Station Paper No. 72

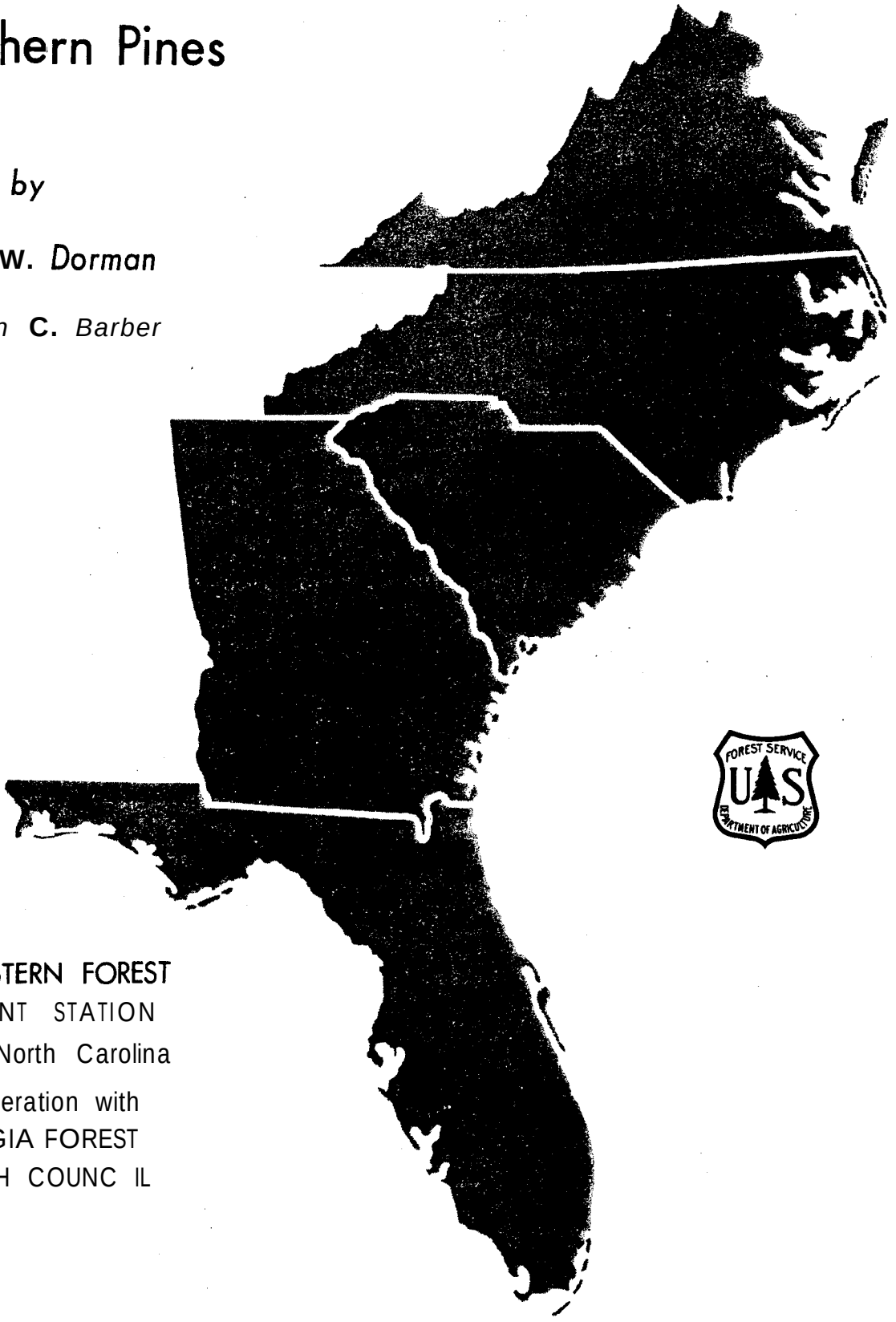
October 1956

Time of Flowering and Seed Ripening in Southern Pines

by

Keith W. Dorman

and John **C.** *Barber*



SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina
in cooperation with
GEORGIA FOREST
RESEARCH COUNC IL

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

FOREWORD

This publication was prepared under the sponsorship of the Committee on Southern Forest Tree Improvement by the Subcommittee on Tree Selection and Breeding. It is the purpose of the Committee: to advise and assist those interested in the improvement of southern forest trees in arranging and conducting research and development programs; to provide a clearing house for information on forest tree improvements; to provide for or assist in coordination in the conduct of a Southwide program of tree improvement research and development; and to foster and encourage the advancement of knowledge of southern tree genetics.

ACKNOWLEDGMENTS

The authors wish to acknowledge with thanks the assistance of many foresters who reported phenological data for southern pines in their areas. Individuals and organizations reporting were:

Frank A. Bennett, U. S. Forest Service,' Cordele, Ga.
V. B. Davis, U. S. Forest Service, Brewton, Ala.
H. J. Derr, U. S. Forest Service, Alexandria, La.
L. T. Easley, West Virginia Pulp and Paper Co., Georgetown, S. C.
Southern Institute of Forest Genetics, Gulfport, Miss.
Glenn P. Haney, U. S. Forest Service, Union, S. C.
B. J. Huckenpahler, U. S. Forest Service, Oxford, Miss.
W. P. LeGrande, Jr., U. S. Forest Service, Moncks Corner, S. C.
Clement Mesavage, U. S. Forest Service, Harrison, Ark.
T. 0. Perry, University of Florida, Gainesville, Fla.
F. I. Righter, U. S. Forest Service, Berkeley, Calif.
R. E. Schoenike, U. S. Forest Service, Crossett, Ark.
George K. Stephenson, U. S. Forest Service, Nacogdoches, Tex.
H. K. Taylor, U. S. Forest Service, Como, N. C.
K. B. Trousdell, U. S. Forest Service, Franklin, Va.
Herbert A. Yoco.m, U. S. Forest Service, Birmingham, Ala.
Bruce Zobel, Texas Forest Service, College Station, Tex.

TIME OF FLOWERING AND SEED RIPENING IN SOUTHERN PINES

by

Keith W. Dorman and John C. Barber
Athens-Macon Research Center, Macon, Georgia

INTRODUCTION

Accurate knowledge of the time of year when pine flowers and seeds ripen is of vital importance to forest tree breeders and foresters responsible for seed procurement. The recent rise in interest and activity in breeding southern yellow pines has pointed up the fact that very little is known about the pattern of flower development and seed ripening for each species over the South. Certainly the need for this information is great. Seedlings of the southern yellow pines are being planted in astronomical numbers--over 300 million in 1954. Selection of superior individual trees and races, controlled pollination within and between species, and studies of inheritance of good and bad traits are being carried on by many workers in the South. Seed orchards are being established with grafted stock of outstanding wild trees. Seed, pollen, and scion material are being widely exchanged by technicians in tree genetics who could much better plan their cooperative work if they knew the time of flowering and seed ripening throughout the 200 million acres of the southern pine area extending from Virginia to Texas.

For such reasons, under the sponsorship of the Southern Tree Improvement Committee, forms for reporting pollen and seed ripening data were sent in January 1954 to forest research personnel at experimental forests and other research stations throughout the South. Cooperators were asked to report data for 1954 and other records that might be available. The response to the questionnaire was excellent. Data were obtained for many locations over the geographic range of the major southern pines. However, the data were very scarce for minor species, and additional observations will be required before accurate dates of flowering and seed ripening are determined for all parts of the range.

EARLY OBSERVATIONS ON PHENOLOGY OF FOREST TREES

Interest of botanists in phenology, which can be defined as the science of the relations between climate and periodic biological phenomena, has been active for years. In 1915; Lamb (6) published in chart form for a great many species the time of leafing, full foliage, flowering, seed ripening, seed falling, and leaf falling. In 1953, Duffield (4) revised an earlier publication, giving pine pollen collection dates with data on annual and geographic variation based on observation at the Institute of Forest Genetics in California. He states that Pinus ponderosa *on* the *west* slope of the Sierra Nevada show a difference of 8

days in pollen collection per 1, OOO-feet difference in elevation, and that his figure agrees moderately well with Hopkins' (5) constant of 4 days for each 400-feet difference in elevation. The order of bloom of trees and shrubs at the Arnold Arboretum has been given by Wyman (15). A method for describing and comparing blooming seasons has been given by Anderson and Hubricht (1).

In the northeast, Wright (13) reported date of flowering of a large number of hardwood and softwood species for 1947 through 1951. He states that there was a slight telescoping of the over-all flowering season in years when flowering, started late. The telescoping was not equal for all species or all portions of the flowering season, because weather during and before the season influenced flowering. The spread in flowering time within species was greatest in the early-flowering maples and ashes. This spread varied from 0 to 2 weeks in different years. Much of the spread was associated with location of the trees. But in all species half or more of the spread occurred within rather small groups of trees. In most species, extreme cases of earliness or lateness remained constant from year-to-year, whereas trees differing by only a few days often shifted their relative order in flowering. He also reviews published phenological records for the Northeast and Lake States.

In Australia, Millett (9) observed that air and soil temperatures were associated with the first ripening of male flowers of Monterey pine. Also, he found that the extension of the pollen season beyond the initial ripening stage was more closely related to sunshine, evaporation, and wind than to other meteorologic factors. Leven (7) discussed for European and Japanese larch the effects on flowering of frost, longitude, latitude, altitude, aspect, exposure, and age of tree. The duration of flowering at 17 stations in Scotland is given for both species of larch as well as the earliest dates of flowering for each between 1924 and 1943. Sarvas (10) discussed at length the biology of flowering in Betula verrucosa Ehrh. and Betula pubescens Ehrh. and established the general course of the 'annual and daily cycle of pollination.

Numerous observations on flowering and seed ripening have been made in the South. Coker and Totten (2) mention time of pollen shedding for some of the trees described in their book. Dorman, et al. [1/] recorded time of pollen shedding and female flower receptivity for slash and longleaf pine used in breeding for improved gum yields at Lake City, Florida. For slash pine pollen shedding began about February 1 and extended to February 20, but varied from year-to-year. Also, some trees were consistently earlier than others in time of flowering.

In Texas, Zobel and Goddard (16) found that in general slash pine is pollinated from the latter part of January to early in February, loblolly pine and longleaf pine from late February to the middle of March, and shortleaf pine from late March to early in April. They also found variation in time of blooming and seed ripening between trees and between seasons,

1/ Unpublished office reports of the tree-breeding project on file at the Lake City Research Center, Lake City, Florida.

The relation between stages of flower development and various operations in controlled pollination of trees has been discussed for slash pine by Snow, Dorman, and Schopmeyer (11); for northeastern hardwood and softwood species by Wright (14); and for pines in California by Cumming and Righter (3).

Ripening of southern pine seed varies from year to year, but probably greater variation occurs in cone opening, because of variable humidity (16). Based on observations from Georgia, and from Florida to Texas, slash pine cones mature from September 1 to 10; loblolly, September 20 to October 10; and longleaf and shortleaf, October 3. to 20 (12).

POLLEN AND SEED RIPENING DATES FOR SOUTHERN PINES IN 1954

This paper reports data for 1954 for the major species of southern pine and less completely for the minor species. Data for pines growing in the Southern Appalachians are included.

Observations on time of pollen and seed ripening are given in tables 1 through 5. Where dates were reported as early, middle, or late in the month, they were converted to the 5th, 15th, and 25th, respectively, to create uniformity in the tables. The questionnaire suggested that the general period of pollen ripening and other dates be reported in general terms; however, actual day and month were reported in most instances. The location was reported by county or parish. The latitude was read from maps, so the fractional part of a degree should be regarded as an approximation.

The data show a consistent pattern over the South in the sequence of bloom, with slash pine first, followed by longleaf, loblolly, and shortleaf.

Slash pine, with the most limited geographic range, varied least in time of pollen ripening, although the earliest reported in Alachua County, Florida, was January 20, and the latest, February 21, from a plantation of unknown source in Rapides Parish, Louisiana. Seed ripening was estimated to vary between September 1 to 15.

Longleaf pine pollen was reported ripening February 5 in Alachua County, Florida, and April 16 at Hertford County, North Carolina, which is near the northern extension of the natural range. In Jefferson County, Alabama, at an elevation of 500 feet, pollen was ripe March 20. Over a wide range, seed ripened September 10 to mid-October.

In loblolly and shortleaf pine, a similar pattern of time of bloom in relation to latitude and elevation occurred. In Berkeley County, South Carolina, which is near the coast at an elevation of about 40 feet, loblolly pollen ripened March 1. In Union County, where the elevation was 800 feet, it ripened April 1. Shortleaf pine pollen ripened March 7 and April 16 at the same stations. Seed ripened between September 20 and October 20 for both species.

Table 1. --Slash pine flowering and seed ripening dates in 1954 by state, county, latitude, and elevation

State	County	North latitude	Elevation	Pollen ripening		Seed ripening	
				Start	End	Start	End
		Degrees	Feet	Date			
South Carolina 1/	Georgetown	33° 25'	--	2-10	--	--	--
Georgia	Dooly	32° 0 '	350	2-2	2-25	9-15	10-5
Florida	Columbia	30° 20'	200	1-27	2-15	9-l	IO-12
Florida	Alachua	29° 35'	155	l-21	--	9-14	--
Florida 2/	Hendry	26° 40'	30	l-20	2-20	9-5	11-1
Alabama	Escambia	31° 0 '	200	l-25	2-5	9-25	10-15
Mississipp 1/	Harrison	30° 40'	228	2-l	2-9	9-15	--
Louisiana 1/	Rapides	31° 10'	200-300	3/ 2-1	2-12	9-15	--
Louisiana	Rapides	31° 10'	200-300	2-21	--	9-15	--
Arkansas 1/	Ashley	33° 5 '	175	2-16	2-26	9-15	10-5
Texas 1/	Newton	30° 55'	100	l-25	2-15	9-15	10-15

1/ Plantation, source of seed unknown.
2/ South Florida slash pine (Pinus elliottii var. densa).
3/ For 1951 season.

Table 2. --Longleaf pine flowering and seed ripening dates in 1954 by state, county. latitude, and elevation

State	County	North latitude	Elevation	Pollen ripening		Seed ripening	
				Start	End	Start	End
		Degrees	Feet	Date			
North Carolina	Hertford	36° 30'	40	4-16	4-22	__	__
South Carolina	Georgetown	33° 25'	--	3-12	--	--	--
South Carolina	Berkeley	33° 25'	30	3-7	3-17	9-10	10-l
Georgia	Dooly	32° 0 '	350	2-25	3-26	10-l	10-30
Florida	Columbia	30° 20'	200	2-15	3-l	10-1	11-1
Florida	Alachua	29° 35'	155	2-5	3-l	--	--
Alabama	Jefferson	33° 35'	500	3-20	4-5	--	--
Alabama	Escambia	31° 0 '	250	2-23	3-15	10-15	11-10
Mississippi	Harrison	30° 40'	228	2-16	3-11	10-15	--
Louisiana	Rapides	31° 10'	200-300	2-21	3-15	1/ 10-15	--
Louisiana	Rapides	31° 10'	200-300	2/ 3-2	__	10-18	--
Arkansas 3/	Ashley	33° 5 '	175	3-13	3-25	10-5	10-25
Texas	San Augustine	31° 20'	--	--	3-12	__	__
Texas	Newton	30° 55'	100	3-15	3-25	10-5	10-25

1/ Average of 1949 to 1952.
2/ For 1951 season
3/ Plantation, source of seed unknown.

Table 3. --Loblolly pine flowering and seed ripening dates in 1954 by state, county, latitude, and elevation

State	County	North latitude	Elevation	Pollen ripening		Seed ripening	
				Start	End	Start	End
		Degrees	Feet	Date			
North Carolina	Hertford	36° 30'	40	4-6	4-15	--	11-1
South Carolina	Georgetown	33° 25'	--	3-2	--	--	--
South Carolina	Berkeley	33° 25'	30	3-1	3-15	9-20	10-15
South Carolina	Union	34° 40'	800	4-1	4-7	10-15	--
South Carolina	Union	34° 40'	800	1/ 4-16	4-23	10-15	--
Georgia	Dooly	32° 0'	350	3-8	3-27	10-10	11-15
Florida	Alachua	29° 35'	155	2-20	3-16	--	--
Alabama	Jefferson	33° 35'	500	3-20	4-5	10-15	--
Alabama	Escambia	31° 0'	150	3-8	4-1	--	--
Mississippi	Harrison	30° 40'	228	2-22	3-11	--	--
Louisiana	Rapides	31° 10'	200-300	1/ 2-21	3-15	2/ --	--
Louisiana	Rapides	31° 10'	200-300	1/ 3-4	--	2/ 10-17	--
Arkansas	Ashley	33° 5'	175	3-12	3-30	10-5	10-25
Texas	Nacogdoches	31° 35'	300	3-1	3-26	3/ --	--
Texas	Montgomery	30° 20'	150	3-5	3-30	3/ 10-1	10-15
Texas	Angelina	31° 20'	250	2-25	3-20	3/ 10-3	10-20
Texas	Bastrop	30° 5'	200	2-12	3-11	3/ 9-28	10-15

1/ For 1951 season.
2/ For 1950 season.
3/ For 1953 season.

Table 4.-- Shortleaf pine flowering and seed ripening dates in 1954 by state, county, latitude, and elevation

State	County	North latitude	Elevation	Pollen ripening		Seed ripening	
				Start	End	Start	End
		Degrees	Feet	Date			
North Carolina	Hertford	36° 30'	40	4-24	4-29	--	--
North Carolina	Durham	36° 0'	--	4-16	5-5	10-1	10-18
North Carolina	Buncombe	35° 35'	2300	5-5	5-18	10-20	11-1
South Carolina	Berkeley	33° 25'	30	3-27	4-7	--	--
South Carolina	Union	34° 40'	800	1/ 4-16	4-23	10-25	--
South Carolina	Union	34° 40'	800	1/ 4-26	--	--	--
Alabama	Jefferson	33° 35'	500	4-1	4-15	--	--
Mississippi	Harrison	30° 40'	228	3-26	4-7	--	--
Mississippi	Lafayette	34° 10'	450	4-2	4-16	10-15	11-1
Louisiana	Rapides	31° 10'	200-300	1/ 3-27	4-8	2/ 10-17	--
Louisiana	Rapides	31° 10'	200-300	1/ 3-30	--	--	--
Arkansas	Boone	36° 10'	1200	4-15	5-13	1/ 10-10	1/ 11-15
Arkansas	Ashley	33° 5'	175	4-1	4-10	10-15	11-5
Texas	Nacogdoches	31° 35'	300	3-20	4-15	--	--
Texas	Angelina	31° 20'	250	3-25	4-5	10-15	10-25

1/ For 1951 season.
2/ For 1952 season.

Table 5.-- Dates of flowering and seed ripening in 1954 for Appalachian Mountain and minor species of southern pine

Pine species	State	County	Elevation	Pollen ripening		Seed ripening	
				Start	End	Start	End
			Feet	Date			
Pond	North Carolina	Hertford	40	5-1	5-5	--	--
Pond	South Carolina	Georgetown	--	4-7	--	--	--
Pond	Florida	Columbia	200	3-24	--	--	--
Virginia	North Carolina	Buncombe	2300	4-29	--	--	--
Virginia	Alabama	Jefferson	500	3-15	3-30	--	--
Virginia 1/	Mississippi	Lafayette	450	3-30	4-19	--	--
Pitch	North Carolina	Buncombe	2300	4-29	2/ 5-11	--	--
Table-Mountain	North Carolina	Buncombe	2300	4-8	4-20	10-20	--
Spruce	South Carolina	Berkeley	30	3-15	--	--	--
Spruce	Mississippi	Harrison	228	2-23	3-7	10-25	--
Sand	Florida	--	--	12-25	1-25	--	--
Eastern white	North Carolina	Buncombe	2300	5-29	6-15	--	--

1/ Plantation, seed source unknown.
2/ Pollen in full flight.

VARIATION IN POLLEN AND SEED RIPENING IN RELATION TO LATITUDE

Time of pollen ripening in southern pines is strongly related to latitude, as shown in figures 1 through 3. This relation holds true for slash pine although the species occurs over a relatively narrow range in latitude. Slash pine plantations of unknown seed source apparently follow the same trend as wild stands. Longleaf, loblolly, and shortleaf pine pollen may ripen over a period of 2 weeks in the same latitude. Elevation becomes a factor here, and also proximity to the seacoast. However, the variation does not appear to be greater than what might be expected in year-to-year variation or tree-to-tree variation in the same stand. An exception to this generalization might occur in mountain stands as compared with others. Buncombe County, North Carolina, has elevations in excess of 2300 feet, and shortleaf pine reportedly blooms 3 weeks later than in the Piedmont.

Seed ripening occurs over a period of about 3 weeks for widely distributed species such as shortleaf, loblolly, and longleaf pine, and does not appear to vary greatly with latitude. Slash pine *seems* to vary little although two reports fell outside the general pattern. It should be kept in mind that seed ripening is difficult to observe and that considerable variation can be expected in data from different sources.

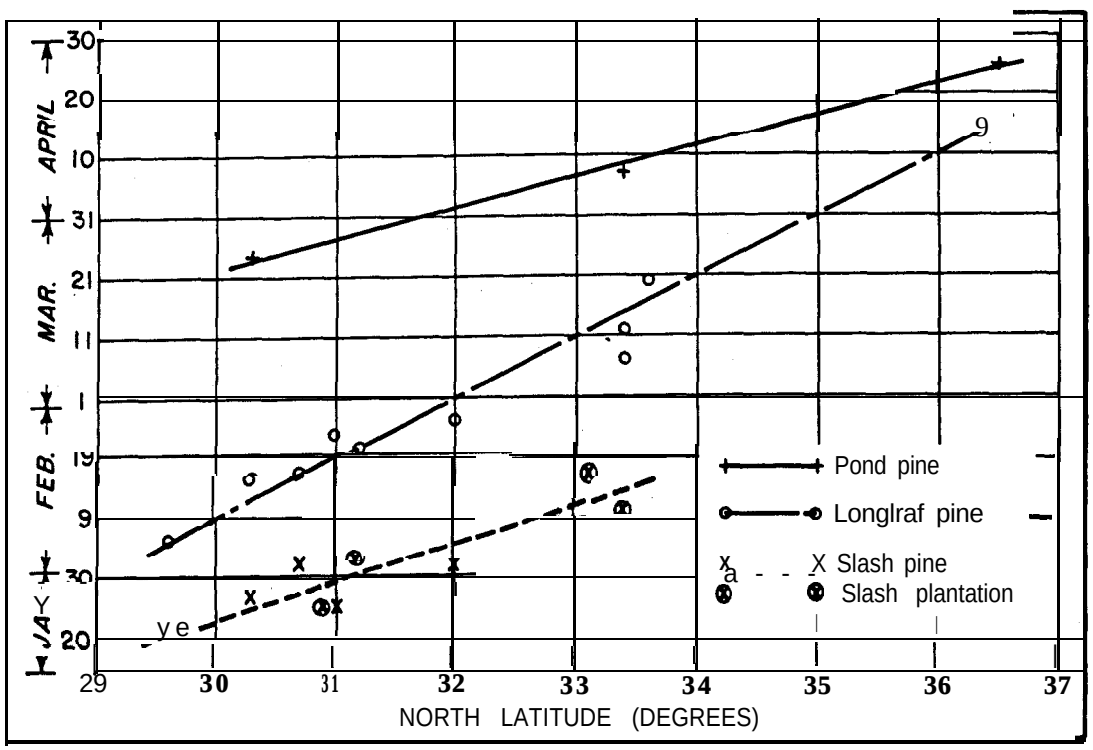


Figure 1. --Pollen ripening of pond, longleaf, and slash pine in relation to latitude,

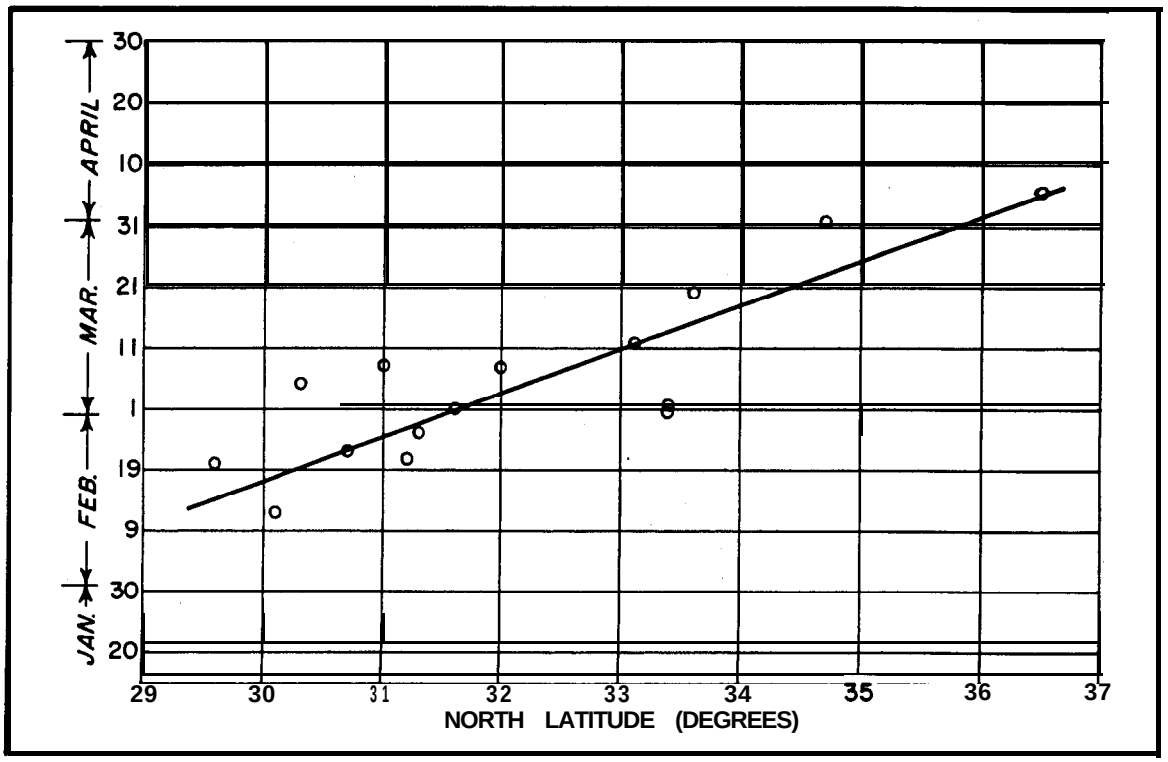


Figure 2.--Pollen ripening of loblolly pine in relation to latitude.

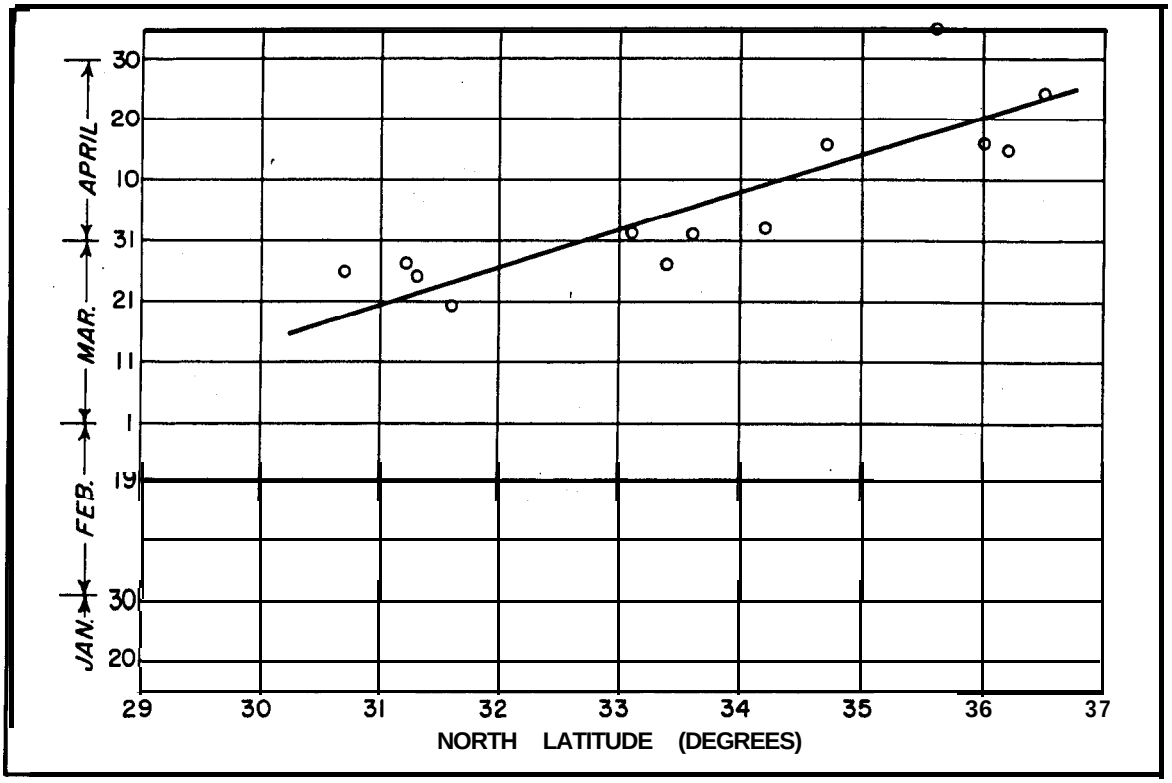


Figure 3.--Pollen ripening of shortleaf pine in relation to latitude.

VARIATION IN POLLEN RIPENING BETWEEN YEARS AND BETWEEN STANDS

At Franklin, Virginia, in the Bigwoods Experimental Forest, loblolly pine pollen was first noted on the following dates from 1948 through 1954:

Year	Date
1948	4-2
1949	3-27
1950	4-4
1951	4-12
1952	4-10
1953	3-30
1954	4-6

At the Lake City Research Center, records of stage of flower development have been kept during the pollinating season for trees in the tree breeding project. Records for a tree in Clinch County, Georgia, and a tree 10 miles south of Lake City in Columbia County, Florida, are given in table 6. These trees are about 70 miles apart. Time of pollen ripening did not vary widely between the two areas or between years except that 1949 was somewhat earlier than others.

Table 6.--Dates of pollen collection from single slash pine trees in south Georgia and northern Florida

Year	Clinch County, Georgia		Columbia County, Florida	
	Pollen ripe	Pollen shed	Pollen ripe	Pollen shed
	Date	Date	Date	Date
1943	2-2	2-12	--	--
1944	2-5	2-21	2-2	2-15
1946	2-4	--	1-23	2-11
1947	--	--	1-24	2-7
1949	1-19	--	1-21	--

In Florida, T. O. Perry [4/] observed that within a 15-mile radius of Gainesville there is a 3-week stand-to-stand spread in the time of flowering for any given species. In 1953, on the Austin Cary Forest, one stand flowered on February 5 and the other on February 20. These two stands were less than 3 miles apart. He also reported that during the spring of 1954, there was ample overlapping in the time of flowering so that slash pollen could fall on receptive longleaf conelets, and longleaf pollen could fall on receptive loblolly conelets.

4/ Personal communication.

VARIATION IN POLLEN RIPENING BETWEEN SPECIES

Table 7 gives the time of pollen ripening for six species of southern pines growing at the Institute of Forest Genetics in California. At 2700 feet elevation, time of bloom in slash pine was much later than in the South. Shortleaf and loblolly pine ripened their pollen about the same time as in areas in the upper South. However, the ending date in some cases was much later. Table 8 shows time of pollen ripening in 1954 for the major species of southern pines at the Southern Institute of Forest Genetics in Mississippi.

Table 7.--Time of pollen ripening for major species of southern pines at 2700 feet elevation at the Institute of Forest Genetics in California

Pine species	Pollen ripening period	
	Start	End
	Date	Date
Shortleaf pine	4-3	4-23
Loblolly pine	3-23	5-10
Slash pine	3-31 1/	--
Longleaf pine	(2/)	--
Virginia pine	4-11	4-23
Pitch pine	4-8	4-29
Spruce pine	4-15	--

1/ Average pollen collection date.
2/ None produced to date by 20-year-old trees.

Table 8.--Time of pollen ripeninp for major species of southern pines at the Southern Institute of Forest Genetics at Mississippi

Pine spe cies	Pollen ripening period	
	Start	End
	Date	Date
Slash pine	2-1	2-9
Longleaf pine	2-16	3-11
Loblolly pine	2-22	3-11
Shortleaf pine	3-26	4-7

DISCUSSION

A knowledge of time of pollen and seed ripening in southern pines will help tree improvement workers to plan field work and arrange for the exchange of pollen and seed. It should be remembered that the time of ripening may vary as much as 3 weeks between years and between trees in the same stand. Therefore, the need for pollen and seed should be anticipated as far in advance as possible and arrangements for obtaining it made accordingly.

, Pollen and seed are more easily extracted if the male strobilus and cones are picked just prior to the time they would open on the tree. If it is not possible to collect at this time, then the earliest collection time that will give viable material becomes important. In California, where trees used for breeding at the Institute of Forest Genetics are sometimes located in inaccessible places, Cumming and Righter (3) suggest that if aceto-carmine smears show that pollen grains have completed the second division in the development of the gametophyte (remnants of two prothallial cells will be visible), the male strobilus will ripen after picking; but those collected prior to that stage may not ripen. A field microscope is required for this examination. The time at which pollen of various species of southern pine in the South could be collected, based on stage of development of the gametophyte, is unknown. However, it is expected that this information will be forthcoming as a result of studies in flower development now being undertaken.

Viable seed can be obtained from cones collected in advance of the normal time of opening, but extraction may require removal of the cone scales by hand. Wakeley (12) states that southern pine cones with a specific gravity of 0.89 are still closed, but that they have matured enough to open if picked and dried. He reports that cones on the tree usually open at a specific gravity of about 0.70. The time of year at which cones can be collected and viable seed obtained, even with hand extraction, should be determined for the major species of southern pine. Early collection of hand-pollinated cones would reduce the possibility of loss to squirrels and premature opening on the tree, and remove the necessity for bagging the cones on the tree. Also, the cone collecting season will be lengthened.

Seed of closed cone species, such as pond, sand, and Table-Mountain pine can be collected at any time, but viability is apt to be highest for seed of the current year. Cones of these species can be opened by soaking them briefly in hot water (8).

Sand pine and South Florida slash pine commonly form conelets at several periods during the spring. The conelets, and later the cones, appear in successive whorls at short intervals along the twigs. The interval between cones of different years is much longer. Formation of male strobili at more than one period has not been reported. Thus, late-blooming conelets are apt to have poorly-filled seed.

SUMMARY

Approximate dates of pollen and seed ripening have been tabulated for slash, longleaf, loblolly, and shortleaf pines for many stations throughout the natural ranges of the species. Similar data at a few stations have also been reported for the minor southern pines and the pines of the Appalachian Mountains.

In Alachua County, Florida (Gainesville), latitude 29° 35' N., slash pine pollen was ripe January 2 1. In Dooly County, Georgia (Cordele), latitude 32° 0' N., it was ripe by February 2. Longleaf pine in Alachua County, Florida, was ripe February 5, and in Hertford County, North Carolina (Murfreesboro), about latitude 30° 30' N., it wasn't ripe until April 16, or nearly 6 weeks later. Loblolly pine in Alachua County, Florida, was ripe February 25, and in Hertford County, North Carolina, April 4, about 6 weeks later. Shortleaf pine at Harrison County, Mississippi (Gulfport), latitude 30° 40' N., was ripe about March 25, and at Hertford County, North Carolina, around April 25 or about 4 weeks later.

Slash pine seed ripened about September 15; longleaf pine, October 1 through 20;. loblolly pine, October 5 through '15; and shortleaf pine, October 15 through 30. No strong relationship with latitude was indicated, but it might have been obscured by the difficulty of observing when seed was ripe.

LITERATURE CITED

(1) Anderson, E., and Hubricht, L.
1940. A method for describing and comparing blooming seasons. Torrey Club Bul. 67(8): 639-691.

(2) Coker, W. C., and Totten, H. R.
1945. Trees of the southeastern states. 417 pp., illus. Univ. of North Carolina 'Press, Chapel Hill.

(3) Cumming, W. C., and Righter, F. I.
1948. Methods used to control pollination of pines in the Sierra Nevada of California. U. S. Dept. Agr. Cir. 792, 18 pp. illus.

(4) Duffield, John W.
1953. Pine pollen collection dates- -annual and geographic varia-, tion. U. S. Forest Serv. California Forest and Range Expt. Sta. Forest Res. Note 85, 9 pp.

(5) Hopkins, A. D.
1918. The bioclimatic law. U. S. Dept. Agr., Weather Bur. Monthly Weather Rev. Supplement No.. 9, pp. l-42.

(6) Lamb, George N.
1915. Calendar of the leafing, flowering, and seeding of the common trees of the eastern United States. U. S. Weather Bur. Monthly Weather Rev. Supplement No. 2, 19 pp.

(7) Leven, J. K.
1951. Flowering times of Japanese larch (L. leptolepis Murray) and European larch (L. europea, D. C.). Schotush Forest. 5(2): 33-34, illus.

(8) Little, Elbert L., Jr., and Dorman, Keith W.
1952. Geographic differences in cone-opening in sand pine. Jour. Forestry 50(3): 204-205.

(9) Millett, M. R. 0.
1944. Pollen shed of Monterey pine. Austral. Commonwealth Forestry Bur . Leaflet 59, 8 pp.

(10) Sarvas, Risto
1952. On the flowering of birch and the quality of seed crop. Communi.cationes Instituti Forestalis Fenniae 40.7, 38 pp., illus. (Reprint.)

(11) Snow, A. G. , Jr. , Dorman, K. W., and Schopmeyer, C. S.
1943. Developmental stages of female strobili in slash pine. Jour. Forestry 41(12): 922-933.

(12) Wakeley, Philip C.
1954. Planting the southern pines. U. S. Dept. Agr. , Agr. Monograph 18, 233 pp., illus.

(13) Wright, Jonathan
1953. Notes on flowering and fruiting of northeastern trees. U. S. Forest Serv. Northeastern Forest Expt. Sta. Paper 60, 38 pp.

(14) _____
1953. Summary of tree-breeding experiments by the Northeastern Forest Experiment Station. U. S. Forest Serv. Northeastern Forest Expt. Sta. 'Paper 56, 47 pp.

(15) Wyman, D.
1939. The order of bloom of trees and shrubs at the Arnold Arboretum. Arnold Arb. Pop. Inf. Bul. Ser. 4, 7(11): 53-64.

(16) Zobel, Bruce J., and Goddard, Ray E.
1954. Pine flowering and seed ripening in Texas. Texas Forest Serv. Res. Note 8, 10 pp., illus.

MEMBERSHIP OF SUBCOMMITTEE ON TREE SELECTION AND BREEDING

Keith W. Dorman, Southeastern Forest Experiment Station (Chairman)
Woolford B. Baker, Emory University
C. C. Doak, Agricultural and Mechanical College of Texas
Ellwood S. Harrar, Duke University
Paul H. Harvey, North Carolina State College
C. M. Kaufman, University of Florida
Scott S. Pauley, University of Minnesota
Maxon Y. Pillow, Forest Products Laboratory
F. I. Righter, California Forest and Range Experiment Station
Ernst J. Schreiner, Northeastern Forest Experiment Station
Bratislav Zak, Southeastern Forest Experiment Station
Bruce Zobel, Texas Forest Service

PUBLICATIONS AND REPORTS PREPARED IN COOPERATION WITH THE COMMITTEE ON SOUTHERN FOREST TREE IMPROVEMENT:

Report of the first southern conference on forest tree improvement. Atlanta, Georgia, January 9 - 10, 1951. U. S. Forest Serv., Atlanta, Ga. (Mimeo.)

Proposal for a cooperative study of geographic sources of southern pine seed. Subcommittee on Geographic Source of Seed, Philip C. Wakeley, Chairman. Southern Forest Expt. Sta. 1951. (Mimeo.)

Standardized working plan for local tests of seed source. Subcommittee on Geographic Source of Seed, Philip C. Wakeley, Chairman. Southern Forest Expt. Sta. 1951. (Mimeo.)

Hereditary variation as the basis for selecting superior forest trees. Subcommittee on Tree Selection and Breeding, Keith W. Dorman, Chairman. Southeastern Forest Expt. Sta. Paper 15. 1952.

Directory of forest genetic activities in the South. Subcommittee on Tree Selection and Breeding, Keith W. Dorman, Chairman. Southeastern Forest Expt. Sta. Paper 17. 1952.

Working plan for cooperative study of geographic sources of southern pine seed. Subcommittee on Geographic Sources of Seed, Philip C. Wakeley, Chairman. Southern Forest Expt. Sta. 1952.

Suggested projects in genetic improvement of southern forest trees. Committee on Southern Forest Tree Improvement. Southeastern Forest Expt. Sta. Paper 20. 1952.

Testing tree progeny. A guide prepared by the Subcommittee on Progeny Testing, E. G. Wiesehuegel, Chairman. Tennessee Valley Authority, Technical Note No. 14. 1952.

Report of the second southern conference on forest tree improvement. U. S. Forest Serv., Atlanta, Ga. 1953. (Mimeo.)

Progress in study of pine races. Philip C. Wakeley. Southern Lumberman 187(2345): 137-140. December 15, 1953.

The role of genetics in southern forest management. Special subcommittee of the Committee on Southern Forest Tree Improvement, Bruce Zobel, Chairman. Pt. 1, Forest Farmer 14(1): 4-6, 14-15. Pt. 2,' Forest Farmer 14(2): 8, 14-19. Pt. 3, Forest Farmer 14(3): 8-9, 14-15. (Reprint, 11 pp. 1954.)

Proceedings of third southern conference on forest tree improvement. Southern Forest Expt. Sta. 1955.

Better seed for better southern forests. Subcommittee on Genetic Control of Seed, T. E. Maki, Chairman. N. C. State College School of Forestry Tech. Rpt. 9. 1955.

Forest tree improvement for the South. Committee on Southern Forest Tree Improvement, T. E. Bercaw, Chairman. 1955.

Time of flowering and seed ripening in southern pines. Subcommittee on Tree Selection and Breeding, Keith W. Dorman, Chairman, and John C. Barber. Southeastern Forest Expt. Sta. Paper 72. 1956.

Agriculture- -Asheville