker — All tree species: horizontal rows of small holes encircling tree bole. Bark below hole usually streaked or stained by oozing sap.

Diseases

Fusiform rust-Slash, loblolly, pitch, pond, and shortleaf pines: spindle-shaped galls on stems or branches. Older galls appear as cankers with sunken centers surrounded by a callus ridge. Witches-broom is common at the galls. The fungi produce bright orange spores in the spring. All stem cankers and only branch cankers occurring within 12 inches of the bole are reported.

Hardwood cankers -All hardwoods: dead sunken areas on stem, frequently surrounded by callus ridges.

Littleleaf disease--Primarily shortleaf pine, some loblolly pines: yellow needles, reduced shoot growth, and large stress crops of undersized cones. Usually occurs on heavy soils with poor internal drainage. Affected trees exist in groups.

Pitch canker-Primarily slash, loblolly, and shortleaf pines, but also Virginia, longleaf, eastern white, Scotch, Table Mountain, and pitch pines: flagging at branch ends, pitch flow from affected area, slight swelling of stems and twigs. Crooks in main stems and wilting of new shoots are common. Slight bark depression may occur in early stages.

Root rots-All tree species: groups of dead or windthrown trees. Tufted, thin, yellowing crowns. Conks (fruiting bodies) of fungi may be present at or near base of diseased trees. Usually in stressed trees or those with butt or root injury.

Other diseases -All tree species: all disease damage not separately identified. Includes red heart of pine, brown spot, and leaf diseases.

Growth Defects

Basal ***defects-All*** tree species: butt swelling, curls, V-shaped stump sprouts, frost seams, and low stubs below breast height. Conks of decay fungi often associated with defect.

Branch stubs -All tree species: branch holes or stubs greater than 4 inches in diameter on stem (trees 5.0 inches in d.b.h. and larger). Branch holes or stubs greater than 1 inch in diameter on stem (trees 1.0 to 4.9 inches in d.b.h.).

Dieback-All hardwoods: tips of branches die initially, entire branches die in advanced stages.

Forking-All tree species: forks formed by natural causes or by unknown agents. Applicable only if fork is in butt log or potential log and no other serious damage is present.

Form-All tree species: all trees with form damage that could not be classified in one of the other categories.

Inhibiting vegetation -All tree species: vines causing suppression or strangulation. Tree class affected.

Suppression and stagnation-All tree species: characterized by poor form. Suppressed trees with small crowns are overtopped and receive indirect sunlight,

Stagnated trees have thin foliage and receive some direct sun. Associated with overstocking or poor growingsites.

Human Activities

Logging damage- All tree species: logging scars on stems, callus ridges appear 1 to 2 years after wounding. Limb breakage and/or stem scar near crown caused by felling of nearby trees. Skid trails, stumps, etc., in general area.

People -All tree species: initials carved in bark, nails in tree, lantern burns, ax marks, wires around stem, stripped bark, callused roots, etc.

Turpentining – Longleaf, slash, and loblolly pines: exposed wood in V-shaped wounds with heavy pitch flow.

Insects

Bark beetles --All pines: yellow, cream, or pink resin globs resembling popcorn on bark surface. Tunnels or egg galleries may be present on inner bark or the sapwood surface. Streaks caused by blue stain fungi often present on sapwood. Foliage gradually yellows and then reddens as infestation progresses.

Hardwood borers -All hardwoods: initially cause dark sap spot on bark surface (often mixed with frass). Eventually, coarse boring particles appear in bark cracks and crevices beneath point of attack. Old damage appears as knobby overgrowths or scars on barksurface.

Terminal shoot and stem borers-All tree species: fresh attacks have boring dust and frass at entrance holes, located most often at base of leaf petioles and buds. White to pinkish globs of resin may appear at attack points. Shoots turn yellow, then red, and finally brown. Terminal or branch dieback may result.

Other insects -All tree species: all insect damage not separately identified. Includes pine defoliators such as the redheaded pine sawfly and hardwood defoliators.

Natural Phenomena

Fire – All tree species: fire scars at base of stem. Signs of charring may be present on stem. Damage usually on uphill side of trees.

Flooding- All tree species: high water and silt marks on tree boles. Yellowing and/or curling downward of leaves, premature leaf fall, branch or top dieback.

Lightning -All tree species: bark stripping or cracks running spirally or straight from strike point to ground. Tops faded from root damage or top breakage. May subsequently be attacked by bark beetles.

Other weather-All tree species: windthrow, ice, frost crack (above breast height), broken tops, broken branches, marginal leaf burn, and winter burn.

Clarke, Stephen; Redmond, Clair; May, Dennis; Starkey, Dale. 1994. Incidence and impact of damage to east Oklahoma's timber, 1986. Resour. Bull. SO-186. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 12 p.

Data on timber damage detected during a 1986 survey of east Oklahoma's forests are presented and discussed.

Keywords: Economic timber losses, forest diseases, forest insects, forest inventory analysis.

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