2.18
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Sec. 2.7.1
Reference 2
also Section 4.1
reference 2

REFERENCE 2-18

ORNL/TM-5833

Forest Management Plan, ERDA Oak Ridge Reservation: 1976-1980

D. M. Bradburn

ENVIRONMENTAL SCIENCES DIVISION
Publication No. 1056

OAK RIDGE NATIONAL LABORATORY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy $4.50; Microfiche $3.00

ORNL/TM-5833

Contract No. W-7405-eng-26

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Date Published: June 1977

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

ABSTRACT

BRADBURN, D. M. 1977. Forest Management Plan, ERDA Oak Ridge Reservation: 1976-1980. ORNL/TM-5833. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 64 pp.

The ERDA Oak Ridge Reservation Forest Management Plan is utilized as a guide in the managing and administering of the natural resources of the forest. A revised management plan summarizes the goals and accomplishment of the previous plan while recommending necessary improvements and alternatives for the ensuing management cycle. The management plan contains programmatic assessments of silvicultural activities and their environmental impacts.

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INTRODUCTION

The forest management program on the ERDA Reservation (formerly the AEC Reservation) has completed two five-year management cycles with this being the second revision of the original management plan written in 1965. Initial efforts to establish a forest management program on the ERDA Reservation were begun in 1964. Summarization of these efforts was presented in the 1965 Forest Management Plan (Curlin, 1965) and continued in the 1970 revision (Strock, 1970). The management plan is a flexible guide describing the resources of a forest and used as a program in the treatment and management of these resources.

Periodic revisions of the management plan are needed to update practices and instigate new techniques to meet overall objectives. Revisions are normally made at five-year intervals (called a management cycle) and since another management cycle has elapsed during which time numerous changes have occurred, another revision is in order.

FOREST MANAGEMENT AT OAK RIDGE

History of Management at Oak Ridge

The Oak Ridge Reservation was formed from numerous small private farms in the early 1940s leaving no written history of the forest prior to 1942. After acquisition of the original 58,800-acre reservation in 1942, the Department of the Army requested that TVA provide them a confidential estimate of the amount of structural lumber that

could be logged from the area. Since this estimate was confidential there were no records as to the amount of timber harvested for the construction of the Oak Ridge facilities. Other than this timber cut for the construction of Oak Ridge, the forest was undisturbed until 1947 (Curlin, 1965).

In 1947 a reforestation program was instigated by Management Services Incorporated (MSI), an Atomic Energy Commission (AEC) contractor then responsible for operation of the City of Oak Ridge. A total of 9 million pine seedlings had been planted in old fields and open areas comprising a total of approximately 4300 acres by the termination of MSI's program in 1960. Species planted in these plantations in order of acreages were shortleaf pine (Pinus echinata) 40%, loblolly pine (Pinus taeda) 30%, eastern white pine (Pinus strobus) 20%, and Virginia pine (Pinus virginia) 10%.

A timber inventory of the Reservation forest using the Continuous Forest Inventory (CFI) system was made by TVA in 1961, and a prospectus was compiled for the AEC summarizing the timber resources and outlining the potential benefits of a forest management program. A forest management program was instituted at the Oak Ridge National Laboratory in 1964 as a result of this prospectus. The first management plan for the Reservation forest was prepared in 1965 to formulate long-range objectives and short-range plans for the period 1965-1970. A revision of this plan was made in 1970 for the 1970-1975 period. The forestry plan and program is administered by the Forest Management Department of the Environmental Sciences Division of the Oak Ridge National Laboratory.

Management Objectives

The objectives of the forest management program on the Oak Ridge Reservation incorporate the multiple-use concept of good forest management. The two-fold objectives include an ecological park for research studies and the production of high-quality timber products through intensive forest management and sound conservation practices. Due to the primary objectives of ERDA's production programs and environmental research, ours is a multiple-use approach designed to yield valuable products - plant production sites with buffers, long-range environmental research, and high-quality, high-value timber products.

Timber Harvest

After initial logging for construction purposes in the early 1940s, no further timber was harvested until 1952. From 1952 to 1956, 2.7 million board feet of sawtimber and 134 cords of pulpwood were sold for $55,835 (Table 1). No timber was cut between 1956 and 1964 at which time the first forest management activities were initiated.

Due to the occurrence of a widespread epidemic of southern pine beetles (Dendroctonus frontalis) and a sluggish timber market, the allowable cutting goal of 1.5 million board feet of sawtimber per year was not achieved. Sawtimber sales over the first five-year management cycle totalled only 4.3 million board feet or 0.86 million board feet per year. Thinnings in the 4300 acres of pine plantations progressed as planned with approximately 2000 acres yielding 10,544 cords of pine pulpwood. The sale of timber harvested from the ERDA

Table 1. Timber harvest since 1964 on the ERDA Reservation

Period	Standard cord[a]	Million board feet[b]	Total value ($)
1942-1947	Unknown	Unknown	Unknown
1947-1952	None	None	None
1952-1956	134	2.7	55,835
1956-1964	None	None	None
1964-1970	26,499[c]	4.3	175,928
1970-1975	14,145[c]	6.8	234,216
Total	40,778	13.8	465,979

[a]128 cubic feet.

[b]International 1/4-inch rule.

[c]Includes beetle-infested timber.

Reservation during the first five-year management period totalled $175,928 (Table 1).

In order to entice an integrated wood utilization industry into the Oak Ridge area, the AEC, along with the Tennessee Valley Authority, City of Norris, and Emory River Land Company, entered into a ten-year timber contract with Longleaf Industries, Inc., in 1969. A volume of timber equal to the allowable cut of 1.5 million board feet a year was offered by the AEC under this contract consisting of 12.4 million board feet of hardwood and 2.6 million board feet of pine sawtimber. Due to erratic mill operation and an unpredictable lumber market only 7.7 million board feet of pine and hardwood sawtimber was harvested from 1970 through 1975, 1.3 million board feet below the anticipated volume. Total value of this 7.7 million board feet of timber was $183,496.

Analysis of the original inventory data available when the program began in 1964 indicated the reservation could sustain an annual harvest of 1.5 million board feet from the 32,696 forested acres of the ERDA Reservation. Such a harvest would stimulate timber growth, while improving the quality of the growing stock during the rotation period.

With the exception of approximately 500 acres of small diameter shortleaf and loblolly pine, all of the merchantable plantations on the Reservation had been thinned at least once by the end of 1973. Thinning of pine plantations ceased during the latter part of 1973 due to another serious outbreak of the southern pine beetle. Control efforts beginning in 1973 caused a sharp increase in the harvesting of pine pulpwood and has continued through 1975. In 1975 alone,

4800 cords of damaged pine timber were salvaged. The annual revenue values in Table 2 are based on a calendar year. Average annual income for the five-year period 1971-1975 was $61,000[1] with a total for this five-year period of $234 216 (Table 2).

Land-Use Allocation

The Energy Reorganization Act of 1974 abolished the Atomic Energy Commission (AEC) and in its place established the Energy Research and Development Administration (ERDA). ERDA's responsibilities involve energy research and development to pursue solutions to the nation's problems involving all energy sources. An indepth analysis of available land resources required to accomplish ERDA's programmatic objectives at Oak Ridge, Tennessee was completed in 1975. This study, Oak Ridge Reservation Land-Use Plan (ORO-748, 1975), establishes a long-range land-use plan for present and projected program requirements incorporating the ecological concept that recognizes the multiple-use approach to forest land utilization. Good forest management embraces the multiple-use aspect of land management. Application of this principle was one of the primary objectives when the forest management program was initiated in 1964 on the Oak Ridge Reservation, and continues as a central guide to program development.

There are presently five separate plants located within the ERDA Reservation. Four of these plants operated by Union Carbide Corporation include ORNL (X-10), the Y-12 Plant, ORGDP (K-25), and the Experimental

---

[1]See Insect and Disease Section for additional income.

Table 2. Timber products and market values from 1971 to 1975

Period	Standard cords[a]	Dollar value	Cedar sawtimber (bd. ft)[b]	Dollar value	Longleaf sawtimber (MMBF)[c]	Dollar value	Total dollar value
1971	1,605	7,561	37,296	1,426	1.2	23,036	32,022
1972	1,776	8,588	42,197	1,477	2.5	54,347	64,412
1973	2,920	11,784	56,926	1,744	1.0	23,538	37,066
1974	3,163	14,109	193,738	3,532	-	-	17,641
1975	4,781	20,089	-	982[d]	2.1	62,003	83,074
Total	14,145	62,131	330,157	9,161	6.8	162,924	234,216[e]

[a]128 cubic feet.

[b]International 1/4-inch rule.

[c]Million board feet.

[d]Comprised of fence post and firewood sales revenue.

[e]Does not include $81,147 in Southern Pine Beetle control funds from the USFS.

Gas-Cooled Reactor Site. The latter site structure has been converted to offices for staff conducting studies on the Liquid Metal Fast Breeder Reactor. The Comparative Animal Research Laboratory is a fifth plant site operated by the University of Tennessee Agriculture Research Department (UT-ERDA).

Buffer zones are located around these plant sites allowing for special uses and future plant expansion. Forested lands in these areas are categorized as alternate compartments due to limited forest activities in these areas, since plant needs take priority. New plant construction planned for the future includes the Clinch River Breeder Reactor to be built on the TVA Industrial Site and the EXXON Nuclear Fuel Recovery and Recycling Center to be located in compartments #8 and #9. Buffer zones needed around any future plants will be designated as alternate compartments when necessary.

Establishment of the Energy Research and Development Administration has necessitated reassessment of the Oak Ridge Reservation programs under the multiple-use concept. Compatibility of environmental research and technological operations will subsist on a mutually inclusive basis. All acreage on the ERDA Reservation is under primary land management regardless of its designated specific use. Therefore, it is proper to account for all acreages in a management plan when considering multi-disciplinary responsibilities. Previously the management plan has treated the Reservation in segments allocated to different uses. In reality, nearly every acre is subject to a myriad of simultaneous uses.

Therefore, under this plan the Oak Ridge Reservation will be treated as a single entity incorporating multiple uses regulated by

priorities. Forest management is a descriptive term applied by land managers to all forested lands to denote controlled use whether it is research, timber production, plant buffer areas, game preserves, recreation, etc.

Total acreage in the ERDA Reservation is 36,993 of which approximately 26,727 is forested. Primary plant areas with the exception of ORNL and ORGDP are devoid of forest. Programmatic lands (1066 acres) assigned to CARL are primarily pasture with some enclosed woodlots utilized by CARL for animal shelters, thereby serving dual purposes. The 26,727 forested acres will be managed either intensively or extensively while ensuring compatibility with the research program and the requirements of the primary user (Table 3).

TIMBER RESOURCES

Timber Inventory

Timber volume growth estimates were calculated in 1965 by using the 1961 TVA Continuous Forest Inventory (CFI) data. These inventory data were the basis for the original management plan, since no formal inventory was conducted on the Reservation in 1965. A reinventory using temporarily installed CFI plots was made during the summer of 1970 to update timber resource inventory data needed for the first management plan revision. For a more comprehensive comparison of data and growth estimates the original TVA CFI plots were reinventoried in 1975.

Forest management personnel remeasured during the summer of 1975 207 of the original 226 TVA CFI plots located throughout the Oak

Table 3. Administrative units in 1975

Description	Total area (acres)	Forested area (acres)
Research and Management	32,379	26,517
ORNL, Inner Plant Complex[a]	920	10
Y-12, Inner Plant Complex	850	--
ORGDP, Inner Plant Complex[a]	1,740	--
EGCR, Inner Plant Complex	38	--
CARL, UT-AEC	1,066	200
Total	36,993	26,727

[a]Primary plant complexes within fenced areas.

Ridge Reservation with the exception of compartments #1 and #4. All but three of the original plots were located and remeasured. The other 16 plots were lost due to new construction, Melton Hill Lake impoundment or new powerline rights-of-way installed since the initial inventory. Volume determinations were calculated from formulae correlated with Girard Form Class volume tables (Girard and Mesarage, 1956) using a revised computer program with tree diameter (dbh) and merchantable height as the basic computation parameters.

Growing Stock

Initial sawtimber volume on the 26,727 forested acres of the ERDA Reservation was 62.9 million board feet as computed by the 1961 TVA inventory. Using estimated growth rates, the sawtimber volume for 1965 was projected to be 81 million board feet. Due to the difficulty encountered in 1971 in locating the original TVA CFI plots and volume computation program, a temporary inventory system (Strock, 1970) similar to the CFI method was employed to arrive at the 93.6 million board feet volume (Table 4).

The 1975 reinventory of the original CFI plots estimated the sawtimber volume to be 126.9 million board feet. Approximately one-third (30%) of this volume is southern yellow pine, one-seventh is white oak (Quercus alba), with yellow poplar (Liriodendron tulipifera), chestnut oak (Quercus prinus), and red oaks (Quercus sp.) comprising one-tenth each while the remainder of the volume consists of miscellaneous hardwoods such as gums (Nyssa and Liquidamber sp.), sycamore (Platanus occidentalis), maple (Acer sp.), hickory (Carya sp.), and beech

Table 4. Comparison of 1975 reinventory with previous inventories (International 1/4-inch log rule)

Administrative unit	Total area (acres)	Forested area (acres)	Sawtimber volume MBF			
			1961 inventory	1965 projection	1970 inventory	1975 inventory
Research & management	32,372	26,517	62,405	80,362	92,864	126,990
ORNL (X-10)	920	10	24	31	36	47
Y-12	850	—	—	—	—	—
ORGDP (K-25)	1,740	—	—	—	—	—
EGCR	45	—	—	—	—	—
CARL, UT-ERDA	1,066	200	471	607	700	958
Total	36,993	26,727	62,900	81,000	93,600	127,995

(Fagus grandifolia). Over one-half of the total sawtimber volume is in hardwood tree grades 1 and 2 or southern yellow pine tree grade A.

The average annual growth rate including ingrowth into the sawtimber classification (9 inches dbh for pine and 11 inches dbh for hardwoods) for the 26,727 forested acres has been approximately 6.5% from 1961 to 1975. Growth has accrued at the rate of 4.1 million board feet annually or 184 board feet per acre per year from 1961 to 1975. Estimates based on the 1970 and 1975 inventories indicate an accelerated growth rate during this period of 6.5 million board feet annually or 257 board feet per acre per year of which 41% or 105 board feet per acre per year is ingrowth. An average acre in 1975 contained 4,789 board feet as compared with an average of 3,200 board feet per acre in 1970.

Resource Evaluation

Forest management practices during the previous five-year management cycle have necessitated a more intensive resource evaluation system. A new inventory and mapping system was devised in 1974 to describe the forest by timber stands within each compartment. The forest compartment system was revised to adjust for previously unaccounted-for acreage, reduce oversize compartments, and take advantage of physical features for compartmental boundary lines. This revision contains 28 management compartments, 7 alternate compartments (alternate compartments are so designated due to specific management restrictions) and three primary plant areas totalling 36,993 acres (Table 5). Compartment sizes range from 411 acres to 2,365 acres with primary plant areas ranging from 348 acres to 954 acres.

Table 5. Forest acreage by compartments

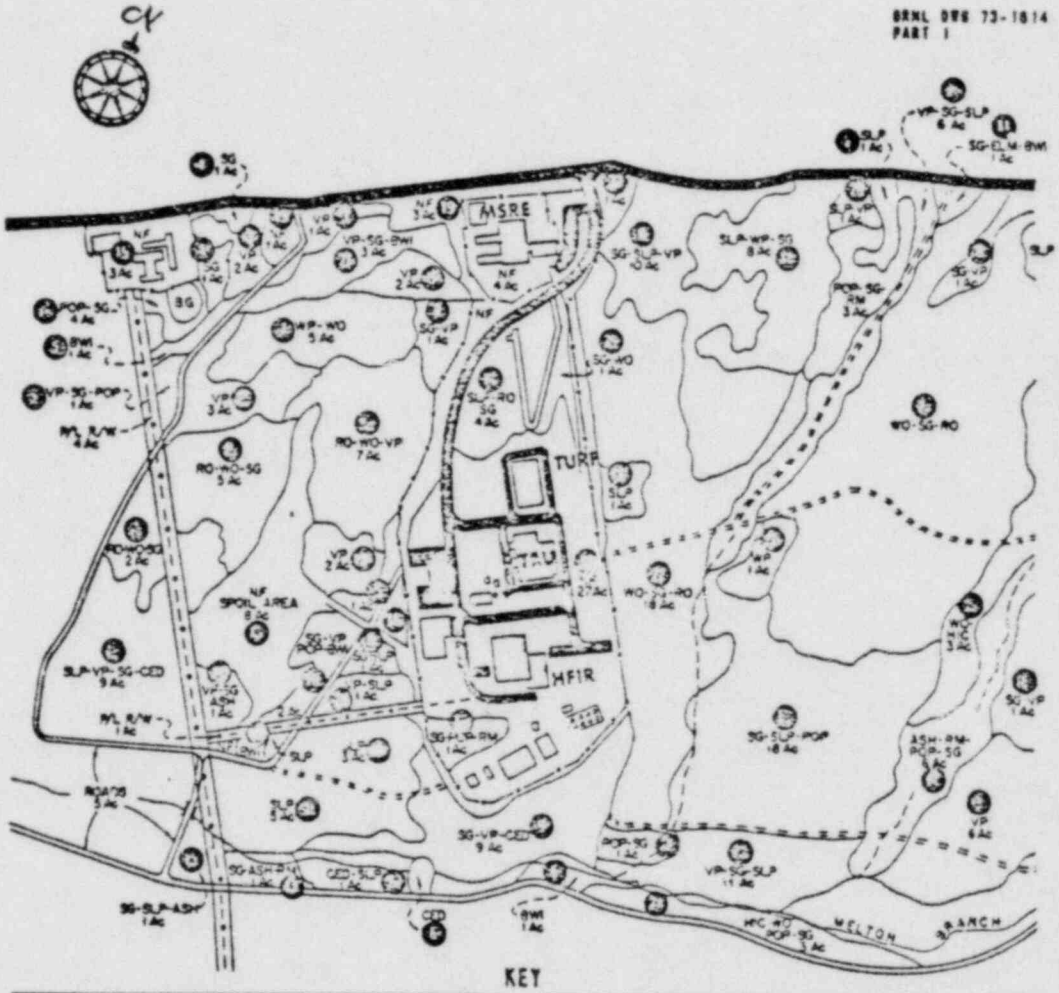
Compartment number	Acres 1970	Revised number of acres 1975	
1	1012	1447	
2	761	787	
3	993	1026	
4	1335	1535	
5	814	922	
6	719	808	
7	767	713	
8	592	627	
9	595	629	
10	2117	898	
11	1106	1109	
12	1066	1103	
13	1134	1215	
14	615	564	
15	1298	1304	
16	696	717	
17	957	1006	
18	818	789	
19	861	1032	
20	831	861	
21	737	815	
22	428	564	
23	1181	1187	
24	903	961	
25	1713	1727	
26	659	682	
27	785	810	27,071
28		1233	
Alt. no. 1 (TSF)		2278	
Alt. no. 2		1641	
Alt. no. 3		862	
Alt. no. 4		757	
Alt. no. 5		1201	
Alt. no. 6		449	
Alt. no. 7		601	
K-25		954	
Y-12		831	
X-10		348	
35 (29 compartments)		36,993 acres	

Under the newly implemented inventory system each compartment is timber-type mapped by individual timber stand. Each stand is then designated within each compartment by a stratum number, dominant and codominant species, and acreage. Stratum areas are summarized in a key by species and total acreage (Fig. 1). Each compartment will be reinventoried and the type map revised during each management period. Therefore, the annual mapping and cruising requirement will be seven compartments based on the five-year cycle.

All sawtimber sales offered on the ERDA Oak Ridge Reservation are computed from volumes based on Girard form class volume tables, International 1/4 Rule (Girard and Mesauage, 1956). It is therefore appropriate to devise an inventory system from which equivalent volumes may be derived coincident with the individually typed timber stands. The new sampling procedure employed involves type mapping and cruising the compartment simultaneously using the Point Sampling, Probability Proportional to size (PPS), cruising technique. Field tallies are separated on merchantability basis into three categories: unmerchantable planted stands, merchantable planted stands, and natural stands. The merchantable stands are tallied for both pulpwood and sawtimber volumes.

Volume determinations are made (through computer programming) using diameter at breast height (D 4.5 ft) and merchantable height (H) in the form of (D^2H). Regression constants fitted to Girard volume tables adjust the final stand volumes by form classes for individual tree species. Resulting volume tables summarize volumes and number of trees by diameter classes and merchantable heights. Thus stand

FIG. 1. SAMPLE COMPARTMENT



KEY

STRA #	VEGETATION TYPE	ACRES
1	WP (WHITE PINE)	1
2	SLP (SHORTLEAF PINE)	10
3	VP (VIRGINIA PINE)	19
4	SG (SWEETGUM)	2
5	BWI (BLACK WILLOW)	3
6	CED, CED-SLP (CEDAR)	1
7	WP-WO (WHITE OAK)	5
8	SG-VP, SG-SLP, SG-SLP-VP	15
9	SG-VP-CED	9
10	SG-SLP-POP, SG-VP-POP-BWI	20
11	SG-ELM-BWI	1
12	SG-POP-RM (RED MAPLE)	1
13	SG-SLP-ASH	1
14	SG-ASH-RM	1
15	SLP-WP-SG	8
16	YP-SG-POP (YELLOW POPLAR)	1
17	SLP-RO-SG (RED OAK)	4
18	SLP-YP-SG-CED	9
19	NF BUILDING SITES (NON FOREST CD)	46
20	YP-SG-SLP	18
21	YP-SG-ASH, YP-SG-BWI-YP-SG-POP	5
22	WO-SG-RO	52
23	WO-HIC (HICKORY)	3
24	HIC-WO-POP-SG	3
25	RO-WO-SG	7
26	POP-SG, POP-SG-RM	4
27	ASH-RM-POP-SG	6
28	SLP-YP, YP-SLP	2
29	SG-WO	1
30	RO-WO-YP	7
31	POWER LINE R/W	5
32	ROADS	5
	TOTAL ACREAGE	275

Fig. 1. Sample compartment Map

treatments and prescriptions may be determined based on the structure and composition of each individual timber stand.

Forest Regulation

The Oak Ridge forest, when originally acquired by ERDA (AEC), was composed of numerous small farms and woodlots. This presented an initial management problem due to differential treatment of each individual woodlot by its previous owner. Some areas had been extensively cut while a few areas had received limited cutting. Areas that had been heavily cut were usually highgraded leaving only trees of poor quality and culls.

During the past five-year cutting cycle, particular attention was given to the previous management plan recommendation of marking and cutting in those stands containing an abundance of mature, overmature, and cull timber in need of substantial timber stand improvement (TSI). Portions of 16 management compartments and alternates have undergone improvement cuts totalling 7.7 million board feet of sawtimber (Table 6). The same cutting policy of harvesting timber in mature and overmature stands will be adhered to during the next management cycle whenever feasible.

Based on the 1975 reinventory of the CFI plots, there was no significant change in species types from 1970 to 1975 with the exception of black cherry (Table 7). No explanation for the percentage decrease of black cherry has been determined at present since this species is rarely marked in sawtimber sales (less than 1000 board feet from 1970 to 1975). An accurate comparison between species volumes and volume percentages from 1970 to 1975 cannot be made since the 1970

Table 6. Selection cuts by compartments from 1970-1975

Year	Compartment(s)	Recommended cut (MMBF)[a]	Actual cut (MMBF)
1970-71	2, 9, 16, 23	3.0	2.1
1972	4, 6, 17, Alt. no. 1	1.5	2.5
1973	25, 27	1.5	1.0
1974	None	1.5	None
1975	10, 13, 14, 15, 25, Alt. no. 2	1.5	2.1
Total		9.0	7.7

[a]Allowable cut from 1970-1975 in million board feet.

Table 7. Sawtimber growing stock by species on the ERDA Oak Ridge Reservation in 1975

Species	Trees per acre	Volume per acre (BF)[a]	Total volume (MBF)[b] 1970	Total volume (MBF)[b] 1975	Volume (%) 1970	Volume (%) 1975
Southern yellow pine	19.4	1460	19,246	39,021	28.4	30.5
White pine	2.2	144	2,223	3,849	3.3	3.0
Red oak	4.6	454	9,245	12,134	13.6	9.5
White oak	6.3	676	8,791	18,067	13.0	14.1
Chestnut oak	4.3	497	4,970	13,283	7.3	10.4
Yellow poplar	3.3	448	11,986	11,974	17.7	9.4
Hickory	3.1	362	4,960	9,675	7.3	7.6
Black cherry	0.3	3	222	80	0.3	<0.01
Black walnut	0.1	8	161	214	0.2	0.2
Misc. hardwoods	6.4	553	4,108	14,780	6.1	11.5
Misc. oaks	2.0	184	1,888	4,918	2.8	3.8
Total	52.0	4789	67,800	127,995	100.0	100.0

[a]Board feet.

[b]Thousand board feet.

inventory figures were based on a temporary plot grid system computed solely on management acreage and the 1975 figures are based on a reinventory of the original CFI plot system and computed on total reservation acreage. Nevertheless, all species except black cherry and yellow poplar show a significant increase in total sawtimber volume. There was no significant decrease in the yellow poplar volume from 1970 to 1975 even though the volume percentage (based on total sawtimber volume) dropped from 17.7% in 1970 to 9.4% in 1975. Volume increase from 1970 to 1975 is accounted for by growth on merchantable stems plus ingrowth into the sawtimber size class from the pulpwood classes, less tree mortality and timber harvested.

A breakdown of timber types on the entire forest indicates that approximately 80% of the area is adequately well-stocked timberland composed of 44% hardwood, 23% pine-hardwood, 8% planted pine, and 16% natural pine. The remaining 9% is comprised of hardwood-cedar, hardwood-cedar-pine, and cedar-pine (Table 8). A well-stocked timber stand is one which has the desirable number of trees for optimum growth and management regardless of size classes.

The cutting schedule for the ensuing five-year management period will concentrate on bringing the total growing stock closer to the optimum level by balancing the timber size classes and areal distributions to ensure a future uniform annual yield (Fig. 2 and 3). A theoretical rotation age or adjustment period of 96 years is needed to fully regulate a hardwood forest of this type. A regulated cutting system will tend to maintain the forest in a healthy vigorous condition by removing mature and overmature timber, diseased and insect-infested trees, and cull

Table 8. Area and volume distribution by major timber types

Timber type	Area		Timber volume		Volume per acre (MBF)[a]
	Acres	Percent	(MBF)[a]	Percent	
Hardwood	9,889	37	56,796	44.4	5,743
Hardwood-pine	5,345	20	28,863	22.6	5,400
Planted-pine	4,544	17	10,906	8.5	2,400
Natural pine	4,276	16	20,097	15.7	4,700
Hardwood-cedar	1,336	5	6,680	5.2	5,000
Hardwood-cedar-pine	802	3	3,850	3.0	4,800
Cedar-pine	535	2	803	0.6	1,500
Total	26,727	100	127,995	100.0	4,789 (Avg)

[a]Thousand board feet.

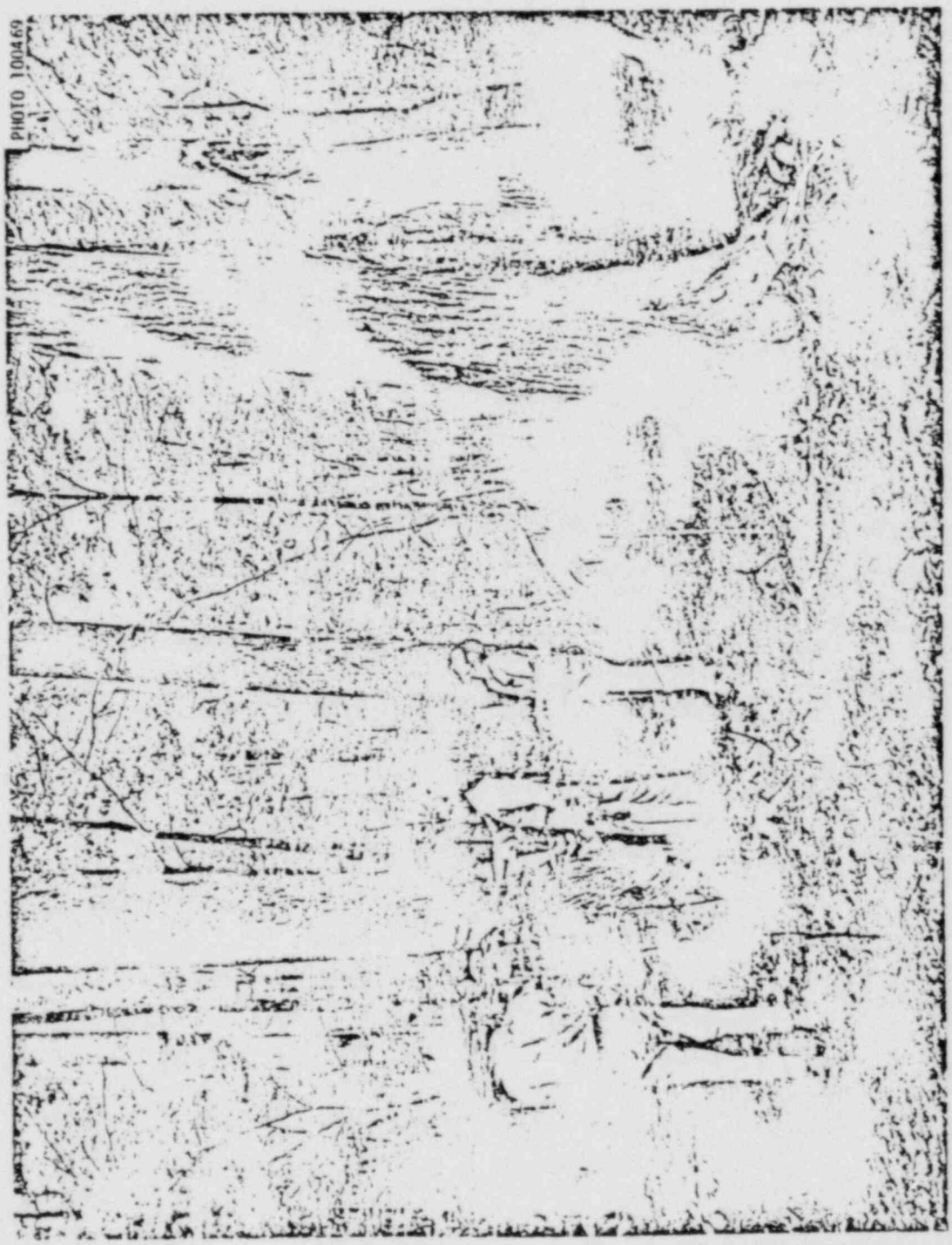


Fig. 2. A 26-inch yellow poplar being marked for an intermediate cut in a near-mature cove stand

Fig. 3. A mixed hardwood stand primarily composed of yellow poplar and white oak 9 years after an intermediate cut

trees. Harvest cuts should be made in at least three compartments annually in order to cover all 35 compartments within the 12-year cutting cycle. Eight management cycles will constitute a rotation of 96 years or the maximum age a hardwood tree will attain when the forest is perfectly regulated. Due to present and future possibilities of reservation acreage losses, the allowable cut has been reduced accordingly as noted in Table 9. Because of insect attacks, disease, research considerations and new construction, this sequence of cutting operations will remain flexible in order to satisfy specific situations.

MANAGEMENT POLICIES AND SILVICULTURAL PRACTICES

Development of the optimum species type(s) for each site is the overall silvicultural aim of the management program. To accomplish this objective, a combination of silvicultural methods is necessary depending on individual site characteristics and species capabilities. The more productive sites produce greater volumes of mature timber faster than the poorer sites. More silvicultural investments can be afforded on good sites since greater timber values can be derived.

Ridges, Upper Slopes, South Slopes, and Other Low-Productivity Sites

These areas range in oak site index[2] from 40 to 60 and loblolly pine site index from 50 to 70. Such sites are generally characterized by dry rocky or cherty ridges, upper and mid-slopes facing south

[2]Site index is a measure of the capability of land to produce timber. It is the height in feet that trees will attain in 50 years on a specific site.

Table 9. Operational sequence of timber cuttings by compartments for the period 1976-1980

Scheduled year	Compartment	Present volume (MBF)[a]	Volume to be cut (MBF)[a]
1976	25, 26	7,988	1,600
1977	1, 19, 20	10,241	1,600
1978	11, 12	9,022	1,600
1979	4, 18, 22	10,320	1,000
1980	21, 24, Alt. no. 1	14,201	1,000
Total		51,772	6,800

[a]Thousand board feet.

(topographic classes 1, 2, and 3) and small areas of severely eroded soil. Timber stands presently occupying these sites are comprised of poor quality oak species (Quercus sp.), Virginia pine (Pinus virginiana Mill), and shortleaf pine (Pinus echinata Mill). Yellow poplar (Liriodendron tulipifera L.) outgrows most of the oak species on the "better" poor sites but will not maintain pure stands. The proportion of yellow poplar can be increased on some of these sites with proper management. Loblolly pine is best suited for the poor sites and should be planted whenever possible. Site conversion with Virginia pine is marginal whereas loblolly pine should return cost-plus due to faster growth and a higher quality tree bole.

Narrow bands of bland soil, a highly erodable soil formed over calcareous siltstone, run east-west across the Reservation and comprise the poorest sites on the forest. During the past five-year management cycle some of these sites have been artificially regenerated with loblolly pine. Seedling survival was satisfactory and growth to date has been approximately 75% of that observed on adjacent sites with better soils.

Sites with low productivity will be managed by either the group selection method (uneven-age forest), or clear cutting method (even-age forest). The system actually used will depend upon what species occupies the site, soil type, and topographic class. Virginia and shortleaf pine occupied many of these sites until the recent southern pine beetle (Dendroctonus frontalis) epidemic which left many of these areas either cut-over or standing dead. Where advanced reproduction is sufficient and of a desirable species, no action is required. Sites with

insufficient advanced reproduction will be regenerated artificially with a more desirable hardwood or pine species. Where pine predominates and is suited to the site, a 40- to 50-year rotation will be established under an even-aged management system. Hardwoods intended for sawlogs will require a 90-to 120-year rotation age.

No species considered undesirable will be maintained or replanted on a low-productivity site, except in ecological study areas. Practices to the contrary would defeat the primary silvicultural objective of the management program by creating more low-quality cull timber.

Coves, Lower Slopes, North Slopes, and Valley Sites

These areas generally range in oak site index from 60 to 80 and yellow poplar site index to 120. Such sites encompass coves, minor bottoms, north slopes, and many lower south slopes (topographic classes 4 through 8). Some ridge tops with relatively deep, well-drained soils derived from limestone parent material are included in this site class.

Many sites of this type can support pure or mixed stands of yellow poplar, black walnut (Juglans nigra L.), northern and southern red oak (Quercus rubra L. and Q. falcata Michx.), sweetgum (Liquidamber styraciflua) and maples (Acer sp.). White oak (Q. alba), red oaks (Quercus sp.), and yellow poplar will be favored on north upper and mid-slopes when present. Even-aged silviculture will be used to manage the productive sites. This will tend to favor the more valuable shade intolerant species such as yellow poplar, black walnut, black cherry (Prunus serotina), cottonwood (Populus deltoides) and ash species

(Fratinus sp.). Two cutting phases comprise one rotation: reproduction (harvest) cut and intermediate cuts (Fig. 2).

The reproduction cut is made the final year of the rotation period, usually in a mature stand although either understocked stands including stands composed of undesirable species may also be cut before biological maturity to facilitate area regeneration with more suitable (valuable) growing stock. A reproduction cut removes all mature timber allowing the germination of seed lying dormant in the forest litter or from surrounding trees. All cull sawtimber trees and non-merchantable trees should be cut and removed for pulpwood. Any residual trees must be deadened shortly after the reproduction cut to assure successful natural regeneration.

Thinnings or improvement cuts should be made every 12 years after the reproduction cut by removal of poorly formed stems and undesirable species. This will maintain a healthy vigorous stand of high-quality stems. Intermediate cuts will also maintain proper spacing and stocking during the interim between regeneration and the rotation cut. Initial thinnings and improvement cuts will at best yield only pulpwood. As the stand matures, sawtimber may also be removed, leaving the best stems each time for crop trees. Stand reproduction is of no concern during the intermediate cutting stages of the rotation period. Thinnings and improvement cuts are usually terminated after the first 60 to 70 years at which time theoretical optimum stocking has been attained.

The best cove and minor bottom sites may yield 24- to 28-inch sawtimber with a 60- to 75-year rotation with certain intolerant to

moderately tolerant hardwood species. Slope sites of intermediate productivity should produce 20- to 24-inch sawtimber with a rotation period of 75 to 90 years given proper thinning and care. These estimates are exclusive of any initial cultivation or fertilization during the rotation.

Plantations

The original reforestation program on the ERDA Reservation was contracted to Management Services Institute (MSI) to plant old field sites located primarily in the valleys and on lower slopes. Species planted in order of preference were shortleaf pine, loblolly pine (Pinus taeda), white pine (Pinus strobus), Virginia pine, and eastern red cedar (Juniperus virginiana). The primary goal at that time was reforestation of non-forested acreage as quickly as possible with no regard to species-site suitability. Shortleaf pine being a native species was heavily favored over the other species, but has since proved least desirable due to its poor growth and high susceptibility to insect and disease attacks. Total trees planted through 1961 by MSI was 6,305,000. Initial tree spacing ranged from 2 x 6 feet to 6 x 6 feet with survival generally good. The oldest plantings (1947) are now 29 years old.

A commercial thinning program was begun in 1967 in the oldest and most heavily stocked pine stands. All but approximately 500 acres of the original 4300 plantation acres have been thinned at least once. An income of $52,970 has been realized from the sale of 14,145 cords of pine pulpwood cut from thinnings and southern pine beetle control (Table 2).

A few pine stands were left unthinned in the past to be used as controls in thinning comparisons (Figs. 4 and 5). These stands will also be thinned to reduce their high susceptibility to southern pine beetle infestations created by over-crowded stand conditions. Thinnings are presently behind schedule since all cutting efforts have been directed toward control of the southern pine beetle outbreak beginning in 1973. Once this epidemic is under control, cutting emphasis will be placed on a second thinning of all loblolly plantations which are becoming severely overcrowded. Second thinnings will involve the removal of both sawtimber and pulpwood, since most stands have grown into the sawtimber classification since their previous thinning. Stands are thinned to a basal area of 80 square feet yielding from 8 to 10 cords of pulpwood per acre. Thinning in white pine plantations began in late 1975 yielding [illegible]ately 8 cords per acre in the first thinning.

Planted areas managed for pine will be maintained on an even-aged rotation of 40 years for loblolly and white pine and 60 years for shortleaf pine. It is doubtful that seed tree cuts will satisfactorily regenerate these species on most of the sites due to hardwood competition and the absence of a mineral soil seedbed at harvest. Therefore, to eliminate the possibility of regenerating an understocked stand, it will be necessary to mechanically prepare the site and replant with improved planting stock (Fig. 6). A shortening of the rotation period will also be realized by artificial regeneration. Areas with satisfactory pine reproduction or desirable "on-site" hardwood reproduction will be managed accordingly by silvicultural methods previously outlined.

Fig. 4. An overcrowded 19-year loblolly pine stand before thinning.

Fig. 5. Three years after thinning in a 19-year old loblolly pine stand.

Fig. 6. A loblolly pine plantation four years after planting with an average height of eight feet.

The most recent southern pine beetle epidemic (1973-1976) has taken a devastating toll on the original shortleaf pine stands, both natural and planted. Pulpwood and sawtimber on approximately 1500 acres have been salvaged since the initial outbreak in 1973. An expanded regeneration program using updated equipment was needed to satisfactorily reforest these areas with high quality pine and hardwood seedlings. Numerous types of mechanical site preparation treatments have been tested with land clearing (KG blade), piling and burning (root rake) and harrowing followed by mechanical planting being the most satisfactory. An annual reforestation goal of 300 acres per year has been established. Table 10 summarizes regeneration activities over the past five-year cycle by species, acreages, and survival rates. Generally a stand survival less than 75% indicates the need for replanting depending on site conditions. Yellow poplar planted in 1975 was not replanted even though stand survival was only 68%. A large amount of die-back and resprouting which occurred during and after the survival data were collected coupled with volunteer seedlings should adequately stock this area.

Numerous pine and hardwood species have been test planted during the past three years. Loblolly pine is the most desirable pine species for planting due to its site adaptability, fast growth, and resistance to insect and disease attack. Of the various hardwood species planted, the most desirable are black walnut and eastern cottonwood on the best bottomland sites, yellow poplar, sycamore, and green ash on the lower north slopes and coves, and river birch and sweet gum on the wet sites. Specific criteria used to match species to site are soil type, soil

Table 10. Regeneration by species from 1971-1975

Year	Species	No. of seedlings	No. of acres	Stand survival (%)	Seedling survival (%)
1971	Loblolly	20,000	20	68.0	68.0
1972	Loblolly	21,500	22	84.4	90.9
	Yellow poplar	800	1	82.1	88.4
1973	Loblolly	153,500	240	96.0	96.5
	Yellow poplar	280	0.5	82.5	82.5
	Oaks	170	0.5	<10.0	<10.0
1974	Loblolly	200,000	289	63.3	64.0
	E. cottonwood	11,000	17	81.0	81.0
1975	Loblolly	153,000	184	95.0	95.0
	Yellow poplar	42,000	56	68.0	69.0
	E. cottonwood	11,000	17	78.0	89.0
	Sweetgum	5,400	8	85.0	87.0
	B. walnut	4,000	9	98.0	99.0
	Sycamore	4,000	8	86.0	86.0
	Green ash	3,000	6	93.0	98.0
	River birch	2,000	3	81.0	84.0
Total		631,650	881		

drainage, slope, aspect, accessibility, planting and site preparation techniques, and seedling supply.

Release

Timber stand improvement is needed in some form on all timber stands at some point in time to enhance the stand's quality. Cull trees have little monetary value but compete with the better growing stock for light, moisture, and nutrients. Cull tree removal in both young and old stands can also be accomplished during thinnings and intermediate cuts. Pre-commercial thinnings are necessary in non-merchantable overstocked stands with poor growth. Monthly cultivation during the growing season will be needed in the newly planted eastern cottonwood and black walnut plantations to release them from the herbaceous vegetation and stimulate growth. This treatment will be needed for at least the first three years after establishment.

Prescribed fire is one of the most valuable tools used in the management of southern yellow pines. A controlled burn during the winter months reduces the fire hazard by removing litter buildup, removes much of the competing vegetation, and releases nutrients tied up in forest floor litter (Fig. 7). Controlled burning in pine plantations can commence when a stand is six to ten years old, or when the average stand height is approximately 25 feet. Burns at three to five year intervals will maintain a low vegetative understory and improve the stand's accessibility to other activities.

Kudzu has become a problem worthy of much attention on the reservation during the past few years due to its fast growth rate (as much

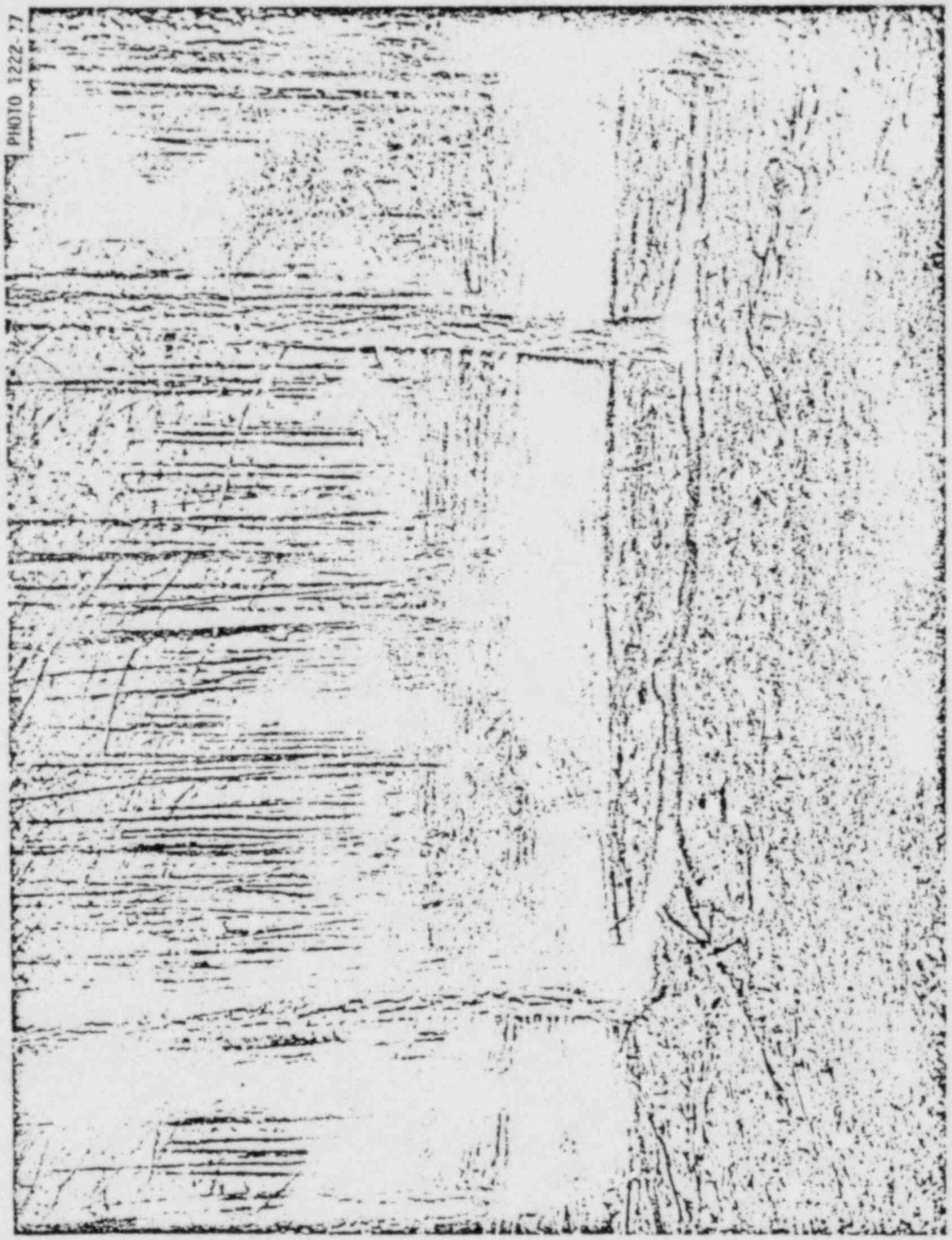


Fig. 7. Two weeks after a prescribe burn in a 26-year old loblolly pine stand

as two feet per week during the growing season) and ability to overgrow trees, roads, buildings, powerlines, and bridges. Cattle grazing, one of the most common control methods for kudzu is not available for use on the ERDA Reservation. The most effective control method employed is burning during the winter followed by chemical spraying in the early and late summer with a mixture of 2,4-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid and diesel fuel in water. Approximately 50 acres located throughout the reservation will be treated to eradicate kudzu during the next management cycle in order to protect the adjoining timber stands.

Some isolated trees have been left standing during site preparation and replanting. These trees should be basally injected or girdled since leaving them will only create more culls and reduce seedling growth by shading.

New Programs

A diminishing land base coupled with the need for more intensive forest management requires updating old practices and the installation of new management practices. Evaluations of both present practices and new programs are needed to assess the benefits and environmental impacts of these programs.

Regeneration studies will allow an evaluation of the effectiveness of site preparation techniques and seedling survival rates. Growth and yield study plots will be installed in hardwood plantations to determine the effectiveness of cultivation and fertilization techniques, changes in growth increments, and nutrient losses due to run-off. Long-term monitoring of site prepared areas will determine the amount of

soil loss through sheet erosion per acre during that time in which the soil is denuded. Control plots will be installed in unburned loblolly pine stands to evaluate the effectiveness of prescribed burning in pine plantations.

FOREST PROTECTION

Insects and Diseases

The southern pine beetle (Dendroctonus frontalis Zimm.) reached epidemic proportions on the reservation during the summer of 1973. A cooperative survey conducted by the U.S. Forest Service under provisions of the Federal Forest Pest Control Act indicated that 1,757 trees were infested in August 1973 with a brood density of 610 beetles per square foot of bark surface (Ward, et al. 1973).

Project proposals requesting federal assistance were prepared for FY 1973, 1974, and 1975 for insect and disease control funds totalling $64,795. These funds were utilized for direct control procedures of the southern pine beetle. Chemical control was abandoned during this outbreak primarily due to the high treatment cost per unit (tree) treated. Present control procedures entail locating and mapping the individual spots, salvaging all merchantable timber including a 75-ft buffer strip around the infected area, then piling and burning all residual trees, limbs, and tops. Due to the extent of the present outbreak, it has become more feasible to pile and burn by compartments instead of individual spots. Therefore, an entire compartment(s) can be treated and replanted without wasting valuable time transporting equipment. The infestation incidence has taken a downward turn during

the latter part of 1975 indicating a possible cessation of the present epidemic.

Other insect pests causing timber damage and mortality during this same time period include the eastern juniper bark beetle (Phloeosinus dentatus Say) on eastern red cedar (Juniperus virginiana), hickory bark beetle (Scolytus quadrispinosas Say) on hickory species (Carya sp.), sassafras (Sassafras albidum) damaged by (Hypothenemus chapuisi Eichh.) and noticeable elm (Ulmus sp.) killed by the smaller European elm bark beetle (Scolytus multistriatus) acting as the vector for Dutch elm disease fungus (Ceratocystis ulmi). With the exception of elms and cedar, the kills have been scattered and spotty. Cedar kills have been scattered throughout the reservation with entire stands (30 trees) being killed. Elm kills have been observed in many management compartments and range from an individual tree to clusters of three and four. Control of Dutch elm disease can be accomplished to some degree by burning beetle infested elms while the beetles are still present. The most efficient and economical control method utilized on the ERDA Reservation for the bark beetle insect pests is to cut, pile, and burn.

Disease outbreaks on the Reservation during the past have caused relatively light damage as compared with the southern pine bark beetle. An exception to this was the observation of pitch canker (Fusarium lateritium Nees em. S.&H. F. pini) in the late summer of 1973 in compartment #13. An entire shortleaf pine stand of approximately 77 acres was cut due to extensive damage caused by this fungi. Only

isolated infested trees have been observed in other parts of the reservation since the initial infestation.

A root rot on pines caused by (Fomes annosus Fr.) is common in pine stands throughout the southeast. Its occurrence and damage is monitored with permanent plots installed and inventoried periodically by the State of Tennessee, Department of Conservation. This disease is most prevalent in stands planted on poor soils and may be spread during the first thinning. Control includes selecting healthy planting stock, planting on compatible sites and treatment of stumps with borax during the first thinning. Root rot mortality caused by F. annosus has shown a marked decrease from 1968 to 1970 (Kauffman, 1975). This could be acccunted for by the fact that most of the first thinnings in pine plantations had been completed by this time (Strock, 1970). Root rot incidence from 1970 to 1975 has been masked by the recent southern pine beetle epidemic. Fomes annosus root rot should be of minor consequence in the coming years due to many off-site stands having been cut during the present southern pine beetle epidemic, nearly all first thinnings have been completed, and borax stump treatment conducted in those stands remaining to be thinned. Of the total tree mortality in pine plantations in 1970, only 3.3% can be attributed to Fomes annosus root rot (Kauffman, 1975).

Fire

The reservation has an excellent fire history since acquisition in 1942. Wildfires on the reservation have resulted from construction and waste disposal, incendiary, and lightning. Only three wildfires were

recorded on the reservation during the past management cycle. A control burn jumped a fire line in 1974 and burned grass on approximately one-tenth acre with no timber damage. A construction company's warming fire burned approximately three acres in compartment #8 in 1975 with little damage to the standing timber. Both fires were brought under control by the Forest Management Department. A roadside grass fire of a possible incendiary nature was contained by the K-25 fire department also in 1975.

Suppression of most woods fires can be effectively handled by the Forest Management Department. The department operates two 4-wheel drive pickups, one equipped with a 75-gallon pump tank and the other with a 150-gallon pump tank. Both trucks carry numerous hand tools which can be used to manually construct fire lines in areas where mechanical line construction is impossible and for control of fires in their initial stages. Labor crews are also available from the Plant and Equipment Division for fire control assistance. These crews are trained annually in fire line construction. A 350 series John Deere crawler tractor mounted with a fireline plow is maintained on stand-by basis during fire seasons. Primary backup of the Forest Management Department for forest fir control is the Oak Ridge Fire Department with secondary assistance from the three plant fire departments. In a large-scale effort, assistance would also be available from the Tennessee State Division of Forestry, which has suppression crews located at Kingston, Knoxville and Rockwood.

TIMBER SALES POLICIES

Under the previous management plan, all sawtimber sold from the reservation was under long-term contract (No. At-(40-1)-S-1182) between AEC (ERDA) and Longleaf Industries, Inc. Longleaf Industries, Inc. was in the process of selling all their interests to American Forest Products, Inc., a subsidiary of Bendix Corporation in the latter part of 1975 (Fig. 8). Negotiations are under way to revise the present timber sales contract to reduce the total timber commitment to AFP while retaining previous contract conditions favoring good forest management practices. Under the renegotiated contract (E(40-1)-S-1182), an option to extend the original contract another 10-year period (1978 to 1988) is primarily dependent upon AFP's completion of a planning mill at the Marlow Site.

Timber volumes to be cut during the remaining contract period (December 31, 1978) are 4.2 million board feet of hardwood sawtimber and 0.9 million board feet of pine sawtimber. Timber volumes to be cut under the optional 10-year period totalled 11.0 million board feet, of which 8.1 million board feet is hardwood and 2.9 million is pine sawtimber. Under this contract, the ERDA-ORNL forester is responsible for: (1) marking and computing timber volumes to be sold; (2) making joint cruises with American Forest Products when there is disagreement on computed timber types and volumes; (3) assisting American Forest Products and their loggers in locating the timber boundary(ies) to be cut, skid trails, log loading areas, and access routes; (4) maintaining periodic checks on the cutting

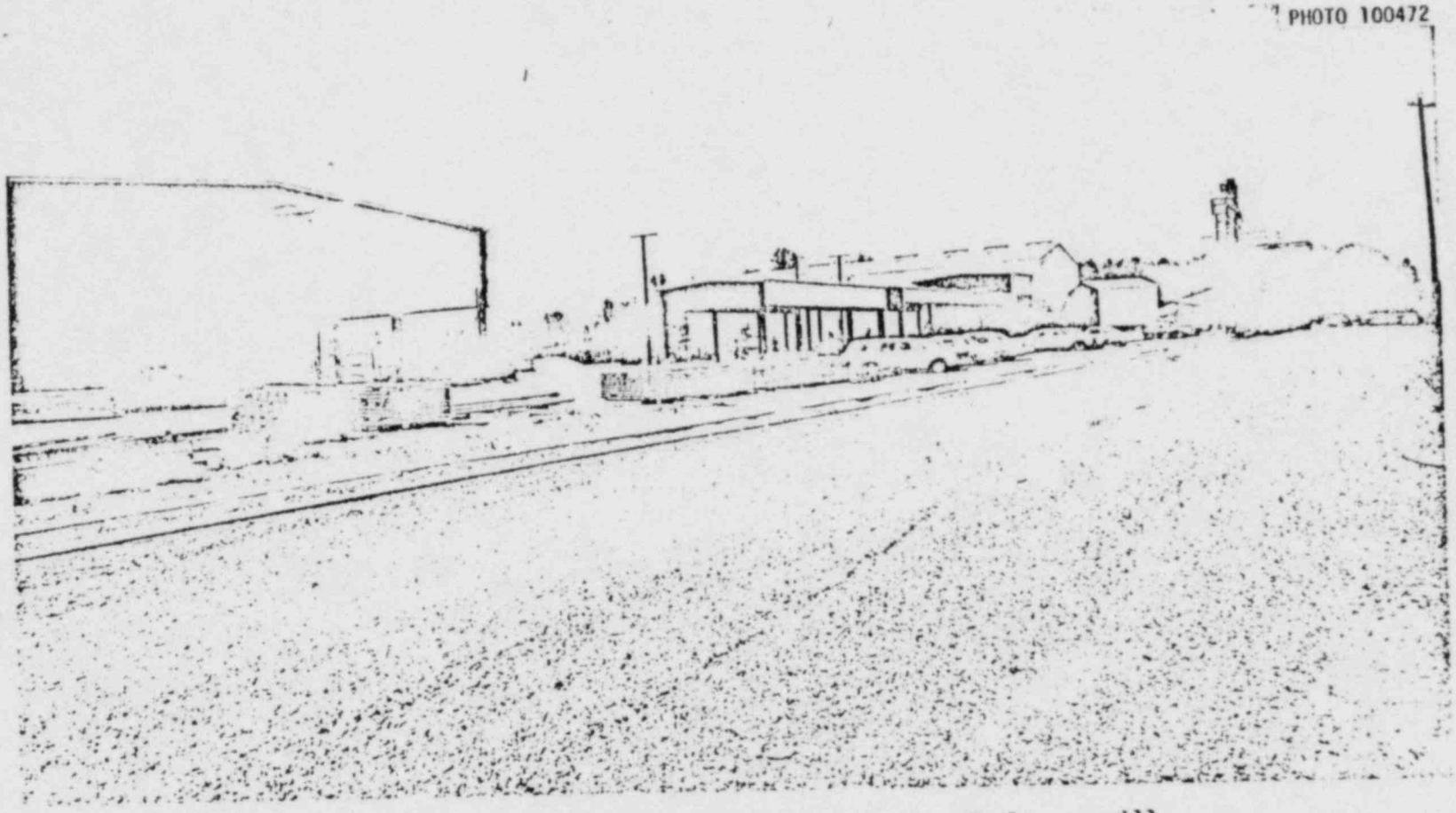


Fig. 8. American Forest Products Corporation, Marlow sawmill

operations; (5) overseeing all cleanup operations at the sales end; and (6) maintaining records to establish yearly contract obligations.

All pulpwood sales are under short-term contract (6 months to one year) primarily to Anderson County Pulpwood Company located in Clinton, Tennessee. The pulpwood sales conditions are similar to the timber sales contract specifying an amount of pulpwood to be cut and its location. Pulpwood sales and any other miscellaneous timber products sales are sealed bid sales open to the general public. All timber sales are handled through the Purchasing Division, Nuclear Division, Union Carbide Corporation.

CONTROL RECORDS

Detailed records and maps of all timber product sales are kept in the Forest Management Department's office file. Other records on file include maps of the reservation showing timber types, roads, past, present and future cutting areas, site preparation, tree planting, control burning, and other cultural operations. Aerial photographs taken every five years for activity planning and updating maps are filed by numbers corresponding to photo indices.

MANAGEMENT PLAN REVISION

The management plan will be revised again in 1980 with a re-inventory of the permanent sample plots and individual management compartment cruises and timber type maps. Timber cutting will be revised, if necessary, based on growth estimates and stand development information from analysis of these inventories. A complete

assessment will be made of all forest management activities during the interim management cycle to update practices and procedures for a more effective and efficient program.

ENVIRONMENTAL STATEMENT

The primary purpose of the forest management program on the ERDA Oak Ridge Reservation is to maintain a continuous yield of high quality timber thereby providing an economic stimulus to the Oak Ridge area through jobs and the manufacture of forest products. Management of such a large diversified forested area involves the use of numerous silvicultural or management tools in order to accomplish specific goals within the varied forest stand types. Therefore, each silvicultural practice employed under the present management plan will be assessed individually due to impact variability between practices.

Pollution control in forestry does not consist of rectification and treatment of polluted effluents prior to discharge, since pollution from forest lands is nonpoint in origin. Therefore, treatment and control methodology is built into the management system. The management system incorporates practices and methods utilized in the harvest of trees, log transport, site preparation and reforestation, forest protection (fire, disease, insects, and weed tree control), and growth stimulations as necessary to achieve environmental goals in conjunction with management goals which include the production of timber and other forest products achieved through the harvest of trees (EPA 430/9-73-010, 1973).

Timber Harvesting. The two primary timber harvesting systems utilized on the ERDA Reservation are the selection method and the clearcutting method. Both systems are designed and implemented to perpetuate the forest either by even-aged stand management (pine and some hardwood species) or uneven-aged stand management (hardwood species). The two principal pollutants associated with timber harvesting are a diminishing of aesthetic values primarily due to logging slash and debris and sedimentation caused by erosion of logging roads, log skidding trails, and loading ramps irrespective of the harvesting system (USEPA 430/9-73-010, 1973). Logging slash is retained in selectively harvested areas and that adjacent to primary roads is minimal, while logging slash in clear-cut areas for southern pine beetle control is heavy. Therefore, beetle kill areas adjacent to primary roads are given a high priority for cleanup, slash disposal, and reforestation.

Direct techniques utilized to minimize erosion in timber harvest areas include water barriers located at intervals along skid trails with logging slash being deposited in problem spots, clearing of debris from loading ramps and either grassing and strawing the entire ramp area or planting with appropriate tree seedlings. Erosion of logging roads is minimized by proper road maintenance before, during, and after the harvesting operation. Ditches and culverts are periodically cleaned out, road beds graded, crowned, and graveled, and all ditches properly sloped.

Indirect control methods involve proper planning in the location and construction of all roads, trails, and ramps prior to harvesting

in order to reduce the soil erosion potential (Hewlett and Douglas, 1968).

The principal long-term effects attributed to the selection system of timber harvesting in individual stands is a change in species composition toward high quality, tolerant or moderately tolerant, timber species such as white oak (Quercus alba), yellow poplar (Liriodendron tulipifera), red oaks (Quercus sps.), white pine (Pinus strobus), and black walnut (Juglans nigra). The overall forest species composition diversity is maintained by planting intolerant and moderately shade-tolerant species when artificial regeneration of an individual timber stand is necessary. An additional long-term effect is an increase in both basal area and number of trees per acre in harvested areas (Schlesinger, 1975). The forest is maintained in a healthier, more vigorous condition by removal of the overmature and cull trees, which improves both timber production and wildlife habitat (Schlesinger, 1976; Smith, 1962; Della-Bianca, 1975).

Site Preparation and Tree Planting. Proper treatment of the site prior to planting accomplishes numerous management goals, both short-term and long-term. Site preparation on the ERDA Oak Ridge Reservation has been utilized either in old fields stocked with species unsuitable for timber, or on those areas cleared of pine for southern pine beetle control. The principal site preparation technique utilized is total shearing of any residual unmerchantable trees with a KG blade, windrowing this material along with the logging slash, burning the windrows, and then flat disking with a six-ton woods harrow. Impacts beneficial to reforested stands obtained through this treatment are removal of

logging slash which improves the aesthetics and reduces the fire hazard, elimination of competing cull trees and undesirable advanced reproduction, improvement of early soil moisture conditions, reduction of soil compaction induced during logging operation, improved planting conditions, increased seedling survival and growth, shortening of the harvest cycle, thinning schedule, or rotation, improved wildlife food and cover, plus increased accessibility for fire control and harvesting equipment (Balmer, 1976; Smith, 1962).

Advantages of establishing the forest stand by planting are: (1) assurance of a well-stocked stand; (2) immediate stand establishment; (3) choice of species matched to its specific sites; (4) improved genetic stock from seed orchards; (5) shortening of stand establishment time and rotation; and (6) increased seedling and stand survival (McQuilkin and McNamara, 1967; Smith, 1962; Belanger and Saucier, 1975). Additionally, habitats for numerous wildlife species such as bobwhite quail, doves, meadowlark, and white tail deer, are improved through site preparation and planting by the creation of open areas and the development of herbaceous and woody vegetation which invades these sites the first spring after treatment (Cooper, 1971). A future evaluation may ascertain the impact of these open areas on "deep woods" wildlife species.

Susceptibility of the site to soil erosion is the primary impact of site preparation and planting. This erosion is minimized by the short period of time (from one to three years) during which the soil is denuded. Practices utilized to minimize soil erosion are clearing, windrowing, disking, and planting on the contour as in strip farming

(EPA 430/9-73-010, 1973; Smith, 1962). Site preparation activities are scheduled in the summer and fall months with planting being conducted in the following winter and spring months. On slopes or soils extremely sensitive to erosion, windrows are left unburned or strips between rows are planted with wildlife food, grasses, and legumes. To prevent sediment from entering streams timbered buffer strips are left, (width depends on soil type, adjacent slope per cent, residual timber type, and the extent of clearing), to act as dams or filters during heavy runoff (EPA 430/9-73-010).

Prescribed Burning. Prescribed fire is a useful tool utilized to manage various timber species through the reduction of the hazards of wildfire and elimination of competing vegetation. Fire is an important and economical means of control of the southern pine beetle, elimination of logging slash and debris during site preparation and in the control of some diseases such as Fomes annosus (Cooper, 1971; Smith, 1962). Periodic control burns can increase available soil nutrients; in the upper 2 inches of the soil nitrogen may increase as much as 13.7% (Wells, 1971). Herbaceous game-food plants are more abundant on burned areas than on unburned areas (Hilmon and Hughes, 1965). Periodic prescribed fires improve the habitat for deer, turkey, bobwhite quail, rabbits, and doves and many songbirds (Perkins, 1971; Davis, 1959).

Adverse environmental impacts of prescribed fire are the discharge of smoke and particulate matter into the air. Proper scheduling of burns can minimize the amount of emission since rainfall, wind, and temperature play important roles in pollution control (USEPA 430/9-73-010). Emissions can be minimized by burning in small blocks with proper

weather conditions. Smoke impact is reduced by burning during afternoon and evening hours against the wind prior to the movement of a frontal low-pressure system into the area (Davis, 1959; Sackett, 1975; Pharo and Hauck, 1975). Gaseous and particulate pollutants can be minimized with properly planned burns, while most of those emitted are washed out by rainfall or fallout as a result of wind or gravity (Cooper, 1971; Dieterich, 1971).

Control burning is scheduled by the Forest Management Department with regulation through the ERDA, Oak Ridge office of Industrial Safety and Fire Protection Branch. Notifications of all burns are made on the day of the burn to ERDA Industrial Safety and Fire Protection Branch, the Oak Ridge Fire Department, the State Forestry Service, the ORNL Fire and Guard Department, and the K-25, X-10, and Y-12 shift supervisors.

Chemicals. Chemicals presently utilized in the forest management program are Tordon 101, 2,4-dichlorophenoxyacetic acid, and 2,4,5-trichlorophenoxyacetic acid for control of certain undesirable woody and herbaceous plant species. Undesirable hardwood trees are mechanically injected with Tordon 101 directly into the stem in one milliliter doses. Chemicals applied in this manner tend to have a minimal environmental impact due to the low dosage rate and application method.

Kudzu control is achieved by foliar spraying with a mixture of 2,4-D, 2,4,5-T, diesel fuel, and water. All spraying is conducted during appropriate weather conditions to avoid drift, with no spraying over open water, since these chemicals can be toxic to some forms of aquatic life. Tordon 101, 2,4-D and 2,4,5-T are biodegradeable, water

soluble, auxin herbicides making them short-lived in the environment (Smith, 1962, DWR Pub. No. 84). When these chemicals are utilized according to EPA regulations environmental damages and harm to personnel can be avoided (USEPA, 1976a, USEPA, 1976b).

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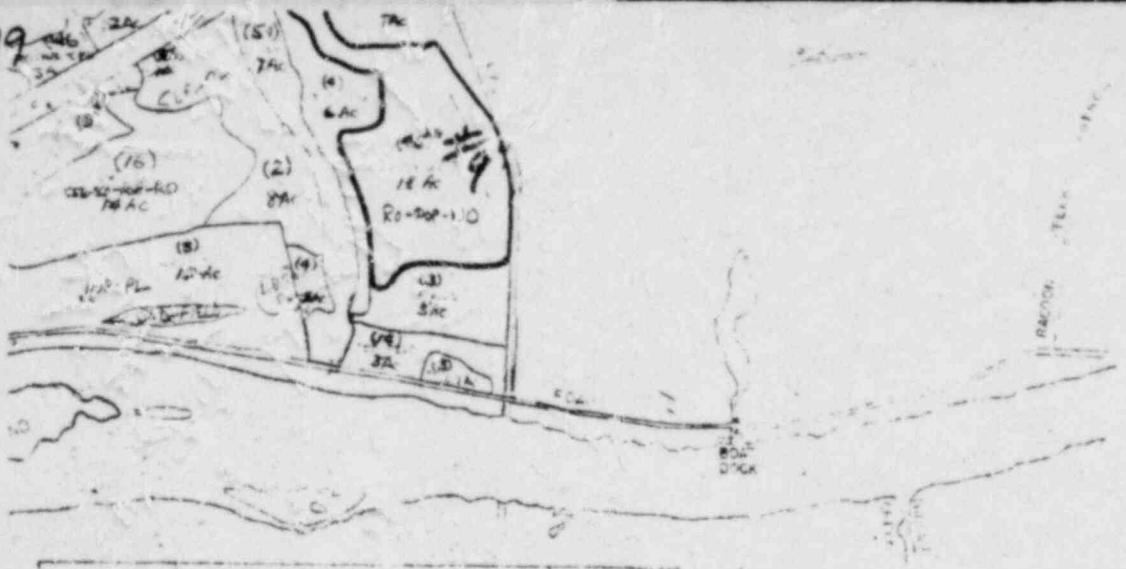


STRATUM #	FOREST COVER TYPE	ACREAGE
1	LOB - PL - 48	42
2	SLP - PL - 81	75
3	WP - PL - 51	81
4	LOB - PL - 51	36
5	LOW/SLP PL 51	7
6	WP AND PL - 52	7
7	SLP - PL - 52	6
8	WP PL - 52	37
9	WP - PL - 52	13
10	LOB - PL - 54	29
11	SLP - PL - 54	61
12	WP - PL - 54	28
13	MAT PINES (VP & SLP, VP & SLP & [illegible])	120
14	CED - PINE (CED - WP, CED SLP - WP, CED - PINE, CED - PINE - RO)	16
15	CED - SCO	2
16	CED - SCO - ASH - RO	14
17	CED - WO - RO	31
18	CED - SG - POP	11
19	PINE - WO	2
20	POP - RO	9
21	POP - RO - MAPLE - ASH	33
22	SG	4
23	SG - PINES (VP, LVP - SLP)	42
24	SLP - POP - SRO - HIC	11
25	SWC - ABANDONED	4
26	SWC - BLK - BOX ELDER - D. WILLOW	9
27	SWC - ELM - OAK - ELDER - MAPLE	13
28	SWC - POP - BLK - WALNUT	2
29	LOCUST - HACKBERRY - HACKBERRY - ELM	2
30	ELM - ISO - ELDER	3
31	ASH - HACKBERRY - WALNUT	5
32	BIRCH - WO - RO - CEDAR	5
33	BIRCH - RO - POP - MAPLE	5
34	S. MAPLE - ELM	2
35	S. MAPLE - WO - POP - HIC	10
36	CED - BC	17
37	WO (LO) - RO - POP - MAPLE - HICK	91
38	WO - HIC - SG - RO - POP	128
39	WO - RO - POP - HIC (WO - HIC - POP - RO)	55
40	RO (SRO) - WO	6
41	RO - ASH - SLP	2
42	RO (SRO) - POP - WO - HIC	30
43	RO - WO - POP - PINE - CED	11
44	RO - WO - SG - CED	13
45	RO - POP - WO (RO - WO - POP)	28
46	RO - HIC - PINE (RO - HIC - CED)	11
47	RO (WO) - PINE - POP	10
48	RO - PINE - CED	4
49	BC - HIC - POP	2
50	SRO - SLP - WO	7
51	SWC - POP - SG	7
52	BORROW & CONSTRUCTION SITES	4
53	ROADS	13
54	POWER LINE RIGHT-OF-WAYS	58
55	CONTINUOUS CLEARED ROAD FIELDS AT	7
56	WO - RO - HIC - SG	4
		1,364

LEGEND

- ABANDONED DWELLING
- INDIAN MOUND
- FENCED AREA
- CEMETERY
- POWER LINE
- STATE LINE

600
600
1,200

Note: areas marked in red contain unique vegetation associations which should be preserved if possible.

TYPE MAP OF T.V.A. & LMFBR SITE

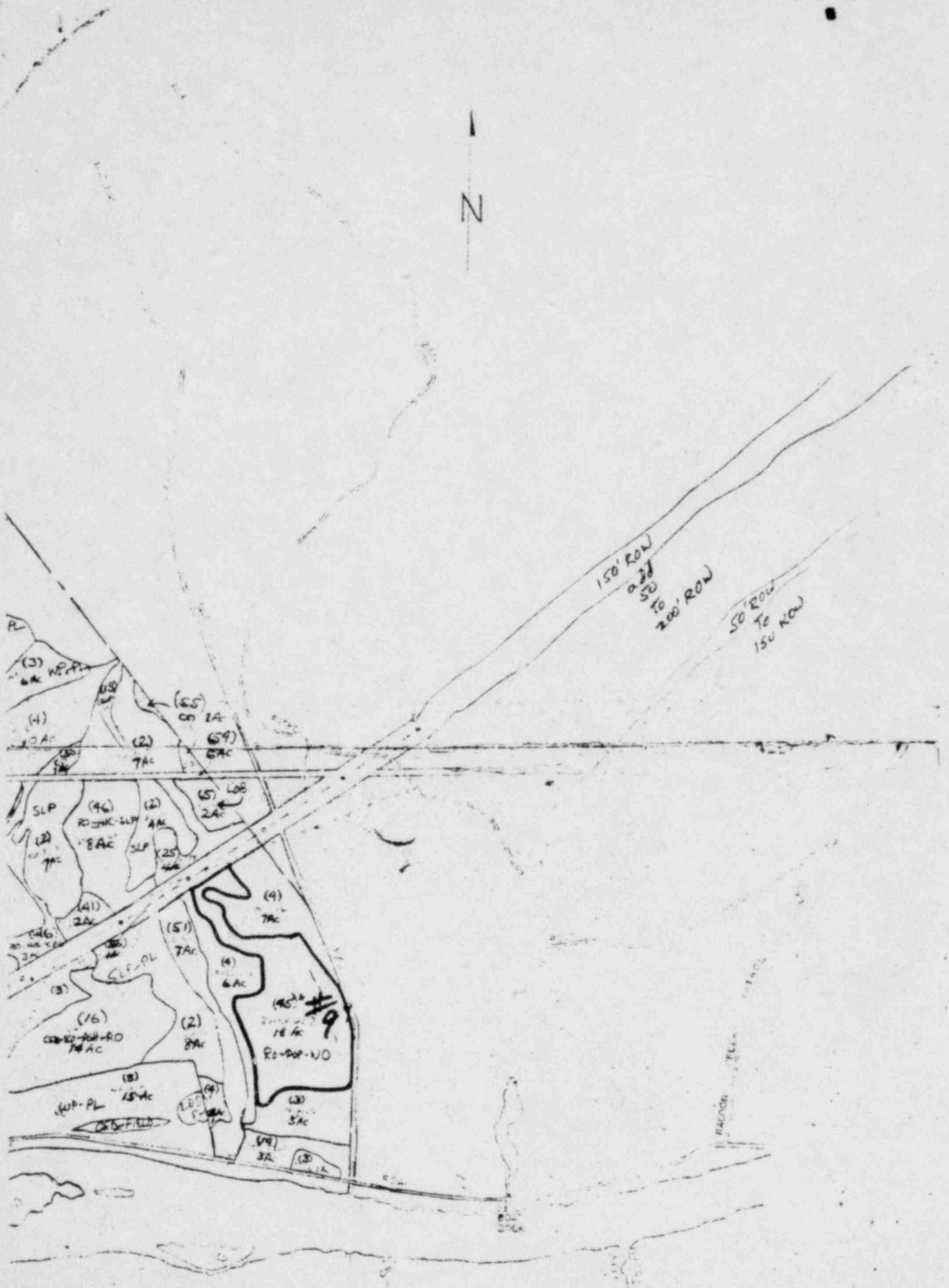
PORTIONS OF FOREST MANAGEMENT COMPARTMENTS NO. B 5 14

1,364 Acres

- DMB 4-73 SCALE 1" = 800'

PMC Fig 2.7-B

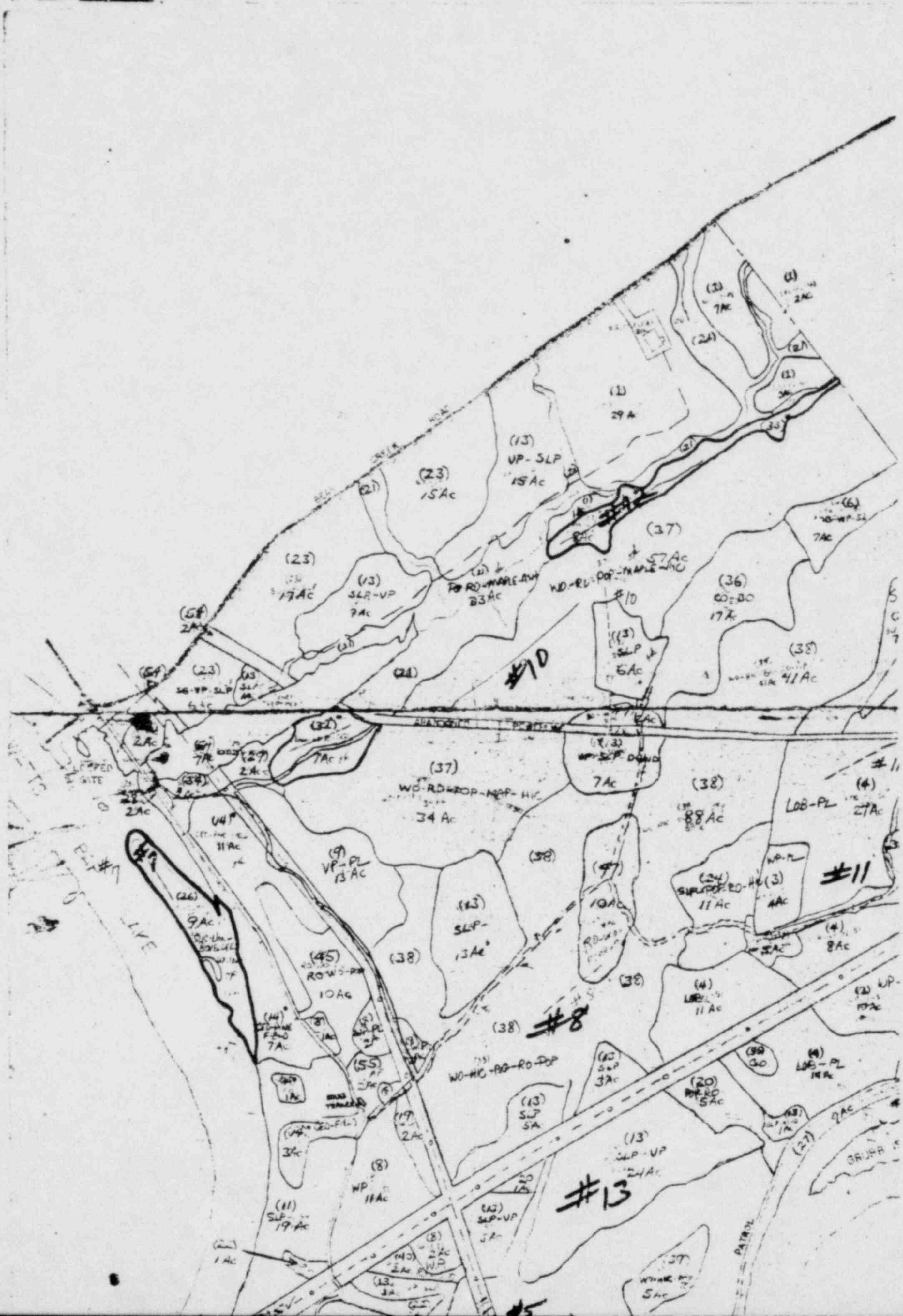
Frank Harris - ORNL



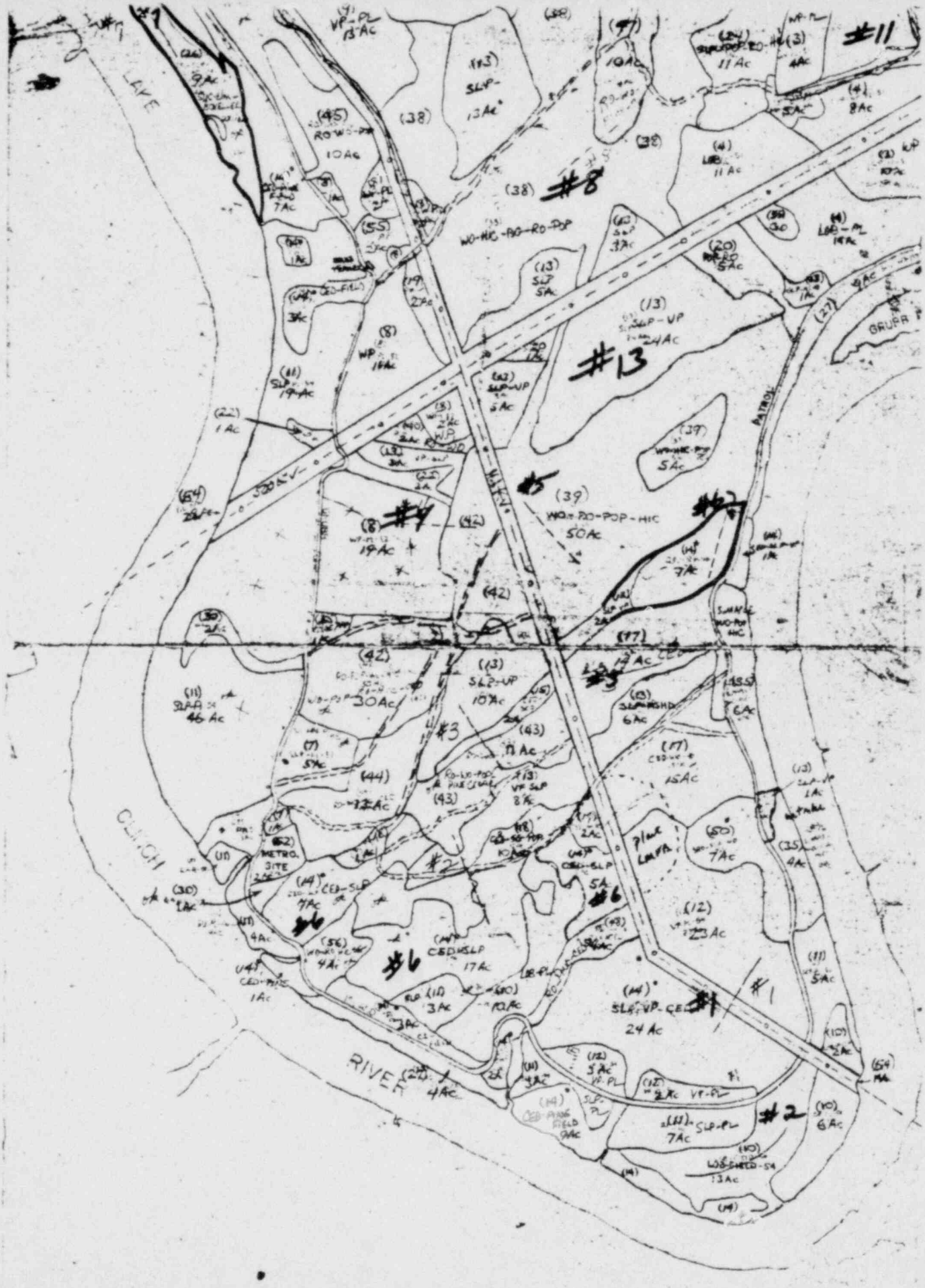
STRATUM #	FOREST COVER TYPE	ACREAGE
1	LOB - PL - 48	42
2	SLP - PL - 81	35
3	WP - PL - 51	37
4	LOB - PL - 51	14
5	LOB SLP - PL 51	2
6	LOB WP - PL - 52	7
7	SLP - PL 52	6
8	WP PL - 52	37

LEGEND

- ABANDONED DWELLING
- INDIAN MOUND



#10
#11
#8
#13
(1)
29 A
(13)
VP-SLP
15 Ac
(23)
15 Ac
(23)
17 Ac
(13)
SLR-VP
7 Ac
(37)
57 Ac
(36)
CO-BO
17 Ac
(38)
41 Ac
(37)
34 Ac
(38)
88 Ac
LOB-PL
(4)
27 Ac
(9)
VP-PL
13 Ac
(13)
SLP
13 Ac
(45)
10 Ac
(38)
(13)
SLP-VP
24 Ac
(8)
WP
11 Ac
(11)
SLP
19 Ac
(20)
(4)
8 Ac
PATROL


#1
#2
#3
#4
#5
#6
#7
#8
#11
#13
LAKE
CLINCH
RIVER
PATRIOT
GRUFF
(38)
(39)
(42)
(44)
(43)
(45)
(55)
(54)
(13) SLP-UP 24Ac
(39) WO-RO-POP-HIC 50Ac
(42) 30Ac
(8) 19Ac
(44) 32Ac
(43) 11Ac
(38) #8
(13) #13
(42) #4
(39) #5
(44) #6
(43) #3
(44) #1
(42) #2
(45) RO-WO-POP 10Ac
(38) 13Ac
(13) SLP 10Ac
(13) SLP-UP 10Ac
(11) SLP-PL 46 Ac
(44) CED-SLP 17Ac
(44) SLP-VP-CED 24 Ac
(42) METRO SITE
(42) 19Ac
(39) 50Ac
(43) 11 Ac
(42) 30Ac
(44) 32Ac
(44) CED-SLP 17Ac
(44) SLP-VP-CED 24 Ac

2-20

Section 2.7.1
Reference 17

REFERENCE 2-20

16

JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE
VOLUME 54, NUMBER 3, JULY, 1979

PLANT SPECIES ON THE DEPARTMENT OF ENERGY-OAK RIDGE RESERVATION THAT ARE RARE, THREATENED OR OF SPECIAL CONCERN [1,2]

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ABSTRACT

The need to protect endangered organisms has gained increased awareness during the past decade. These efforts have only recently been expanded to include plants. Lists of candidate species have been compiled for review and status designation by appropriate governmental actions. The Smithsonian Report (U.S. Congress 1975) has recommended that the preservation of critical habitats be adopted as a major management practice to ensure the survival of endangered and threatened plant species.

In compliance with federal guidelines, plants occurring on the U.S. Department of Energy (DOE) Oak Ridge Reservation that are considered rare, threatened or of special concern have been located, identified and provided protection (Oak Ridge Operations 1975). Although only nine candidate species are known to occur on the area, efforts are being made to locate additional species that have been casually observed and reported but not verified by voucher specimens. The purpose of this activity is to summarize present knowledge of the occurrence and distribution of threatened and endangered plant species for long-range management decisions of the DOE-Oak Ridge Reservation.

INTRODUCTION

In 1973 the Endangered Species Act was expanded to include plants in addition to fish and wildlife already protected. As stated, "the purposes of this act are to provide a means whereby ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth . . ." (U.S. Congress 1973).

A. J. Sharp of the University of Tennessee published a list of "Rare Plants of Tennessee" in July 1974. He stated that "the only satisfactory way of avoiding the extinction of rare plants is the selection and maintenance of areas in which are found the peculiar habitats necessary to their survival" (Sharp 1974). Life history studies and propagation may be alternative methods of not only avoiding plant extinction but also for obtaining knowledge necessary for selection and maintenance of the habitats of the plants.

The Smithsonian's "Report on Endangered and Threatened Plant Species of the United States" was published in December 1974 (U.S. Congress 1975). It included the first national tabulation of candidate species for designation as endangered, threatened, recently extinct, or commercially exploited plant species of the United States (including Alaska and Hawaii). Recommendations to Congress were presented, along with discussion of the value of retaining diverse plant species, causes of rarity, and preservation. The major recommendation made concerned the preservation of the habitats of endangered and threatened species of plants.

In May 1975, the U.S. Department of Agriculture, Soil Conservation Service, published "Rare, Threatened, or Endangered Plant Species of Tennessee." The report emphasized the importance of plant habitat consideration in land-use planning (Soil Conservation Service 1975).

The U.S. Department of the Interior, Fish and Wildlife Service, printed the Smithsonian Report in the *Federal Register* June 1976 (*Federal Register* 1975). The Director, U.S. Fish and Wildlife Service, has proposed that the approximately 1700 native, U.S. vascular plant taxa on the Smithsonian list to be considered as endangered species.

A "Workshop on Rare Tennessee Plants" was held November 18, 1976, to discuss and incorporate comments on a preliminary list of "Tennessee Rare Plants" prepared by members of the Tennessee Committee for Rare Plants (Tennessee Committee for Rare Plants 1976). In addition to discussing the list, concern was expressed regarding the need for accurate information regarding the status of Tennessee's rare plants in order to achieve environmentally sound land-use planning and development in the future.

HABITAT AND SPECIES PRESERVATION

The establishment of several natural areas on the Oak Ridge Reservation reflects the DOE concern for the preservation of unique or representative biotic features. In response to a request by the DOE Division of Biomedical and Environmental Research personnel, the

[1] Research sponsored by the Department of Energy under contract with Union Carbide Corporation.
[2] Publication No. 1144, Environmental Sciences Division, ORNL.

Environmental Sciences Division at Oak Ridge National Laboratory reviewed the Fish and Wildlife Service Endangered Species list with regard to the DOE Oak Ridge Reservation. Most of the rare plants on the DOE Oak Ridge Reservation that have been located are in Environmental Research Park natural areas (Kitchings and Mann 1976). In order to ensure protection of additional species, efforts are being made to locate species that have been seen at one time but not verified by voucher specimens or species whose habitat requirements suggest there is a high probability they occur on the DOE Oak Ridge Reservation.

Locating and identifying endangered species are important first steps to be taken in species preservation. Long-term protection of sensitive species is potentially hampered by the lack of knowledge concerning species biology. Protection of endangered species in their native habitat is considered by some as the best method of ensuring their survival (Forest Service 1977). Indiscriminant modification or destruction of habitat could not only cause a reduction of the population but also result in a restriction of the population's expansion and recovery. Many species, however, are rare because they occupy unusual, often temporary habitats and may be dependent on some type of interference. Natural history studies and propagation of sensitive species are important in determining the plant's environmental requirements. Careful management of the habitat might be necessary to maintain the species. But before any habitat can be managed to protect a species, it is necessary to determine whether the species is reproducing and its reproductive potential. Once propagules are dispersed it is essential to know the processes active in establishing the species. Thus, the species autecology must be studied to plan for scientific and beneficial management of the habitats where the species survive.

Methods and Results

A combined rare plant list was compiled incorporating all candidate species included on each of the following lists: USDA-SCS, USDI-Federal Register, Tennessee Committee for Rare Plants, and A. J. Sharp. The computer output was an alphabetical listing of the species, the lists on which they occurred and their current status.

The "Combined Rare Plant List" was then compared to the species listed in "Oak Ridge, Tennessee, Flora: Habitats of the Vascular Plants—Revised Inventory" (Mann and Bierner 1975). Species included in the Mann-Bierner report are recorded from Anderson, Knox, Loudon, Morgan and Roane Counties. Species listed as occurring in Anderson and Roane Counties were checked in the Oak Ridge National Laboratory (ORNL) and University of Tennessee (UT) herbaria to verify their identity and occurrence on the Oak Ridge Reservation.

TABLE 1: *Plants of the Oak Ridge Reservation that are Rare, Threatened or of Special Concern*

Genus Species Authority	Family	Common Name	List	Status	Flower	Seed	Habitat
Cimicifuga rubifolia Kearney	Ranunculaceae	Bugbane	USDI-Fed Reg [1] USDA-SCS [4]	Threatened Threatened	August	August	Rich, sheltered steep limestone bluff
Delphinium exaltatum Ait.	Ranunculaceae	Tall Larkspur	TCRP [3]	Special concern	July-August	October	Dry, calcareous, open woodland
Fothergilla major (Sims) Lodd	Hamamelidaceae	Large Fothergilla	TCRP [3] Sharp [2] USDA-SCS [4]	Threatened Rare Rare	April-May	July-October	Dry woods
Hydrastis canadensis L.	Ranunculaceae	Goldenseal	Sharp [2]	Rare	April-May	July	Rich woods
Lilium canadense L.	Liliaceae	Canada Lily	TCRP [3]	Threatened	June-July	July-August	Edge of woods
Panax quinquefolius L.	Araliaceae	Ginseng	Sharp [2] USDA-SCS [4]	Rare Rare	June-July	August-October	Rich, cool, moist woods
Philadelphus sharpianus Hu	Saxifragaceae	Sharp's Mock-Orange	Sharp [2]	Rare	May	June-September	Wooded, limestone bluff
Saxifraga careyana Gray	Saxifragaceae	Carey's Saxifrage	USDI-Fed Reg [1] USDA-SCS [4]	Threatened Threatened	April	June	Wooded, limestone bluff
Spiranthes ovalis Lindley	Orchidaceae	Lesser Ladies' Tresses	TCRP [3] USDA-SCS [4]	Special Concern Rare	August-October	November	Moist, shady, rich woods

[1] Federal Register—Threatened or Endangered Fauna or Flora, Vol. 4[illegible] No. 127, 1975.
[2] Sharp, A. J. *Tennessee Conservationist*, July 1974.
[3] Tennessee Committee for Rare Plants, J. L. Collins (TVA), H. R. DeSelm (UT), A. M. Evans (UT), R. Kral (Vanderbilt) and B. E. Wofford (UT), September 1976.
[4] Rare, Threatened or Endangered Plant Species of Tennessee, U.S. Dept. of Agriculture, Soil Conservation Service, Nashville, May 1975.

A summary of the status of rare plants on the DOE-Oak Ridge Reservation is presented in Table 1. The three categories (rare, threatened, and special concern) are defined as follows:

Rare—species which presently occur infrequently, are relatively few and widely separated, possibly due to habitat requirements, habitat destruction or commercial exploitation.

Threatened—as described by Tennessee Committee for Rare Plants (1978), species likely to become endangered in the immediately foreseeable future as a result of present rapid habitat destruction or commercial exploitation.

Special Concern—plants listed by Tennessee Committee for Rare Plants (1978) as requiring particular attention because they are at the limit or near-limit of the geographic range in Tennessee, or because their status is undetermined due to insufficient information.

Information concerning common name, phenology and habitat was obtained from both reference materials and herbarium specimens. Further information on each species and county occurrence maps are available (Parr and Taylor 1978).

Three plant species, although not listed on any rare plant species lists for Tennessee, are of special interest in this area. Trailing arbutus (*Epigea repens* L.) has become scarce or disappeared over a large part of its extensive range. In remote areas and in places where it is protected, it continues to thrive (Stupka 1965). This prostrate shrub occurs frequently on the DOE Oak Ridge Reservation growing on gravelly, wooded, acidic slopes. Prickly pear [*Opuntia compressa* (Salisb.) Macbr.] is abundant in the cedar glades and limestone soils of Middle and East Tennessee. Occurrence on the DOE-Oak Ridge Reservation is limited to cedar glades and barrens on limestone outcrops. Scarcity of prickly pear in this area is most likely due to absence of appropriate habitat substrata. Compass plant (*Silphium terebrinthinaceum* Jacq.) is indicative of barren (prairie) areas. Its presence on the DOE-Oak Ridge Reservation may actually be increasing due to opening up and clearing of previously forested areas.

With increased demands on natural resources, land management decisions and practices have an added potential to influence the status of threatened and endangered plant species. The review of the status of plant species in any area is a logical first step in summarizing the present knowledge of the occurrence and distribution of rare or endangered species. A primary purpose of this activity has been to verify the identity and existence of endangered species on the Oak Ridge Reservation. A secondary objective has been to stimulate interest in species biology. Knowledge of species biology, combined with occurrence and distribution data, is essential to delineate maintenance strategies for land management decisions.

ACKNOWLEDGEMENTS

The suggestions and assistance in locating rare plants by Linda Mann and Tom Kitchings is greatly appreciated. Lynn Tharp of the Computer Sciences Division is gratefully acknowledged for assistance in programming the "Combined Rare Plant List." Appreciation is also expressed to Dr. H. R. DeSelm of the University of Tennessee.

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ENDANGERED AND THREATENED PLANTS OF THE UNITED STATES

EDWARD S. AYENSU

and

ROBERT A. DeFILIPPS

With the Assistance of

SAM E. FOWLER, MARY G. MANGONE,

CAROL MATTI-NATELLA, *and* WILLIAM E. RICE

Published jointly by

the SMITHSONIAN INSTITUTION *and the* WORLD WILDLIFE FUND, INC.

Washington, D.C.

1978

STATE LISTS OF ENDANGERED, EXTINCT AND THREATENED SPECIES IN THE CONTINENTAL UNITED STATES

STATE	STATUS	FAMILY	SPECIES
SOUTH CAROLINA	THREATENED	LAURACEAE	LITSEA AESTIVALIS
SOUTH CAROLINA	THREATENED	LILIACEAE	TRILLIUM PUSILLUM VAR. PUSILLUM
SOUTH CAROLINA	THREATENED	ORCHIDACEAE	PLATANTHERA FLAVA
SOUTH CAROLINA	THREATENED	ORCHIDACEAE	PLATANTHERA INTEGRA
SOUTH CAROLINA	THREATENED	ORCHIDACEAE	PLATANTHERA PERAMOENA
SOUTH CAROLINA	THREATENED	POACEAE	CALAMOVILFA BREVIPILIS VAR. BREVIPILIS
SOUTH CAROLINA	THREATENED	POACEAE	PANICUM LITHOPHILUM
SOUTH CAROLINA	THREATENED	POACEAE	SPOROBOLUS TERETIFOLIUS
SOUTH CAROLINA	THREATENED	PRIMULACEAE	LYSIMACHIA ASPERULAEFOLIA
SOUTH CAROLINA	THREATENED	RHAMNACEAE	SAGERETIA MINUTIFLORA
SOUTH CAROLINA	THREATENED	ROSACEAE	AGRIMONIA INCISA
SOUTH CAROLINA	THREATENED	ROSACEAE	WALDSTEINIA LOBATA
SOUTH CAROLINA	THREATENED	RUBIACEAE	PINCKNEYA PUBENS
SOUTH CAROLINA	THREATENED	SANTALACEAE	NESTRONIA UMBELLULA
SOUTH CAROLINA	THREATENED	SCHISANDRACEAE	SCHISANDRA GLABRA
SOUTH CAROLINA	THREATENED	SCROPHULARIACEAE	SCHWALBEA AMERICANA
SOUTH DAKOTA	THREATENED	ORCHIDACEAE	CYPRIPEDIUM CANDIDUM
SOUTH DAKOTA	THREATENED	ORCHIDACEAE	PLATANTHERA LEUCOPHAEA
TENNESSEE	ENDANGERED	ASTERACEAE	ECHINACEA TENNESSEENSIS
TENNESSEE	ENDANGERED	ASTERACEAE	HETEROTHECA RUTHII
TENNESSEE	ENDANGERED	ASTERACEAE	SILPHIUM BRACHIATUM
TENNESSEE	ENDANGERED	ASTERACEAE	SILPHIUM INTEGRIFOLIUM VAR. GATTINGERI
TENNESSEE	ENDANGERED	BRASSICACEAE	ARABIS PERSTELLATA VAR. AMPLA
TENNESSEE	ENDANGERED	BRASSICACEAE	DENTARIA INCISA
TENNESSEE	ENDANGERED	BRASSICACEAE	LEAVENWORTHIA EXIGUA VAR. LUTEA
TENNESSEE	ENDANGERED	BRASSICACEAE	LESQUERELLA DENSIPILA
TENNESSEE	ENDANGERED	BRASSICACEAE	LESQUERELLA PERFORATA
TENNESSEE	ENDANGERED	BRASSICACEAE	LESQUERELLA STONENSIS
TENNESSEE	ENDANGERED	CRASSULACEAE	SEDUM NEVII
TENNESSEE	ENDANGERED	EUPHORBIACEAE	CROTON ALABAMENSIS
TENNESSEE	ENDANGERED	FABACEAE	APIOS PRICEANA
TENNESSEE	ENDANGERED	FABACEAE	PETALOSTEMUM FOLIOSUM
TENNESSEE	ENDANGERED	LAMIACEAE	CONRADINA VERTICILLATA
TENNESSEE	ENDANGERED	LAMIACEAE	PYCNANTHEMUM CURVIPES
TENNESSEE	ENDANGERED	POACEAE	CALAMOVILFA ARCUATA
TENNESSEE	ENDANGERED	POACEAE	GLYCERIA NUBIGENA
TENNESSEE	ENDANGERED	POLYGONACEAE	ERIOGONUM LONGIFOLIUM VAR. HARPERI
TENNESSEE	ENDANGERED	POLYPODIACEAE	PHYLLITIS SCOLOPENDRIUM VAR. AMERICANUM
TENNESSEE	ENDANGERED	RANUNCULACEAE	CLEMATIS GATTINGERI
TENNESSEE	ENDANGERED	ROSACEAE	GEUM GENICULATUM
TENNESSEE	ENDANGERED	ROSACEAE	GEUM RADIATUM
TENNESSEE	EXTINCT	HYDROCHARITACEAE	ELODEA LINEARIS
TENNESSEE	THREATENED	ARALIACEAE	PANAX QUINQUEFOLIUS

STATE LISTS OF ENDANGERED, EXTINCT AND THREATENED SPECIES IN THE CONTINENTAL UNITED STATES

STATE	STATUS	FAMILY	SPECIES
TENNESSEE	THREATENED	ARISTOLOCHIACEAE	HEXASTYLIS CONTRACTA
TENNESSEE	THREATENED	ASTERACEAE	CACALIA RUGELIA
TENNESSEE	THREATENED	ASTERACEAE	PRENANTHES ROANENSIS
TENNESSEE	THREATENED	ASTERACEAE	SOLIDAGO SPITHAMAEA
TENNESSEE	THREATENED	BORAGINACEAE	ONOSMODIUM MOLLE
TENNESSEE	THREATENED	BRASSICACEAE	LEAVENWORTHIA EXIGUA VAR. EXIGUA
TENNESSEE	THREATENED	BRASSICACEAE	LEAVENWORTHIA STYLOSA
TENNESSEE	THREATENED	BRASSICACEAE	LEAVENWORTHIA TORULOSA
TENNESSEE	THREATENED	BRASSICACEAE	LESQUERELLA GLOBOSA
TENNESSEE	THREATENED	BRASSICACEAE	LESQUERELLA LESCURII
TENNESSEE	THREATENED	CAMPANULACEAE	LOBELIA GATTINGERI
TENNESSEE	THREATENED	CARYOPHYLLACEAE	ARENARIA FONTINALIS
TENNESSEE	THREATENED	CYPERACEAE	CAREX AUSTROCAROLINIANA
TENNESSEE	THREATENED	CYPERACEAE	CAREX MISERA
TENNESSEE	THREATENED	CYPERACEAE	CAREX PURPURIFERA
TENNESSEE	THREATENED	CYPERACEAE	CAREX ROANENSIS
TENNESSEE	THREATENED	CYPERACEAE	CYMOPHYLLUS FRASERI
TENNESSEE	THREATENED	ERICACEAE	RHODODENDRON BAKERI
TENNESSEE	THREATENED	FABACEAE	ASTRAGALUS TENNESSEENSIS
TENNESSEE	THREATENED	FABACEAE	CLADRASTIS LUTEA
TENNESSEE	THREATENED	FABACEAE	PETALOSTEMUM GATTINGERI
TENNESSEE	THREATENED	FABACEAE	PSORALEA SUBACAULIS
TENNESSEE	THREATENED	HYPERICACEAE	HYPERICUM SPHAEROCARPUM VAR. TURGIDUM
TENNESSEE	THREATENED	JUNCACEAE	JUNCUS GYMNOCARPUS
TENNESSEE	THREATENED	LAMIACEAE	SCUTELLARIA MONTANA
TENNESSEE	THREATENED	LAMIACEAE	SYNANDRA HISPIDULA
TENNESSEE	THREATENED	LILIACEAE	LILIUM GRAYII
TENNESSEE	THREATENED	LILIACEAE	TRILLIUM PUSILLUM VAR. PUSILLUM
TENNESSEE	THREATENED	ORCHIDACEAE	PLATANTHERA FLAVA
TENNESSEE	THREATENED	ORCHIDACEAE	PLATANTHERA INTEGRA
TENNESSEE	THREATENED	ORCHIDACEAE	PLATANTHERA PERAMOENA
TENNESSEE	THREATENED	POACEAE	CALAMAGROSTIS CAINII
TENNESSEE	THREATENED	POACEAE	MUHLENBERGIA TORREYANA
TENNESSEE	THREATENED	PORTULACACEAE	TALINUM CALCARICUM
TENNESSEE	THREATENED	PORTULACACEAE	TALINUM MENGESII
TENNESSEE	THREATENED	RANUNCULACEAE	CIMICIFUGA RUBIFOLIA
TENNESSEE	THREATENED	RANUNCULACEAE	HYDRASTIS CANADENSIS
TENNESSEE	THREATENED	RUBIACEAE	HEDYOTIS PURPUREA VAR. MONTANA
TENNESSEE	THREATENED	SANTALACEAE	BUCKLEYA DISTICHOPHYLLA
TENNESSEE	THREATENED	SAXIFRAGACEAE	SAXIFRAGA CAREYANA
TENNESSEE	THREATENED	SAXIFRAGACEAE	SAXIFRAGA CAROLINIANA
TENNESSEE	THREATENED	SCHISANDRACEAE	SCHISANDRA GLABRA
TENNESSEE	THREATENED	SCROPHULARIACEAE	AUREOLARIA PATULA

STATE LISTS OF ENDANGERED, EXTINCT AND THREATENED SPECIES IN THE CONTINENTAL UNITED STATES

STATE	STATUS	FAMILY	SPECIES
TENNESSEE	THREATENED	SCROPHULARIACEAE	SCHWALBEA AMERICANA
TENNESSEE	THREATENED	VIOLACEAE	VIOLA EGGLESTONII
TEXAS	ENDANGERED	ASCLEPIADACEAE	MATELEA EDWARDSENSIS
TEXAS	ENDANGERED	ASCLEPIADACEAE	MATELEA TEXENSIS
TEXAS	ENDANGERED	ASTERACEAE	AMBROSIA CHEIRANTHIFOLIA
TEXAS	ENDANGERED	ASTERACEAE	BRICKELLIA VIEJENSIS
TEXAS	ENDANGERED	ASTERACEAE	COREOPSIS INTERMEDIA
TEXAS	ENDANGERED	ASTERACEAE	DYSSODIA TEPHROLEUCA
TEXAS	ENDANGERED	ASTERACEAE	ERIGERON GEISERI VAR. CALCICOLA
TEXAS	ENDANGERED	ASTERACEAE	GRINDELIA DOLEPIS
TEXAS	ENDANGERED	ASTERACEAE	HELIANTHUS PARADOXUS
TEXAS	ENDANGERED	ASTERACEAE	MACHAERANTHERA AUREA
TEXAS	ENDANGERED	ASTERACEAE	PERITYLE BISETOSA VAR. BISETOSA
TEXAS	ENDANGERED	ASTERACEAE	PERITYLE BISETOSA VAR. SCALARIS
TEXAS	ENDANGERED	ASTERACEAE	PERITYLE CINEREA
TEXAS	ENDANGERED	ASTERACEAE	PERITYLE LINDHEIMERI VAR. HALIMIFOLIA
TEXAS	ENDANGERED	ASTERACEAE	PERITYLE VITREOMONTANA
TEXAS	ENDANGERED	ASTERACEAE	VIGUIERA LUDENS
TEXAS	ENDANGERED	BRASSICACEAE	LEAVENWORTHIA AUREA
TEXAS	ENDANGERED	BRASSICACEAE	LESQUERELLA VALIDA
TEXAS	ENDANGERED	BRASSICACEAE	SELENIA JONESII
TEXAS	ENDANGERED	BRASSICACEAE	STREPTANTHUS SPARSIFLORUS
TEXAS	ENDANGERED	BRASSICACEAE	THELYPODIUM TEXANUM
TEXAS	ENDANGERED	CACTACEAE	ANCISTROCACTUS TOBUSCHII
TEXAS	ENDANGERED	CACTACEAE	CORYPHANTHA MINIMA
TEXAS	ENDANGERED	CACTACEAE	CORYPHANTHA RAMILLOSA
TEXAS	ENDANGERED	CACTACEAE	CORYPHANTHA SNEEDII VAR. SNEEDII
TEXAS	ENDANGERED	CACTACEAE	CORYPHANTHA STROBILIFORMIS VAR. DURISPINA
TEXAS	ENDANGERED	CACTACEAE	ECHINOCEREUS CHLORANTHUS VAR. NEOCAPILLUS
TEXAS	ENDANGERED	CACTACEAE	ECHINOCEREUS LLOYDII
TEXAS	ENDANGERED	CACTACEAE	ECHINOCEREUS REICHENBACHII VAR. ALBERTII
TEXAS	ENDANGERED	CACTACEAE	ECHINOCEREUS RUSSANTHUS
TEXAS	ENDANGERED	CACTACEAE	ECHINOCEREUS VIRIDIFLORUS VAR. DAVISII
TEXAS	ENDANGERED	CACTACEAE	NEOLLOYDIA GAUTII
TEXAS	ENDANGERED	CACTACEAE	NEOLLOYDIA MARIPOSENSIS
TEXAS	ENDANGERED	CAPPARIDACEAE	CLEOME MULTICAULIS
TEXAS	ENDANGERED	CARYOPHYLLACEAE	CERASTIUM CLAWSONII
TEXAS	ENDANGERED	CARYOPHYLLACEAE	PARONYCHIA CONGESTA
TEXAS	ENDANGERED	CARYOPHYLLACEAE	PARONYCHIA MACCARTII
TEXAS	ENDANGERED	CARYOPHYLLACEAE	SILENE PLANKII
TEXAS	ENDANGERED	CHENOPODIACEAE	ATRIPLEX KLEBERGORUM
TEXAS	ENDANGERED	CHENOPODIACEAE	SUAEDA DURIPES
TEXAS	ENDANGERED	CISTACEAE	LECHEA MENSALIS