

ABSTRACT

HALL, KAREN RENAE. COMPUTERIZED DENDROLOGY: The identification and natural history of the pine trees of southeastern North America. (Under the direction of Richard R. Braham.)

A computer database of the pines of southeastern North America was developed using hyper-text markup language. This interactive program allows users to learn about bark, buds, leaves, reproductive structures, geographic range, climate, and natural history of pines. Audio files pronounce the scientific and vernacular names of trees. A search engine allows comparison of textual and graphic information of different characteristics.

COMPUTERIZED DENDROLOGY:

**The identification and natural history of the pine trees of
southeastern North America**

by

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KAREN RENAE HALL

Karen Renae Hall was born on November 10, 1969 in Lenoir, North Carolina. She grew up in Lenoir where she graduated from Hibriten High School in May 1988. She continued her education at the University of North Carolina at Chapel Hill and received a Bachelor of Science degree in Biology with a minor in Chemistry in May 1992. Currently, she is pursuing a Master of Science degree in Forestry with a minor in Botany.

ACKNOWLEDGMENTS

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Thanks to all my family and friends for their support throughout my school career. I thank Buck for being a loyal companion during the many long nights spent in the lab working on this project. Finally, I wish to thank all those before and after me who have or who will contribute to the study of trees.

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INTRODUCTION

The use of computers for teaching has enormous potential to serve not only as learning devices for students, but also as teaching supplements for instructors. Plant sciences have already utilized computer technology for dichotomous keys and plant identification programs available on compact discs or the World Wide Web. The full potential of computer assisted learning includes a capacity to store and easily access large amounts of textual, graphic, and audio information in a way that is efficient and user-friendly.

As shown below few, if any, currently available programs reach their full potential. Urban Trees of North Carolina (Russell, 1996), for example, is a slide show placed on compact disc, complete with audio and visual information of plant nomenclature and basic plant morphology. This program has numerous quality images and descriptive audio throughout, but no mechanism to locate information quickly. Users basically turn “electronic pages” and have limited control in the information delivery. Although useful for the identification of urban trees, this program lacks information on natural forest ecosystems and naturally-occurring species. Thus it has limited usefulness for foresters, wildlife biologists, and other natural scientists.

Woody Plant ID (Seiler, 1997) is an interactive identification tutorial covering 129 woody plants species found throughout the eastern United States. Contained on compact discs, this program contains many images of trees and morphological characteristics as well as user-friendly pathways of accessing and comparing information. However, this program is not information-rich; morphological descriptions lack detail. Habitat

descriptions do not include climate variations, soil ranges, or detailed geographic range information. Expansive natural history information, such as human and animal uses are lacking. Audio files are also absent, making learning the pronunciation of scientific and vernacular names difficult.

Trees of the Pacific Northwest (Littlefield and Jensen, 1997) is a World Wide Web tree identification program which assists users in identifying common conifers of the northwestern states. Complete with images of leaves, reproductive structures, and range maps, these Web pages contain information about nomenclature, morphology, and distribution. Although user-friendly, this program (1) covers only trees native to northwestern North America, (2) has small images which are difficult to see, and (3) lacks silvics information such as soil and climatic conditions. This tree identification program does not take full advantage of the capacity of computers.

Other existing programs are too general and too elementary for advanced study. Tree of Life (Maddison and Maddison, 1997), an on-going Internet project, contains information about phylogeny and biodiversity of all living organisms. Presumably, when all the information is linked, users will navigate through a phylogenetic tree to find specific information. This Web site currently contains no information or multiple images of pines, and access to a general information page on conifers is cumbersome due to the small print and confusing layout. With no audio, images, and text, this program is of little use to advanced study.

Furthermore, these programs contain no search engines, computer mechanisms for locating information, that allow users to compare graphical and textual data. Since some

species closely resemble other species, side-by-side pictures and information would assist users in differentiating between them. Search engines should provide information on morphological characteristics and allow users to choose the comparison.

Currently no user-friendly, information-rich program exists for naturally occurring trees of southeastern North America, one of the most species-rich temperate areas. Given the enormous information contained in the literature, as well as the laborious task of finding it, the time has come to consolidate this information into a computer database. With the rapid innovations in computer technology, creating an efficient and user-friendly information database is possible. The database should include: (1) large amounts of textual information, (2) numerous images, (3) audio of correctly pronounced common and scientific names and terms, and (4) mechanisms to locate information quickly.

This program would be useful to: (1) high school and college students enrolled in plant science courses, (2) high school and college instructors who need supplemental information, (3) foresters who use silvics information for land management, (4) arborists, landscapers, and nurserymen who grow and maintain urban trees, and (5) the general public who may want to learn more about southeastern trees. Furthermore, the information should be available anywhere in the world where access to computers exists.

PROJECT GOAL

This project has one goal, to make finding information about southeastern pines easier.

PROJECT OBJECTIVES

This project had two objectives:

- (1) to develop an information-rich computer database for southeastern pines, and
- (2) to develop user-friendly pathways to access this information.

METHODS AND MATERIALS

To make information easily available, the database was programmed to distribute information via the World Wide Web (WWW) using Netscape 3.0. The word “database” refers to all information available to users. Hyper-text markup language (HTML), a programming language for WWW pages, allows linkage between different information pages. The graphical user interface (GUI) was created on Macintosh and UNIX computer platforms, and the database information was placed in computer project lockers maintained by the NCSU Computing Center.

For database content, key botanical components of eleven southeastern pine species were included: (1) gross morphology of each species, including bark, buds, leaves, and reproductive structures; (2) habitat, including geographic range, climate, and soils; and (3) natural history, including common names, human commercial uses, wildlife uses.

Data on morphological characteristics were researched from Burns and Honkala (1990), Harlow et al. (1996), Krussman (1985), Kurz and Godfrey (1962), Lakela and Wunderlin (1980), Radford et al. (1968), and Vidakovic (1991). Habitat descriptions were compiled from Burns and Honkala (1990), Dorman (1976), and McWilliams, et al. (1986). Range maps from non-copyrighted government publications, (Burns and Honkala, 1990; Little, 1971) were directly scanned into the database using a La Cie Silverscan II flatbed scanner. Natural history information was gathered from Burns and Honkala (1990), Kurz and Godfrey (1962), Ledig and Little (1979), Lewis (1973), McWilliams et al. (1986), Mollenhauer (1939), Peterson (1980), Wacker (1979), Wahlenberg (1946), and Zobel (1969). Sources for the glossary included Harlow et al. (1996), Harris and Harris (1994), Little and Jones (1980), and Radford et al. (1968).

Information and images for pine trees were gathered and structured uniformly for five pages of cross-linked data including: (1) title page, (2) bark page, (3) buds and leaves page, (4) habitat and range page, and (5) reproductive structures page. Supplemental information pages such as a glossary and bibliography were cross-linked to relevant pages within the program. This structured format allows easy access to information as well as future additions of different tree species.

To explore the capabilities of hypermedia programming, several technical enhancements were incorporated into the database infrastructure. Using the programming language PERL, a random-access generator was created to randomly load one of 4 different images of longleaf pine each time this species was accessed. A search engine, programmed using PERL, served as a comparison tool for the database. This engine

worked by displaying an interface which allows users to compare and contrast information on 2 different tree species, choosing different characteristics including:

(1) bark, (2) buds and leaves, and (3) reproductive structures. Results produced textual information and side-by-side images of both species. Each image was also linked to its respective title page so users can quickly access more detailed information.

Using a Canon EOS Rebel XS camera and Kodachrome 64 slide film, numerous color photographs of each pine tree, including bark, leaves, branches, and reproductive structures, were taken in either natural settings or arboreta. Selected objects were set against a black backdrop with a ruler for scale.

Images were digitally scanned into the computer, either in JPEG or GIF format using a Kodak RFS 2035 film scanner, then transferred to the database where each was linked to the appropriate Web page. Range maps and hand-drawn images were scanned using the flatbed scanner. All images were edited and enhanced using Photoshop 3.0 on Macintosh computers and transferred to the locker via Fetch, a Macintosh program for transferring files via File Transfer Protocol on networked computers. Using a computer sound recorder, the scientific name and the most common vernacular name of each tree were recorded and stored as computer sound files. These files were linked to names on each title page, and would be pronounced each time users clicked on the highlighted name.

Additional tree information pages were created and linked to different pages throughout the database. A glossary of botanical terms used in the program was created and linked to most database pages. Each title page contained a link to a bibliographic page. A general diagram of various pine tree characteristics was created and linked to the

starting page. Lastly, a naval stores page and a grass stage page were linked to pine species possessing these characteristics.

RESULTS

The resulting database is a World Wide Web computer linked database, structured in a taxonomic classification of the 11 pines native to southeastern North America. The first classification divides the trees into three sub-generic subsections recognized by Little and Critchfield (1969). Each subsection is subsequently linked to the appropriate pine species page.

The database used 24.8 MB of memory and contained 122 GIF and JPEG images. Table 1 provides an example of the HTML programming used for the shortleaf pine title Web page. Seventy-seven HTML pages similar to the one in Table 1 were created. At present, the Web site is located in computer project lockers maintained by the NCSU Computing Center and has the following Web site address or Uniform Resource Locator (URL): <http://www2.ncsu.edu/unity/lockers/project/dendrology/>

Table 1. HTML programming for shortleaf pine title page

```

<HTML>
<HEAD>
<TITLE> Eastern White Pine </TITLE>
</HEAD>
<H1><I> <A href="strobos.au">Pinus strobus </A> </I>L.</H1>
<H3><A href="whitepine.au"> eastern white pine </A></H3>
(white pine, northern white pine, Weymouth pine, soft pine)
<BODY>
<HR><P>
<IMG SRC="form.gif">
<HR><P>
<B>Tree Characteristics:</B>
<UL>
<LI><B>Height at maturity:</B> <BR>Typical: 25 to 33 m (80 to 100 ft)<BR> Maximum: 48.2 m (158 ft)<P>
<LI><B>Diameter at breast height at maturity:</B><BR>Typical: 90 to 120 cm (36 to 48 in) <BR>Maximum: 170 cm (68 in)<P>
<LI><B>Crown shape:</B> broadly conical with open spaces between branches, producing a layered appearance.
<P>
<LI><B>Stem form:</B> excurrent <P>
<LI><B>Branching habit:</B> horizontally spreading; one tight spiral formed each year along the main bole (uninodal). Thus tree age may be estimated by counting the spirals.<P>
</UL>
<HR><P>
Eastern white pine is the only naturally occurring white pine tree in eastern North America. Of the pines in the United States, this tree is second only in size to sugar pine (<I>Pinus lambertiana</I>) which occurs on the west coast. Considered a long lived tree, this pine commonly lives to 200 years of age, and selected individuals may live to 450 years. <P>
<B>Human uses:</B> Furniture, interior trim, window framing, shelving, and Christmas trees. Also grown for landscaping and stabilization of strip-mine spoils. <P>
<B>Animal uses:</B> Songbirds, such as the yellow-bellied sapsucker (<I>Sphyrapicus varius</I>), pine warbler (<I>Dendroica pinus</I>), and red crossbill (<I>Loxia curvirostra</I>), eat the seeds. A few mammals like the beaver (<I>Castor canadensis</I>), porcupine (<I>Erethizon dorsatum</I>), white-tailed deer (<I>Odocoileus virginianus</I>), and snowshoe hare (<I>Lepus americanus</I>) may also consume seeds, bark and foliage. Favorite tree for bald eagle (<I>Haliaeetus leucocephalus</I>) nests.<P>
<HR><P>
<TABLE CELLPADDING=3 BORDER>
<TR>
<TD> <A href="bark.html"> Bark </A></TD>
<TD ROWSPAN=3> <A href="readings.html">Additional Readings</A></TD>
<TD> <A href="habitat.html"> Range and Habitat </A></TD>
</TR>
<TR>
<TD> <A href="buds.html"> Leaves and Buds </A></TD>
<TD> <A href="reproductive.html"> Reproductive Structures </A></TD>
</TR>
<TR>
<TD> <A href="http://www2.ncsu.edu/unity/lockers/project/dendrology/etc/glossary/glossary.html"> Glossary</A></TD>
<TD> <A href="http://www.cgi-bin.ncsu.edu/dendrology-bin/compare.pl"> Interactive Comparison Tool</A></TD>
</TR>
</TABLE>
</BODY>
</HTML>

```

The following is a printout of the database Web pages, with the following exceptions. Highlighted links cannot be activated and shown on paper, and are therefore not included. Interactive comparison tool results are also not provided because the large number of possible comparisons made printing impractical.

All database pages have been printed in the order that they appear in the program, but the following concessions were necessary. Page numbers have been added to the hard copy to assist in locating material, but no page numbers appear in the computer program. Although a single information page may contain large amounts of data, in World Wide Web format it is treated as one page, and must be scrolled on the computer screen. Therefore, the printout may appear to have disjointed page breaks, which are not present in the actual database.



INTERACTIVE DENDROLOGY

by

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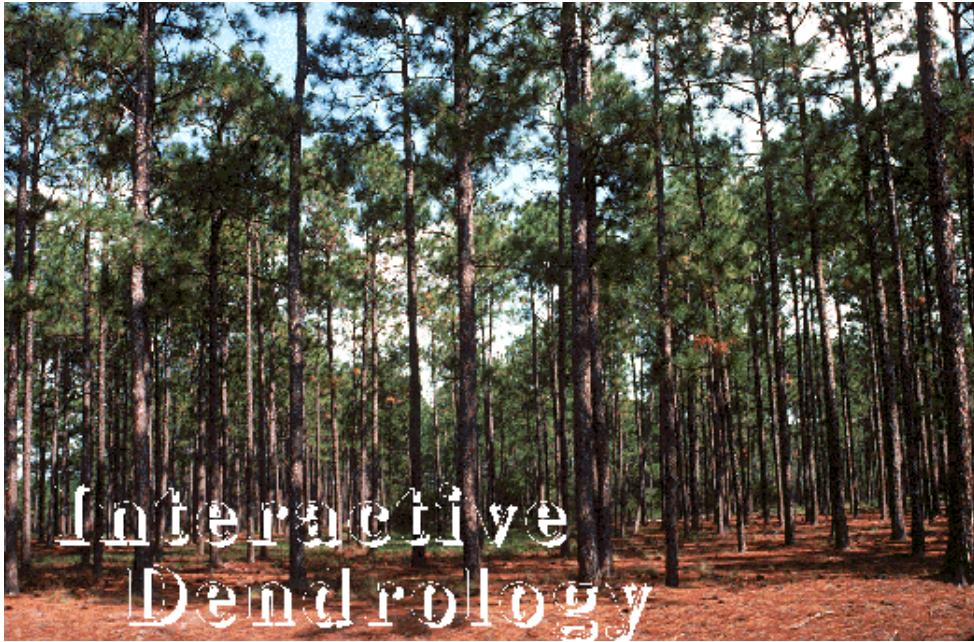
1998

This program is copyrighted © by the author.

Any person who makes an unauthorized copy or adaptation of this material, or redistributes a copy, or publicly performs or displays a copy, except as permitted by title 17 of the US Code, is liable for copyright infringement.

In order to view Interactive Dendrology correctly, you should have a Netscape compatible browser.

[Click here to begin](#)



Welcome to Interactive Dendrology, an on-line database designed to assist dendrology students. Emphasis is placed on woody species native or naturalized in southeastern North America.

How to use this tutorial:

- Clicking the pointer on blue highlighted text will move you through the tutorial.
- To return to the previous page, click on the "Back" button on the browser or the "Back to Previous Page" option at the bottom of a page. To go to the next page, either click on the desired highlighted text or related image.
- At any time, you may go to the glossary by clicking on the highlighted word "Glossary" at the bottom of the tutorial pages.
- On selected pages you may use the "Interactive Comparison Tool" to make comparisons of species.

To begin the tutorial click [here](#)

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Acknowledgements

Bibliography

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Acknowledgements

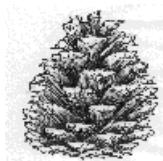
Interactive Dendrology has been developed by Karen Hall, Department of Forestry, NCSU College of Forest Resources; Richard Braham, Department of Forestry, NCSU College of Forest Resources; Robert Stevenson, Design Research Laboratory, NCSU School of Design; John Tector, Design Research Laboratory, NCSU School of Design; and James Tomlinson, Design Research Laboratory, NCSU School of Design.

All images in this program have never before been published. They are from photography taken by Karen Hall and Richard Braham, and from illustrations drawn by Alexander Krings and Iris Schoell.

***Pinus* - The Pines**

Pinus is comprised of trees, occasionally shrubs, which are evergreen, highly resinous, and monoecious. This genus is more important in timber-production than any other conifer genus. Lumber, plywood, poles, pilings, pulp, paper, turpentine, rosin (formerly from naval stores), pine "nuts", Christmas trees, and pine straw and bark mulch are all obtained from pine trees.

Pine trees share many characteristics. For a more descriptive comparison, click on the cone:



Worldwide, 90 to 100 species are distributed in temperate regions and mountains of tropical regions in the northern hemisphere, extending from the northern tree-growing limits of the Arctic south to North Africa, the Philippines, and Central America. One species, *Pinus merkusii*, occurring in Sumatra, is the only pine species that crosses the equator into the southern hemisphere.

***Pinus* is divided into 3 subsections in southeastern North America:**

Australes
the Southern
Pines

Contortae
the Fire Pines

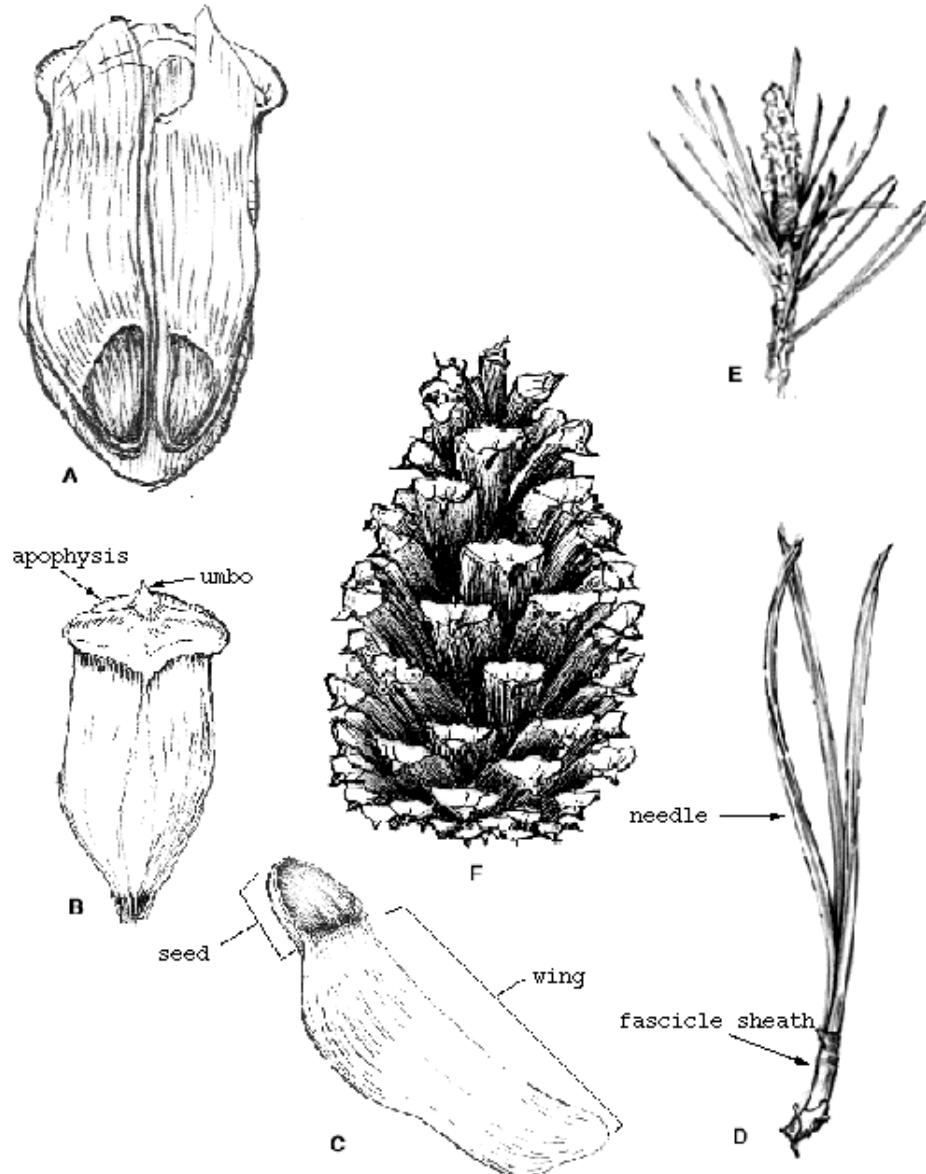
Strobi
the White
Pines



Glossary

Interactive Comparison Tool

Common Pine Tree Features



Pine cone and leaf parts. (A) Inner view of ovulate scale with seed. (B) Outer view of ovulate scale. (C) Winged seed. (D) Needle. (E) Shoot. (F) Mature seed cone.

Pines are unique among the conifers in that they have acicular-shaped leaves, commonly called needles. Needles mostly occur in fascicles of 2 to 8, except *Pinus monophyll*, in which they usually occur singly. The fascicle sheath is comprised of bud scales which can be either deciduous or persistent.

The seed cone usually matures in 2 (rarely 3) years. It is comprised of woody cone scales with subtending bracts spirally arranged around a central axis. The exposed part of a closed cone is called the apophysis. The umbo is the protuberance on the apophysis. On some pines, the apophysis will be armed with a prickle. Seeds usually occur in pairs of 2 at the base of the cone scale and can be winged or wingless.

[Glossary](#)

[Interactive Comparison Tool](#)

[Back to Pinaceae - The Pine Family](#)

Australes, The Southern Pines

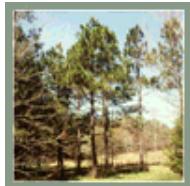
Pinus subsection *Australes* includes 8 species in the eastern United States, and 3 species in West Indies with 1 extending into Central America. Leaves are 2 or 3 per fascicle. Cones are symmetrical, often opening at maturity to release winged seeds. Cone scales are always armed with mostly persistent prickles.

Australes contains 8 species in the southeastern United States:

Pinus echinata
shortleaf pine



Pinus elliottii
slash pine



Pinus glabra
spruce pine



Pinus palustris
longleaf pine



Pinus pungens
Table Mountain pine



Pinus rigida
pitch pine



Pinus serotina
pond pine



Pinus taeda
loblolly pine



Pinus echinata Mill.

shortleaf pine

(southern yellow pine, shortleaf yellow pine, oldfield pine, shortstraw pine, Arkansas soft pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 24 to 30 m (80 to 100 ft)
Maximum: 44 m (146 ft)
- **Diameter at breast height at maturity:**
Typical: 50 to 90 cm (20 to 36 in)
Maximum: 120 cm (48 in)

- **Crown shape:** small, open, narrowly conical
 - **Stem form:** excurrent, but occasionally forked
 - **Branching habit:** compact
-

Shortleaf pine derives its scientific name from the Latin word *echinus* which means hedgehog. The prickle on the umbo provides the spiny "hedgehog-like" appearance of the cone.

One of the four most important southern pines, shortleaf has the widest geographic range of any of its counterparts, and is second only to loblolly pine (*Pinus taeda*) in standing timber volume. Shortleaf's expansive success can be attributed to its ability to grow on a wide range of soil and site conditions. It can withstand competition from other vegetation longer than most other pines. Shortleaf is one of the few pines that can sprout from the root collar if the stem is damaged or killed by fire or other injuries, but only until age 8 to 12 years.

Human uses: lumber, plywood, pulpwood, structural materials, boxes, crates, and ornamental vegetation. Even the taproot can be used for pulpwood.

Animal uses: Provides habitat and food for bobwhite quail (*Colinus virginianus*), mourning dove (*Zenaida macroura*), meadowlark (*Sturnella magna*), eastern cottontail rabbit (*Sylvilagus floridanus*), and a variety of songbirds. Early successional stages provide browse for white-tailed deer (*Odocoileus virginianus*). Older shortleaf pines with red heart rot (*Phellinus pini*) provide red-cockaded woodpecker (*Picoides borealis*) cavity trees.

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus echinata Mill.

Bark



Bark characteristics:

- young bark rough; dark gray to black
 - mature bark furrowed into irregular flat, scaly plates
 - 2 to 3 cm (0.8 to 1.0 in) thick
 - reddish or yellowish-brown to dark brown in color
 - small resin pores occasionally dotted along scaly plates
-

Bark	Back to <i>Pinus echinata</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus echinata Mill.

Leaves and Buds



Bud Characteristics:

- 6 mm (0.2 in) long
- oblong to ovate
- reddish-brown to grayish-brown scales
- resinous

Leaf Characteristics:

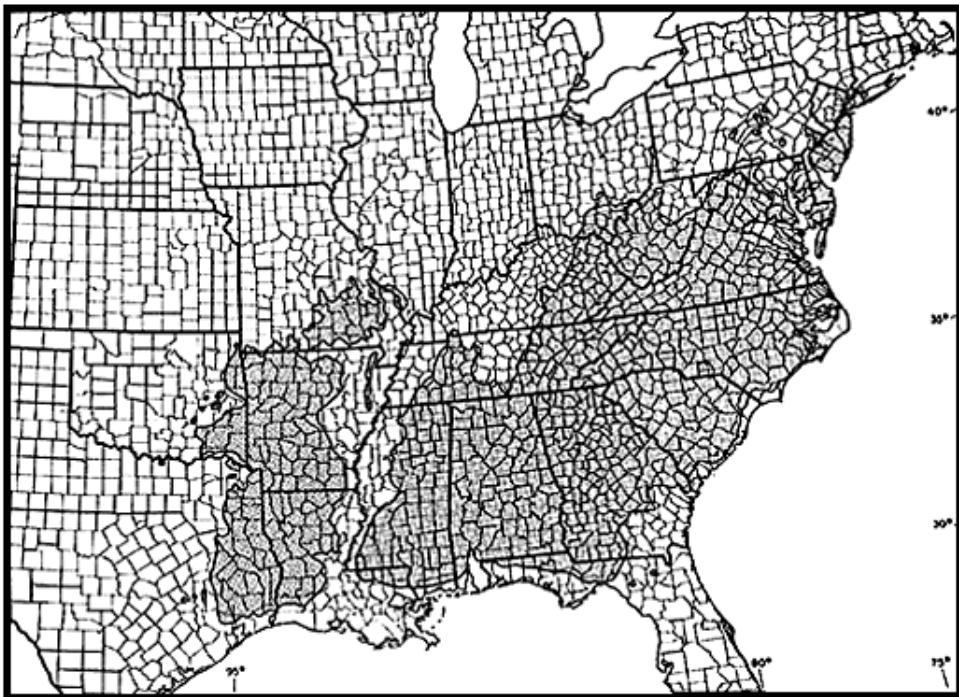
- 7 to 11 cm (2.8 to 4.4 in) long
- 2 (occasionally 3) needles per fascicle
- dark bluish-green to yellowish-green
- acicular, slender, flexible
- persist 2 to 5 years

- fascicle sheath 3 to 6 mm (0.1 to 0.2 in) long; persistent
-

Bark	Back to <i>Pinus echinata</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus echinata Mill.

Range and Habitat



The native range of shortleaf pine. (From Little, 1971.)

Geographic Range

According to Lawson (1990) : "Shortleaf pine has the widest range of any pine in the southeastern United States. It grows in 22 States over more than 1,139,600 km² (440,000 mi²) from southeastern New York and New Jersey west to Pennsylvania, southern Ohio, Kentucky, southwestern Illinois, and southern Missouri; south to eastern Oklahoma and eastern Texas; and east to northern Florida, and northeast through the Atlantic Coast States to Delaware. In 1915, shortleaf pine was reported to grow in 24 States. Fossil pollen found in Michigan suggests that it may have once grown there."

Climate

According to Lawson (1990) : "Shortleaf pine grows in a fairly humid region but is the least exacting of the southern pines as to temperature and moisture. Annual precipitation averages between 1020 mm (40 in) on the western edge of its range and 1520 mm (60 in) at the southern tip of its range. Snowfall averages less than 41 cm (16 in) over most of the shortleaf pine range but may be twice that amount in some of the higher elevations of the Appalachians northward into Pennsylvania. The region of best development for the species is in Arkansas, northern Louisiana, and the southern Piedmont, where precipitation ranges from 1140 to 1400 mm (45 to 55 in) and averages 1270 mm (50 in). The 10 degree C (50 degree F) average annual temperature isoline closely parallels the northern limit of shortleaf pine. Over its range, average annual temperatures vary from 9 degrees C (48 degrees F) in New Jersey to 21

degrees C (70 degrees F) in southeast Texas."

Soils and Topography

Shortleaf pine can adapt to a vast array of site and soil conditions. This pine grows best on deep, well drained soils which are silty or sandy loam in texture, soils characteristic of the South Atlantic region and the Gulf Coastal Plain. The majority of shortleaf pines, however, are found growing in the moist, low organic matter Ultisols, suborder Uduults. Paleuduults and Hapluduults are also found in shortleaf's range. Its large root system and ability to tolerate nutrient deficiencies allow shortleaf to grow on drier, less fertile soils. Shortleaf does not grow well in excessively drained, acidic soils.

Shortleaf grows at elevations from 3 m (10 ft) in southern New Jersey to 910 m (3,000 ft) in the Appalachians. Best development is from 180 m to 460 m (600 ft to 1,500 ft) in the Piedmont region.

Bark	Back to <i>Pinus echinata</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus echinata Mill.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots of branches in lower crown
- 2 to 3 cm (0.8 to 1.2 in) long at maturity
- green to yellow, turning reddish-purple
- mature and release pollen in March and April

Female cones

- occur in clusters of 2 or 4 on stems below new shoots
- 1 to 4 cm (0.4 to 1.6 in) long at time of pollination
- green or red to purple at time of pollination

- 4 to 6 cm (1.6 to 2.4 in) long at maturity
- dull to light brown
- ovoid-oblong to conical
- nearly sessile or short-stalked
- apophysis is reddish-brown and rounded
- umbo armed with small, sharp and occasionally deciduous prickles
- mature and release seed September through October of second season
- persist on branch for several years

Seeds

- 4 to 8 mm (0.2 to 0.3 in) long
 - dark brown
 - triangular
 - wings 8 to 12 mm (0.3 to 0.5 in) long; tan to purplish
-

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus echinata</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Additional Readings

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Pinus elliottii Engelm.

slash pine

(southern pine, yellow slash pine, swamp pine, pitch pine, Cuban pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 18 to 30 m (60 to 100 ft)
Maximum: 45 m (150 ft)
- **Diameter at breast height at maturity:**
Typical: 60 to 80 cm (24 to 32 in)

Maximum: 120 cm (48 in)

- **Crown shape:** narrowly ovate, pointed
 - **Stem form:** excurrent
 - **Branching habit:** horizontally spreading
-

Slash pine is one of the fastest growing and most commercially important yellow pines in the southeastern United States. Commonly planted for timber, it has successfully been grown in plantations in Africa, South America, and Australia. It is also used for naval stores. Two varieties of this pine are recognized: *Pinus elliottii* var. *elliottii*, slash pine, which grows naturally throughout the lower southeastern states, and *Pinus elliottii* var. *densa*, South Florida slash pine, which occurs only in the southern half and Keys of Florida. This later variety differs from the typical variety not only in geographical location, but also in seedling development and wood density. South Florida slash pine produces a grass stage and is comprised of denser wood.

Human uses: pulp, timber, naval stores, soil stabilization on strip mine spoil banks.

Animal uses: White-tailed deer (*Odocoileus virginianus*), utilize trees for cover and browse. Gray squirrel (*Sciurus carolinensis*), fox squirrel (*Sciurus niger*), bobwhite quail (*Colinus virginianus*), and wild turkey (*Meleagris gallopavo*) eat pine seeds and use trees for protective cover.

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus elliottii Engelm.

Bark



Bark characteristics:

- young bark scaly; blackish-gray
 - mature bark thick; furrowed into irregularly overlapping broad, flat scales
 - 2 to 3 cm (0.8 to 1.2 in) thick; outer layers continually shedding
 - orange to reddish-brown
-

Bark	Back to <i>Pinus elliottii</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus elliottii Engelm.

Leaves and Buds



Bud Characteristics:

- 12 to 18 mm (0.5 to 0.7 in) long
- oblong or cylindrical
- covered with light-brown to reddish-brown scales

Leaf Characteristics:

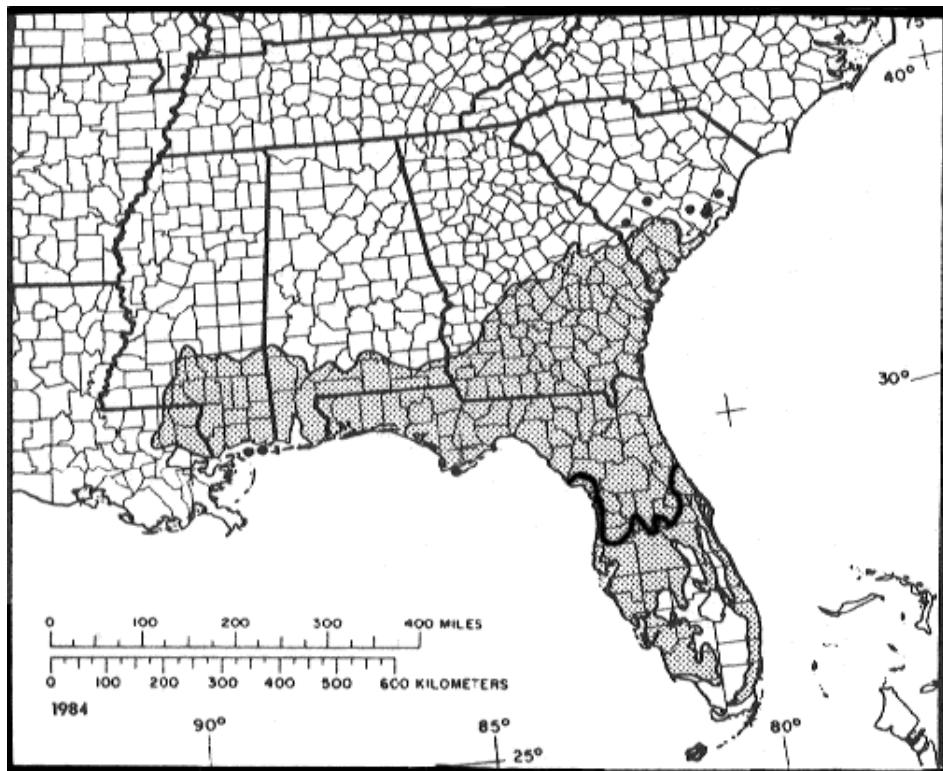
- 10 to 25 cm (4 to 10 in) long
- 2 and 3 needles per fascicle,
- dark green; glossy
- stout, stiff
- persist 2 years
- fascicle sheath 9 to 12 mm (0.4 to 0.5 in) long; persistent

The South Florida slash pine, *Pinus elliottii* var. *densa*, differs from this common variety in that the needles usually occur 2 per fascicle, very rarely 3 per fascicle.

Bark	Back to <i>Pinus elliottii</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus elliottii Engelm.

Range and Habitat



The native range of slash pine. The solid black line separates (northward) the typical variety from (southward) South Florida slash pine, *Pinus elliottii* var. *densa*. (From Little, 1971.)

Geographic Range

According to Lohrey and Kossuth (1990) : "Slash pine has the smallest native range of the four major southern pines. The range extends over 8 degree latitude and 10 degree longitude, and 45 percent of the present growing stock is in Georgia. Slash pine grows naturally from Georgetown County, SC, south to central Florida, and west to Tangipahoa Parish, LA. Its native range includes the lower Coastal Plain, part of the middle Coastal Plain, and the hills of south Georgia. The species has been established by planting as far north as Tennessee, in north central Georgia, and Alabama. It has also been planted and direct-seeded in Louisiana and eastern Texas where it now reproduces naturally."

"Within its natural range, the distribution of slash pine was initially determined by its susceptibility to fire injury during the seedling stage. Slash pine grew throughout the flatwoods of north Florida and south Georgia. It was also common along streams and the edges of swamps and bays. Within these areas either ample soil moisture or standing water protected young seedlings from frequent wildfires in young forest.

"With improved fire protection and heavy cutting of longleaf pine (*Pinus palustris*), slash pine has

spread to drier sites, replaced longleaf pine in mixed stands, and invaded abandoned fields. This increase in acreage was possible because of slash pine's frequent and abundant seed production, rapid early growth, and ability to withstand wildfires and rooting by hogs after the sapling stage."

Climate

According to Lohrey and Kossuth (1990) : "The climate within the natural range of slash pine is warm and humid with wet summers and drier falls and springs. Rainfall averages about 1270 mm (50 in) per year and summer rains of 13 mm (0.5 in) or more occur about four times per month. The mean annual temperature in the slash pine region is 17 degrees C (63 degrees F), with extremes of 41 degree C (106 degrees F) and -18 degrees C (0 degrees F), and growing season of 250 days. It has been suggested that the average minimum temperature may be the most critical factor limiting the distribution of slash pine; however, precipitation, fire, or competition may be important in specific areas."

Soils and Topography

According to Lohrey and Kossuth (1990) : "Soils within the range of slash pine are mostly Spodosols, Ultisols, and Entisols. Spodosols and Entisols are common along the coasts of Florida while the Ultisols are in the northern part of the range. The most frequently found suborders are Uduults, Aquults, Psammments, and Aquods. Topography varies little throughout the southeastern Coastal Plain, but small changes in elevation frequently coincide with abrupt changes in soil and site conditions.

"Although slash pine is adaptable to a variety of site and topographic conditions, it grows best on pond margins and in drainages where soil moisture is ample but not excessive and the soil is well aerated. Growth is unsatisfactory on deep, well drained sands (sandhills) and on poorly drained savanna soils with high water tables (crawfish flats). Growth is intermediate on inadequately drained soils. Specific factors related to height growth, and hence to productivity, vary somewhat, but the most influential are those related to the amount of water or space available to tree roots."

Bark	Back to <i>Pinus elliottii</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus elliottii Engelm.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots of branches in middle and lower crown
- 3 to 5 cm (1.2 to 2 in) long at maturity
- dark purple at maturity
- mature and release pollen in late January through March

Female cones

- occur on higher branches singly or in clusters
- pinkish to purplish at time of pollination
- 2.5 cm (1.0 in) long at time of pollination
- 6 to 15 cm (2.5 to 6.0 in) long at maturity
- orangish-brown to reddish-brown; glossy

- ovoid-conic
- stalked
- apophysis reddish-brown; rounded
- umbo armed with a stout prickle
- mature August to October of second season
- open at maturity; persist to following summer

Seeds

- 6 to 8 mm (0.3 in) long
- dark brown to black
- ovoid to triangular
- wing 20 mm (0.8 in) long

Slash pine cones mature about 20 months after pollination, although this is variable depending on region and climatic factors. Cone production can begin as early as age three, but more typically seed crops begin at 10 to 15 years of age. About every three years, full seed crops are produced. Seeds are released around October, but this also varies with area and environmental conditions. Most of the seeds fall within 46 m (152 ft) of the parent tree.

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus elliottii</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Additional Readings

- Coppen, J.J.W. and G.A. Hone, 1995. *Gum naval stores: turpentine and rosin from pine resin.* Natural Resources Institute, Food and Agriculture Organization of the United Nations, Rome.
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Pinus glabra Walt.

spruce pine

(cedar pine, poor pine, Walter pine, bottom white pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 24 to 27 m (80 to 90 ft)
Maximum: 39 m (125 ft)

- **Diameter at breast height at maturity:**

Typical: 60 to 80 cm (24 to 32 in)

Maximum: 120 m (48 in)

- **Crown shape:** long, narrow

- **Stem form:** excurrent

- **Branching habit:** long and spreading

Spruce pine occurs as scattered trees among the hardwoods and other pine trees of the southeast. This species rarely forms pure stands, and they are of limited commercial use. Unlike most pine trees, spruce pine is shade tolerant and often established in a hardwood understory of oaks (*Quercus* spp.), hickories (*Carya* spp.), and magnolias (*Magnolia* spp.).

Human uses: Pulp, lumber, and Christmas trees. Because the wood is close-grained and brittle, spruce pine is of limited economic use.

Animal uses: Same as other *Australes* pines.

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus glabra Walt.

Bark



Bark characteristics:

- young bark thin, smooth; gray
- mature bark thick; finely furrowed into flat scaly ridges
- dark gray

Spruce pine has bark unlike any of the other southern pines. Not as deeply furrowed, the bark's appearance has been compared to that of southern red oak, *Quercus falcata*.

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus glabra</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus glabra Walt.

Leaves and Buds



Bud Characteristics:

- 2 mm (0.1 in) long
- conical
- covered with reddish-brown scales fringed with white hairs

Leaf Characteristics:

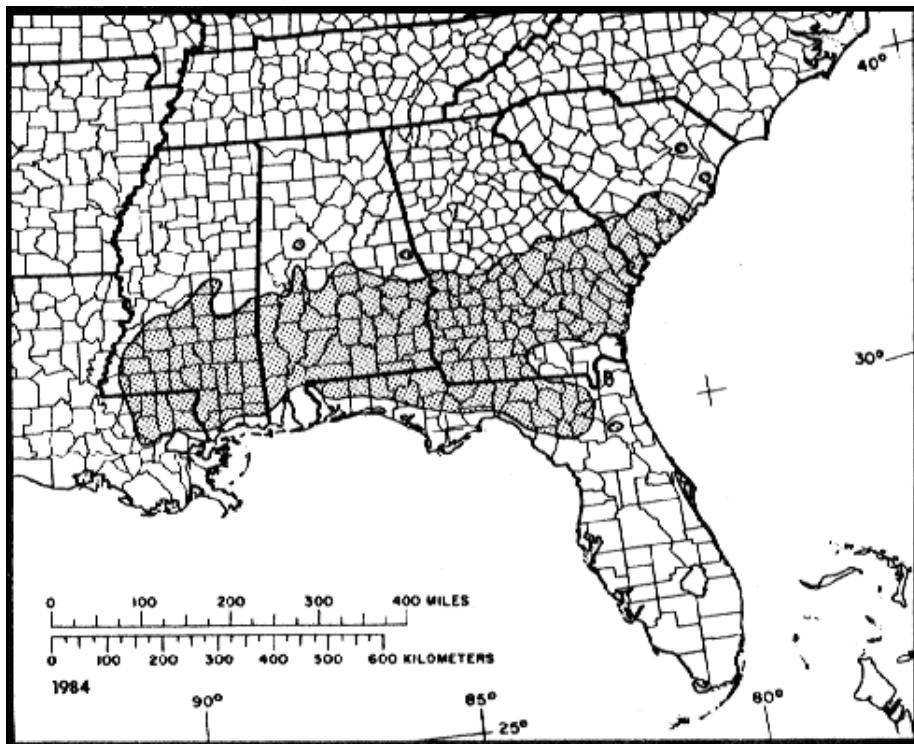
- 4 to 10 cm (1.5 to 4 in) long
- 2 needles per fascicle
- dark green
- acicular, slender
- flexible, often slightly flattened and twisted

- persist 2 or 3 years
 - leaf sheath 5 to 7 mm (0.2 to 0.3 in) long; persistent
-

Bark	Back to <i>Pinus glabra</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus glabra Walt.

Range and Habitat



The native range of spruce pine. (From Little, 1971.)

Geographic Range

According to Kossuth and Michael (1990) : "Although spruce pine is considered a minor yellow pine species, it grows in a wide band across the South. It can be found on the lower Santee River in eastern South Carolina, south to the middle of northwest Florida, and west to the valley of Pearl River in eastern Louisiana. The natural range lies between latitudes 29 degrees to 33 degrees north and longitudes 78 degrees to 91 degrees west."

Climate

According to Kossuth and Michael (1990) : "In the Southeastern United States where spruce pine grows, the climate is characterized by long, hot, humid summers and mild winters. Annual rainfall is about 1270 mm (50 in), which is normally distributed about evenly throughout the year. Fall tends to be the driest season, but summer droughts can occur. The growing season is about 240 days and the average annual temperature is 16 degrees C (61 degrees F)."

Soils and Topography

According to Kossuth and Michael (1990) : "Spruce pine grows on acidic sandy loam soils high in

organic matter, intermediate between dry sandy soils and alluvial bottom land. It grows well on poorly drained areas, often having a high water table, that are intermittently waterlogged, and may be found along stream banks or on rich moist hummocks. These soils are most commonly found in the orders Spodosols and Entisols."

Bark	Back to <i>Pinus glabra</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus glabra Walt.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots of branches in lower crown
- purplish yellow
- 0.5 to 1 cm (0.2 to 0.4 in) long
- shed pollen from March to April

Female cones

- occur near the end of new twigs on higher branches
- purplish at time of pollination
- 3 to 6 cm (1.2 to 2.4 in) long at maturity
- yellowish-brown

- ovoid-oblong to globose
- nearly sessile; pendulous
- apophysis light brown
- umbo slightly armed with a small, weak prickle
- mature and release seed October and November of second season
- shed at maturity, although sometimes may persist on branch 3 to 4 years

Seeds

- 5 mm (0.2 in) long
- dull gray mottled with black
- triangular to oval
- wing 13 mm (0.5 in) long; glossy brown

Although spruce pine begins producing cones by age 10, the peak production occurs between ages 20 to 40 years. One year old seed conlets first appear in March in the northern areas of southern states like Mississippi, and even earlier farther south in its native range.

According to Kossuth and Michael (1990) : "Seedlings develop well in shade of hardwoods and other pines, forming a wide-spreading, lateral taproot near the surface before penetrating deep into the soil. When it invades old or cleared fields, it may become established in the shade of loblolly and shortleaf pines."

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus glabra</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Additional Readings

- Critchfield, W.B., and E.L. Little, Jr., 1966. Geographic Distributions of the Pines of the World. U.S.D.A. For. Serv. Misc. Public. 991, Washington, D.C.
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Pinus palustris Mill.

longleaf pine

(Georgia pine, southern pine, southern yellow pine, longstraw pine, swamp pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 24 to 30 m (80 to 100 ft)
Maximum: 38 m (125 ft)

- **Diameter at breast height at maturity:**
Typical: 60 to 80 cm (24 to 32 in)
Maximum: 100 cm (40 in)

- **Crown shape:** small, irregularly shaped, open
 - **Stem form:** excurrent
 - **Branching habit:** open, spreading
-

Longleaf pine, one of the most important southern pines, exists now only in small fragments throughout the Atlantic and Gulf Coastal Plains. Before the arrival of European settlers, extensive, pure stands could be found throughout the southeast. Now, only about 1% of the estimated original 24 million hectares (60 million acres) exist. Naval stores, grazing, particularly hog grazing, logging, and fire suppression led to the drastic decline of this pine species.

Human uses: Formerly used for naval stores. Currently used for lumber, pulp, pinestraw mulch, poles, pilings, posts, and plywood.

Animal uses: Primary habitat for red-cockaded woodpecker (*Picoides borealis*). Forage for cattle and deer. Formerly, hogs, which were allowed to roam freely through the forest, fed primarily on the starchy, grass stage seedlings, contributing to longleaf pine's decline. Pines seeds are eaten by birds, including bobwhite (*Colinus virginianus*) and mourning dove (*Zenaida macroura*).

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus palustris Mill.

Bark



Bark characteristics:

- young bark rough; grayish
- mature bark thick; furrowed into coarse, scaly plates
- 2 cm (0.8 in) thick; outer layers continually shedding
- orangish to reddish-brown

Longleaf pine has one of the thickest bark coverings of all the southeastern pines, an adaptation to the frequent fires that once burned the extensive longleaf pine forests. The bark, which develops quickly after the grass stage, insulates the cambium against deadly high temperatures during fires.

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus palustris</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus palustris Mill.

Leaves and Buds



Bud Characteristics:

Known for its large bud, longleaf pines are the only native southeastern pine with a white bud. The fringed scales help insulate the bud from fire, especially in the grass stage.

- 3.5 to 6 cm (1.4 to 2.4 in) long
- cylindrical, acute
- silverish-white with fringed scales
- scales reflexed at apex
- non-resinous

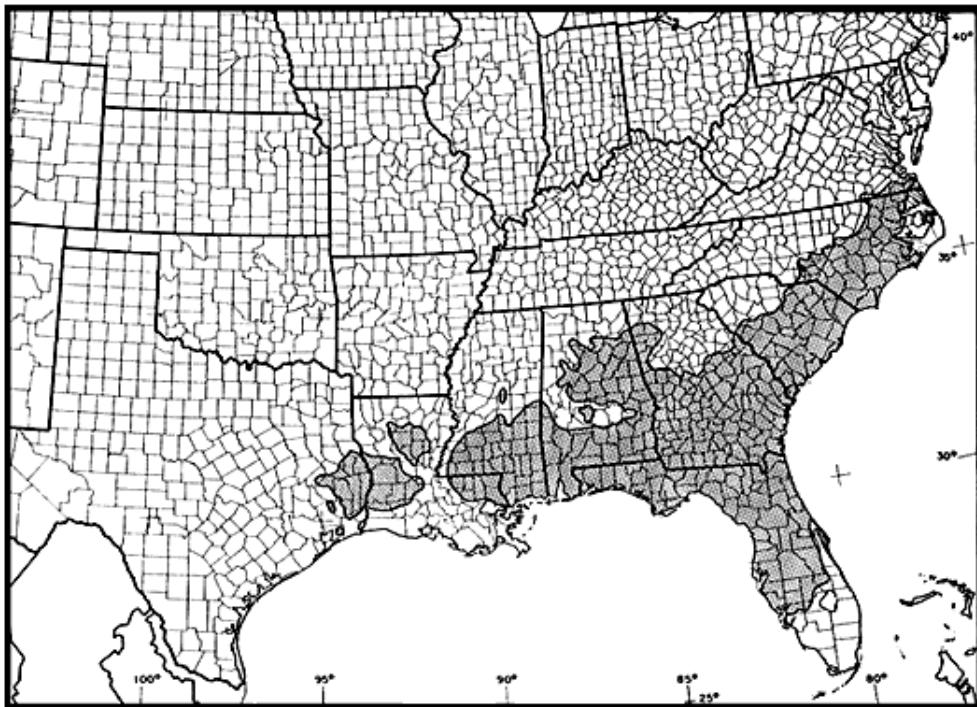
Leaf Characteristics:

- 20 to 60 cm (8 to 24 in) long
 - 3 (rarely 4 or 5) needles per fascicle
 - bright to dark green
 - acicular, slender, flexible; not twisted
 - persist 2 years
 - fascicle sheath 2 to 3.5 cm (0.8 to 1.4 in) long; persistent
-

Bark	Back to <i>Pinus palustris</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus palustris Mill.

Range and Habitat



The native range of longleaf pine. (From Little, 1971.)

Geographic Range

According to Boyer (1990) : "The natural range of longleaf pine includes most of the Atlantic and Gulf Coastal Plains from southeastern Virginia to eastern Texas and south through the northern two-thirds of peninsular Florida. The species also grows in the Piedmont, Ridge and Valley, and Mountain Provinces of Alabama and northwest Georgia."

Climate

According to Boyer (1990) : "Longleaf pine grows in warm, wet temperate climates characterized by hot summers and mild winters. Annual mean temperatures range from 16 to 23 degrees C (60 to 74 degrees F) and annual precipitation from 1090 to 1750 mm (43-50 in) in the Carolinas and Texas and the greatest along the Gulf Coast of Alabama, Mississippi, and extreme west Florida. A distinct summer rainfall peak occurs along the Atlantic Coast, being most pronounced in Florida. A secondary rainfall peak in March becomes pronounced along the Gulf Coast. Fall is the driest season of the year, although droughts during the growing season are not unusual."

Soils and Topography

According to Boyer (1990) : "Longleaf pine is native to a wide variety of sites ranging from wet, poorly

drained flatwoods to dry, rocky mountain ridges. Elevations range from barely above sea level near the beaches on the lower Coastal Plain up to about 600 m (1970 ft) in the mountains of Alabama. Most of the longleaf pine forests are found on the Atlantic and Gulf Coastal plains at elevations below 200 m (660 ft). Here the soils are largely derived from marine sediments and range from deep coarse, excessively drained sands to poorly drained clays. For the most part, surface soils are sandy, acid, low in organic matter, and relatively infertile."

Three soil orders are associated with longleaf pine. The first, Ultisols, are the most expansive in the southeast, excluding peninsular Florida. Entisols make up the Sandhills of the southeastern Atlantic states. Spodosols, which are wet sandy soils, have a fluctuating water table near the ground surface during rainy seasons. This soil is common to flatwood sites of the lower Coastal Plain of Florida.

Bark	Back to <i>Pinus palustris</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus palustris Mill.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots of lower branches in lower crown
- 3 to 5 cm (1.2 to 2.0 in) long at maturity
- purplish to bluish at maturity
- mature and release pollen between March and April

Female cones

- occur singly or in clusters near tips of new branches in upper crown
- pinkish-purple at time of pollination
- 2.5 cm (1.0 in) long at time of pollination
- appear in February and March
- 15 to 30 cm (6 to 12 in) long at maturity

- tan to dark brown; weathering to dull brown
- cylindrical to narrowly ovoid
- sessile
- apophysis brown
- umbo armed with slightly reflexed prickle
- mature and release seed between September and October of second season

Seeds

- seed: 1 to 1.5 cm (0.4 to 0.6 in) long
- dark brown
- oval to oblong
- wing: 4 to 5 cm (1.6 to 2.0 in) long; brown

Bark	Back to <i>Pinus palustris</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
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Additional Readings

- Boyer, W.D., 1990. *Pinus palustris* Mill., Longleaf Pine, pp. 405-412. In R.M. Burns and B.H. Honkala (eds.), *Silvics of North America*, Vol. 1, Conifers, U.S.D.A. For. Serv. Agric. Handbk. 654, Washington, D.C.
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Pinus pungens Lamb.

Table Mountain pine

(hickory pine, mountain pine, prickly pine, squirrel pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 6 to 12 m (20 to 40 ft)
Maximum: 29.6 m (97 ft)
- **Diameter at breast height at maturity:**
Typical: 20 to 30 cm (8 to 12 in)
Maximum: 70 cm (28 in)
- **Crown shape:** round to irregularly shaped

- **Stem form:** excurrent to deliquescent
 - **Branching habit:** long and spreading; stout branches often as long as tree height
-

Table Mountain pine is endemic to the Appalachian Mountains. This tree was first collected around 1794 near Tablerock Mountain in Burke County, North Carolina, hence the common name ‘Table Mountain pine’. Restricted to rocky, dry ridges and slopes, it is scattered throughout its range and sometimes forms small populations in suitable areas.

Human uses: Locally for fuelwood. Commercially used for pulpwood and low-grade timber.

Animal uses: Food and shelter. Using its teeth, the red squirrel, *Tamiasciurus hudsonicus*, will cut a cone-bearing branch from the tree. Once on the ground, the cone is removed from the branch in the same manner. One by one, the squirrel chews away cone scales from the base to the apex of the cone and consumes the seeds inside. Because of this activity, *Pinus pungens* has locally been dubbed ‘squirrel pine’.

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus pungens Lamb.

Bark



Bark characteristics:

- young bark thin, scaly; dark gray
- mature bark thin; furrowed into scaly plates
- 2 to 2.5 cm (0.8 to 1 in) thick
- reddish-brown to dark brown

Unlike its common associate pitch pine, *Pinus rigida*, the bark of Table Mountain pine is not as thick; nor does it possess epicormic branches and dormant lateral buds on the bole. Thus, it is more readily damaged by fire than pitch pine, even though fire is important for regeneration.

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus pungens</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus pungens Lamb.

Leaves and Buds



Bud Characteristics:

- 12 to 18 mm (0.5 to 0.7 in) long
- cylindrical to obtuse
- dark brown, but appearing whitish due to resinous coating
- highly resinous

Leaf Characteristics:

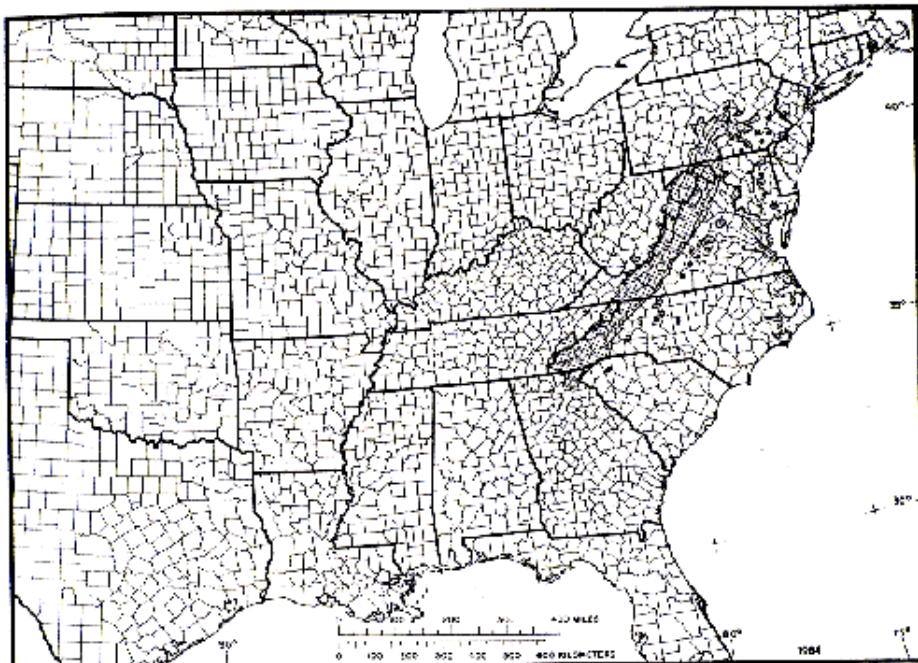
- 3 to 6 cm (1.2 to 2.4 in) long
- 2 (rarely 3) needles per fascicle
- dark green
- acicular, stout, stiff; usually twisted
- persist 2 years

- fascicle sheath 6 mm (0.2 in) long; reddish-brown; persistent
-

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Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus pungens Lamb.

Range and Habitat



The native range of Table Mountain pine. (From Little, 1971.)

Geographic Range

According to Della-Bianca (1990) : "Table Mountain pine, an Appalachian endemic, grows almost entirely within the range of pitch pine, (*Pinus rigida*) and Virginia pine (*P. virginiana*), but is less frequent. In general, Table Mountain pine occupies xeric sites of Appalachian rocky and shaly mountainous areas from Georgia into Pennsylvania. It is frequently found on ridges of the precipitous gorges that dissect the Blue Ridge Mountains."

"Table Mountain pine is unevenly distributed; its range extends from the Northern Appalachians in central Pennsylvania southwest to eastern West Virginia and southward into the Southern Appalachians, ending on the steep western edge of the mountains of North Carolina and Tennessee. To the east and south, its range includes the crest and eastern escarpment of the prominent Blue Ridge Front with its numerous rocky gorges and torrential mountain streams. Toward the southern end of its range, Table Mountain pine reaches its highest elevation of 1760 m (5,780 ft) in the Great Smoky Mountains. There are numerous outlying populations of Table Mountain pine to the east and a few to the west of the Appalachians; many outliers are associated with the monadnocks which rise considerably higher than the surrounding Piedmont."

Climate

According to Della-Bianca (1990) : "Precipitation within the range of Table Mountain pine varies with

latitude and elevation. Warm season rainfall from April through September varies annually from 460 to 610 mm (18 to 24 in) in Pennsylvania to 690 to 990 mm (27 to 39 in) in the Southern Appalachians. Mean annual precipitation ranges from 760 mm (30 in) in Pennsylvania to more than 2030 mm (80 in) in the Great Smoky Mountains. At the northern end of the range, average July temperature varies from 21 to 27 degrees C (70 to 80 degrees F); in the Great Smoky Mountains, the range is 15 to 21 degrees C (60 to 70 degrees F). Average January temperatures in Pennsylvania range from -7 to -1 degrees C (20 to 30 degrees F); in the Great Smoky Mountains, 2 to 5 degrees C (35 to 40 degrees F). In Pennsylvania, the average number of frost-free days varies from 150 to 170, and in the mountains of Tennessee, North Carolina, and north Georgia, from 170 to 180."

Soils and Topography

According to Della-Bianca (1990) : "In Pennsylvania, Table Mountain pine grows on substrates of upper Silurian and lower Devonian rocks. Elsewhere it is known to grow on substrates of the Unicoi, Alligator Back, Loudon, Weverton, Erwin, Pottsville, Chemung, Pocono, Portage, and Hampshire or Catskill Formations. Table Mountain pine is not found over limestone substrates. Although surface rock varies in Table Mountain pine stands in the Great Smoky Mountains, it is often less than 15 percent of total surface cover; however, on narrow ridges, surface rock can range from 35 to 55 percent or more. In about half the stands bedrock occurs less than 50 cm (20 in) below the soil surface. Large amounts of gravel and rocks up to 30 cm (12 in) or more commonly occur in the solum; stone content has been found to range from 24 to 59 percent of air-dry weight.

"Some eleven soil series and rough stony land are associated with Table Mountain pine stands. The most common soil series are Ashe, DeKalb, Ramsey, and Porters. In the Great Smoky Mountains, 57 percent of associated soils are Lithic Dystrochrepts, and 43 percent Typic Dystrochrepts of the order Inceptisols. Generally, A-horizon soils contain an average of 61, 28, and 11 percent sand, silt, and clay, respectively. Most of the B-horizon textures are loams and silt loams; silty clay loam occurs infrequently. Litter depth is about 5 cm (2 in). Organic matter content of the A horizon averages 5.5 percent, and in the B horizon 2.5 percent, respectively. Water-holding capacity in the solum ranges from 5 to 16 percent.

"Table Mountain pine can grow over a wide range in elevation. Known extremes are 46 m (150 ft) in Delaware and 1762 m (5,780 ft) in the Great Smoky Mountains; most often it occurs between 305 and 1200 m (1,000 to 4,000 ft) above sea level. In the Great Smoky Mountains, elevation affects the distribution of Table Mountain pine and Table Mountain pine-pitch pine stands. Above 1060 m (3,480 ft) Table Mountain pine-pitch pine stands were mostly restricted to south-facing ridges; with increasing elevation, pitch pine decreased in abundance. Dominance of Table Mountain pine stands occurred at elevations about 1200 m (4,270 ft). On typical sites, the southwest-facing aspect is of critical importance to the presence of Table Mountain pine although the species can and does grow on other aspects. Slopes on which it occurs in the Great Smoky Mountains average 42 percent."

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Pinus pungens Lamb.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots of branches in lower crown
- 2 to 3 cm (0.8 to 1.2 in) long at maturity
- reddish purple; yellowish at maturity
- mature and release pollen late April to early May

Female cones

- occur in clusters of 2 to 7 near the tips of new shoots
- purplish to greenish-brown at time of pollination
- appear in April or May

- 5 to 9 cm (2 to 3.6 in) long at maturity
- serotinous or non-serotinous
- shiny, light brown
- ovoid
- sessile
- apophysis swollen
- umbo armed with a very stout, curved spine
- matures and partly opens autumn of second season, gradually releasing seeds
- persist on branch for many years

Seeds

- 6 mm (0.2 in) long
- dull black to gray
- triangular to oval
- wing 19 to 25 mm (0.8 to 1.0 in) long

According to Della-Bianca (1990) : "Table Mountain pine needs stand and site disturbance, light, and heat for successful regeneration. In closed stands on western and northern exposures, Table Mountain pine cones are distinctly serotinous, but on southerly and easterly exposures many cones open soon after maturing. A large number of closed cones remain on the trees from 5 to 25 years and the retained seeds remain viable for 9 or more years."

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus pungens</i> title page	Reproductive Structures
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Pinus rigida Mill.

pitch pine

(southern pine, black pine, torch pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 15 to 25 m (50 to 83 ft)
Maximum: 30 m (100 ft)
- **Diameter at breast height at maturity:**
Typical: 30 to 60 cm (12 to 24 in)
Maximum: 76 cm (30 in)
- **Crown shape:** broadly round to irregularly spreading

- **Stem form:** excurrent; sometimes forked
 - **Branching habit:** long and spreading; thick limbs covered with spur shoots
-

Pitch pine is one of the most fire resilient eastern conifers. Where fire kills the foliage, new needles are produced on new branches from suppressed buds on the bole. This adaptation allows for survival in a high frequency fire area such as the Pine Barrens of New Jersey. High resin content in this species produced the name "pitch pine". Early American settlers would often ignite pine knots for torches. Before the widespread use of the southern pines for naval stores, pitch pine was used in the United States for the production of turpentine and rosin.

Human uses: Formerly, old growth pitch pine was used for flooring, sills, window and door frames, and structural beams. Because of high resin content, the decay-resistant wood was popular for ship building, mine props, railroad ties, and fencing. Currently, pitch pine is used in pulpwood and lumber production.

Animal uses: Pitch pine is an important food source for wildlife. Sprouts and seedlings serve as browse for deer (*Odocoileus virginianus*), cottontail rabbits (*Sylvilagus floridanus*), and meadow mice (*Microtus pennsylvanicus*). Pine seeds are eaten by many species of birds and rodents including quail (*Colinus virginianus*), chickadees (*Parus carolinensis*), juncos (*Juncos hyemalis*) and mice (*Peromyscus leucopus*). Red squirrels (*Tamiasciurus hudsonicus*), rely so heavily on serotinous cones for food, they have created a selection pressure for cones with fewer seeds; serotinous cones produce fewer seeds in areas with high squirrel populations in order to discourage seed predation (Ledig and Little, 1979.).

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus rigida Mill.

Bark



Bark characteristics:

- young bark scaly; dark gray
- mature bark thick; deeply furrowed into broad scaly ridges
- 2.5 to 5 cm (1 to 2 in) thick
- dark brown to reddish-brown

An adaptation for survival in fire-prone areas, the thick bark provides protection to the cambium and the suppressed buds on the bole. These buds often sprout after a fire has killed the foliage.

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Pinus rigida Mill.

Leaves and Buds



Bud Characteristics:

- 6 to 14 mm (0.2 to 0.6 in) long
- oblong or cylindrical; acute
- thin, reddish-brown scales
- resinous

Leaf Characteristics:

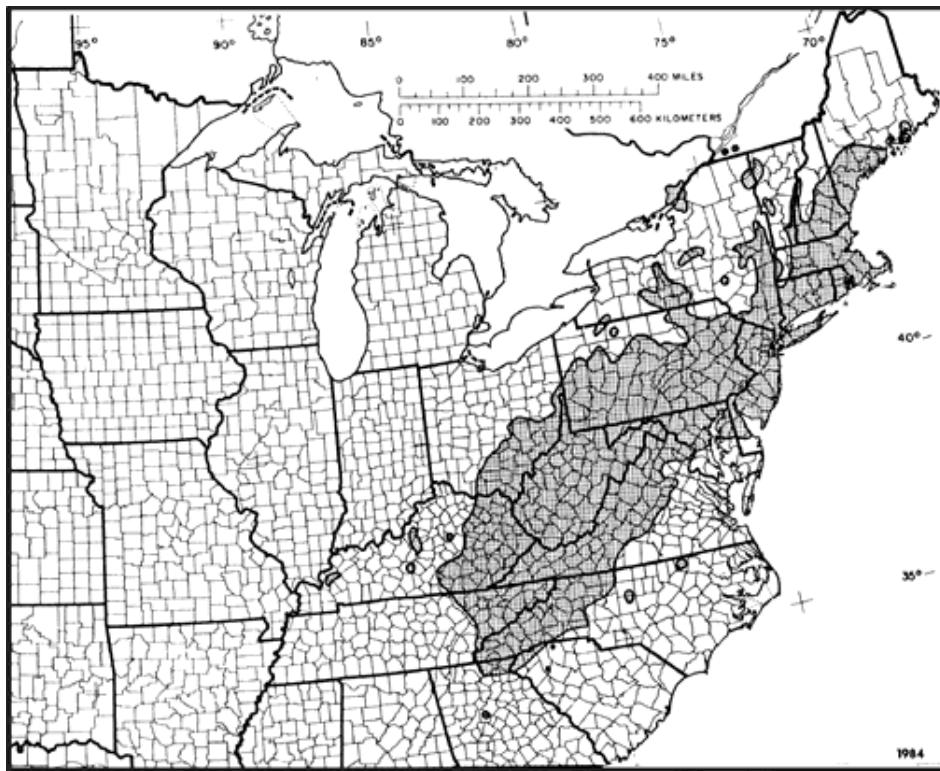
- 7 to 14 cm (2.8 to 5.6 in) long
- 3 needles per fascicle
- green to yellowish-green
- acicular, thin, stiff, sometimes twisted
- persist 2 years

- fascicle sheath 9 to 12 mm (0.4 to 0.5 in) long; persistent
-

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Pinus rigida Mill.

Range and Habitat



The native range of pitch pine. (From Little, 1971.)

Geographic Range

According to Little and Garrett (1990) : "Pitch pine grows over a wide geographical range--from central Maine to New York and extreme southeastern Ontario, south to Virginia and southern Ohio, and in the mountains to eastern Tennessee, northern Georgia, and western South Carolina. Because it grows mostly on the poorer soils, its distribution is spotty. In the Northeast, pitch pine is most common on the sandy soils of Cape Cod, Long Island, and southeastern New Jersey, and in some sections of sandy or shallow soils in Pennsylvania."

The form of pitch pine varies greatly from area to area. In the New Jersey Pine Plains, dwarf trees are characteristicly less than 3.5 m (12 ft) tall, while in Pennsylvania, trees may grow to 30 m (100 ft) tall. Site and soil conditions, as well as fire, play an important role in growth and form of pitch pine throughout its natural range.

Climate

According to Little and Garrett (1990) : "The climate in the range of pitch pine is humid. Average annual precipitation is usually between 940 and 1420 mm (37 and 56 in) and is well distributed

throughout the year. Length of the frost-free season ranges from 112 to 190 days and temperatures range from winter lows of -40 degrees C (-40 degrees F) in the northern part of the range to summer highs of more than 38 degrees C (100 degrees F) in most sections."

Soils and Topography

According to Little and Garrett (1990) : "Pitch pine is usually restricted to the less fertile soils--those of shallow depth, or of sandy or gravelly texture. Many of the northern stands are found on sandy outwash plains of glacial origin. The species also occupies sandy and gravelly soils of alluvial and marine origin. In the highlands of northern New Jersey, southern New York, Pennsylvania, and south through the mountains, it is most common on steep slopes, ridges, and plateaus where the soils are shallow.

"Generally, pitch pine grows on Spodosols, Alfisols, Entisols, and Utisols. In southern New Jersey, the pH of the A and B horizons range from 3.5 to 5.1 and in northern New Jersey, from 4 to 4.5. Pitch pine grows on sites with a wide range of moisture conditions. In southern New Jersey it is found on excessively drained, imperfectly drained, and poorly drained sands and gravels, as well as on muck soils in the white-cedar swamps. Even in the hilly regions it grows on both well drained and excessively drained slopes and in the swamps.

"In New England it is most common in the coastal districts and in river valleys. In New York it is not common above 610 m (2,000 ft), but in Pennsylvania it grows at all elevations up to the highest point in the state 979 m (3,213 ft). In the Great Smoky Mountains and vicinity, pitch pine is found at elevations between 430 and 1370 m (1,400 and 4,500 ft). In hilly sections, pitch pine often occupies the warmer and drier sites, those facing south or west."

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Pinus rigida Mill.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots in lower crown
- 1.3 to 2.5 cm (0.5 to 1.0 in) long at maturity
- yellowish or purplish at maturity
- mature and release pollen in early to late May

Female cones

- occur singly or in pairs on higher branches
- greenish, often showing some red at time of pollination
- 2.0 cm (0.8 in) long at time of pollination
- appear in early May
- 4 to 7 cm (1.6 to 2.8 in) long at maturity

- serotinous or non-serotinous
- dull brown to reddish-brown
- ovoid to globose
- nearly sessile or short-stalked
- apophysis light brown
- umbo armed with a stout prickle
- mature 16 to 18 months after pollination; seed release time varies
- persist on branch for many years

Seeds

- 4 to 5 mm (0.2 in) long
- dull black to gray
- triangular to oval
- wing 15 to 21 mm (0.6 to 0.8 in) long; brownish

Serotiny in pitch pine cones varies from area to area and is a genetically inherited characteristic. Some trees produce cones which open immediately at maturity, while others produce serotinous cones which will only open under intense heat from fire. Intermediates between the two conditions exist as well. Cone production can start as early as age 3, but the average is 8 to 12 years old. Pitch pine may produce large cone crops at 3 year intervals, but timing is variable.

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Pinus serotina Michx.

pond pine

(marsh pine, bay pine, pocosin pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 12 to 21 m (40 to 70 ft)
Maximum: 29 m (94 ft)
- **Diameter at breast height at maturity:**
Typical: 30 to 60 cm (12 to 24 in)
Maximum: 90 cm (36 in)
- **Crown shape:** open, rounded or narrow, irregular

- **Stem form:** excurrent
 - **Branching habit:** often contorted, spreading; limbs and bole sometimes covered with spur shoots
-

Pond Pine is often considered a subspecies or variety of pitch pine, *Pinus rigida*. Where the two ranges overlap, hybridization occurs. Fire is an important disturbance factor in the pond pine community, and many pine stands in the southeastern United States regenerated after wildfire. Adaptations to fire include suppressed buds on the bole and cone serotiny.

Human uses: pulpwood, sawtimber, firewood

Animal uses: Sprouts and seedlings serve as browse for deer (*Odocoileus virginianus*). Pine seeds are eaten by many species of birds and rodents. Pond pine stands also provide habitat for red-cockaded woodpeckers (*Picoides borealis*).

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus serotina Michx.

Bark



Bark characteristics:

- young bark thin, scaly; dark gray
 - mature bark thick; furrowed into scaly, flat plates
 - 1.3 to 2 cm (0.5 to 0.8 in) thick
 - blackish-gray to reddish-brown
-

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Pinus serotina Michx.

Leaves and Buds



Bud Characteristics:

- 5 to 6 mm (0.2 in) long
- oblong or cylindrical
- thin, reddish-brown scales
- resinous

Leaf Characteristics:

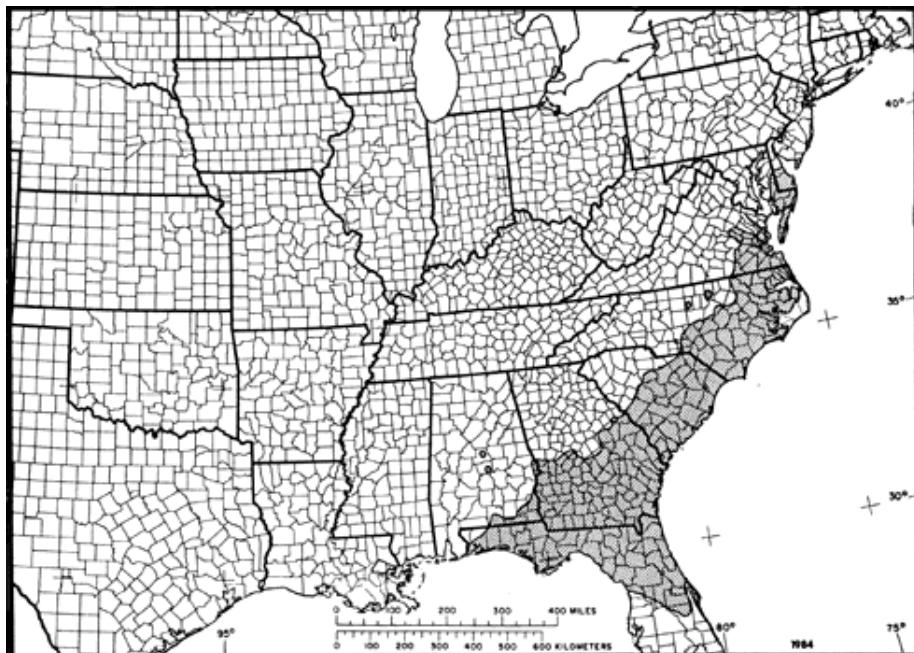
- 15 to 25 cm (6 to 10 in) long
- 3 (rarely 2 or 4) needles per fascicle
- green to yellowish-green
- acicular, thin, stout, slightly twisted
- persist 3 to 4 years

- fascicle sheath 1 cm (0.4 in) long; persistent
-

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Pinus serotina Michx.

Range and Habitat



The native range of pond pine. (From Little, 1971.)

Geographic Range

According to Bramlett (1990) : "Pond pine grows from Cape May, New Jersey, southward through the Coastal Plains of Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia to central Florida and southeastern Alabama. Within its native range, pond pine is most frequently found on wet or poorly drained sites."

Climate

According to Bramlett (1990) : "The climate throughout the pond pine range is mild and humid. Frost-free days range from 210 in the north to 300 in central Florida. The normal January and February daily average temperature is 2 degrees C (35 degrees F) in the northern range, increasing to 16 degrees C (60 degrees F) for the southern range. In July and August, the normal daily average temperature ranges from 29 degrees C (85 degrees F) in the south to 24 degrees C (75 degrees F) in the north. The extremes of temperature within the range have been as low as -23 degrees C (-10 degrees F) and as high as 43 degrees C (110 degrees F). Annual precipitation increases from 1120 to 1370 mm (44 to 54 in) on a transect from north to south and from 1120 to 1420 mm (44 to 56 in) on an inland to coastal transect. July and August have an average rainfall of 100 to 200 mm (4 to 8 in) per month in contrast to 50 to 100 mm (2 to 4 in) for December and January."

Soils and Topography

According to Bramlett (1990) : "The lower terraces of the Coastal Plain in the southeastern United States are characterized by sandy and organic soils. Typical soils are in the Ultisols order, Aquults suborder, Albaquults and Umbraquults great groups. These soils usually have a dark gray, sandy loam surface soil and a heavy subsoil. The entire area has minor topographic relief and is interspersed with major drainage systems that are frequently very broad. Throughout the region are numerous streams, swamps, pocosins, marshes, and bays that are characterized by poorly developed drainage patterns. The pocosins, in particular, have unique topographic features in the Carolinas. The areas are upland bogs with streams draining from them on all sides. The pocosins have a considerable peat accumulation, frequently as deep as 2 m (6 ft). Also, in the southeastern Coastal Plain there are shallow, poorly drained depressions called bays or ponds. Pond pine is frequently found as the major overstory species in these pocosins and bays in association with a heavy understory of shrubby vegetation.

"Although pond pine is most frequently found on poorly drained lands, the species can make excellent growth on mineral soils or on land that is not continuously waterlogged. The slow growth of pond pine is primarily a function of prolonged water saturation and reduced soil aeration. Poor aeration retards decay of organic material and results in the accumulation of muck and peat with high acidity. Although availability of mineral nutrients is usually adequate, nitrogen fixation and nitrification proceed very slowly. Consequently, the amount of available nitrogen is small even though total nitrogen content is high in the undecayed organic matter. Soil saturation also deprives roots of the oxygen required for respiration and growth and tends to keep the soil temperature low."

The term "pocosin pine" comes from a native American name, "pocosin" which means "swamp-on-a-hill". This refers to the slightly raised boggy areas between the drainages. These areas typically contain Histosol soils. Often, pure stands of pond pine will grow on these sites, especially if the area is occasionally burned by fire.

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Glossary		Interactive Comparison Tool

Pinus serotina Michx.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots in lower crown
- 3 to 4 cm (1.2 to 1.6 in) long
- greenish-yellow to pinkish brown
- release pollen in April

Female cones

- occur singly, paired, or in clusters near the tip of new shoots on higher branches
- greenish at time of pollination

- 5 to 6 cm (2 to 2.5 in) long at maturity
- serotinous
- dull brown to reddish-brown
- broadly ovoid to turbinate unopened, conic-ovoid to globose opened
- nearly sessile or short-stalked
- apophysis dark brown
- umbo armed with a weak, deciduous prickle
- persist either unopened or opened on branch for many years

Seeds

- 3 mm (0.1 in) long,
- triangular to oval in shape
- wing 19 mm (0.8 in) long; brownish to tan

Cone production can occur at a young age; trees around 10 years old have been found to produce an average of 8 cones per tree. Best cone production begins at age 30 with each tree producing 175 to 200 cones. Cones can remain on the tree for as long as 10 years, and may become embedded within the growing stems.

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus serotina</i> title page	Reproductive Structures
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Additional Readings

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Pinus taeda L.

loblolly pine

(oldfield pine, North Carolina pine, Arkansas pine, formerly called shortleaf pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 25 to 33 m (90 to 110 ft)
Maximum: 49.7 m (163 ft)

- **Diameter at breast height at maturity:**
Typical: 90 to 120 cm (36 to 48 in)
Maximum: 140 cm (56 in)

- **Crown shape:** broadly conical; dense
 - **Stem form:** excurrent; often slightly crooked or swept
 - **Branching habit:** long and spreading; well developed limbs
-

Loblolly Pine is the most important and widely cultivated timber species in the southern United States. Because it grows rapidly on a wide range of sites, it is extensively planted for lumber and pulpwood. This tree is dominant on 11.7 million hectares (29 million acres) and comprises over half of the standing pine volume in the south. A medium lived tree, loblolly matures in about 150 years, with select trees reaching 300 years in age.

Human uses: Furniture, pulpwood, plywood, composite boards, posts, poles, pilings, crates, boxes, pallets. Loblolly is also planted to stabilize eroded or damaged soils. It can be used for shade or ornamental trees, as well as bark mulch.

Animal uses: Food, cover. White-tailed deer (*Odocoileus virginianus*), gray squirrel (*Sciurus carolinensis*), fox squirrel (*Sciurus niger*), bobwhite quail (*Colinus virginianus*), and wild turkey (*Meleagris gallopavo*) all utilize both pure and mixed loblolly stands for shelter. Red-cockaded woodpeckers (*Picoides borealis*) also use these trees for foraging habitat and nesting, as do a variety of other bird species such as pine warbler (*Dendroica pinus*), brown-headed nuthatch (*Sitta pusilla*), and Bachman's warbler (*Vermivora bachmanii*). Seeds are also eaten for food by songbirds and small mammals. Standing dead trees are frequently used for cavity nests by woodpeckers.

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus taeda L.

Bark



Bark characteristics:

- young bark thin, scaly; yellowish to grayish-black
 - mature bark thick; deeply furrowed into irregular scaly plates
 - 2 to 5 cm (0.8 to 2 in) thick; does not continually shed
 - reddish-brown weathering to grayish-brown color
-

Bark	Back to <i>Pinus taeda</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus taeda L.

Leaves and Buds



Bud Characteristics:

- 6 to 12 mm (0.2 to 0.5 in) long
- oblong or cylindrical; acuminate
- scales thin, reddish-brown fringed
- scales with reflexed tips
- resinous

Leaf Characteristics:

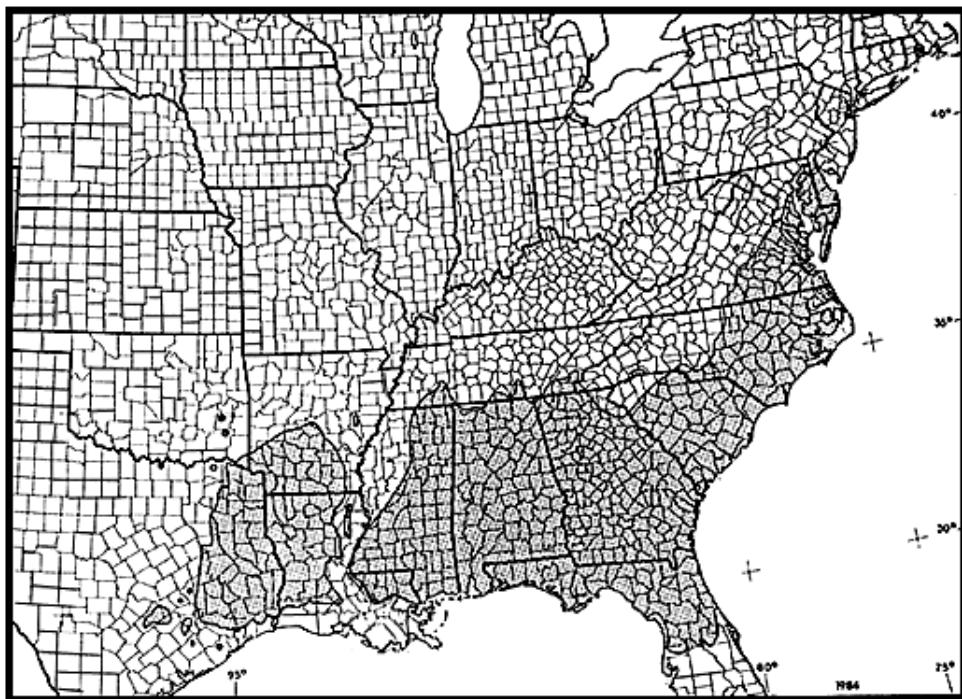
- 10 to 23 cm (4 to 9.2 in) long
- 3 (occasionally 2 or 4) needles per fascicle
- green to yellowish-green

- acicular, thin, stiff, sometimes twisted
 - persist 2 to 3 years
 - fascicle sheath 2.5 cm (1 in) long; brown to yellowish-brown; persistent
-

Bark	Back to <i>Pinus taeda</i> title page	Range and Habitat
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Glossary		Interactive Comparison Tool

Pinus taeda L.

Range and Habitat



The native range of loblolly pine. (From Little, 1971.)

Geographic Range

Pinus taeda is found in 14 states, mostly in the southeastern U.S. It ranges from New Jersey south to central Florida and west to eastern Texas and Oklahoma. This tree occurs in the Atlantic Coastal Plain, the Piedmont Plateau, and the southern extremities of the Cumberland Plateau and Appalachian Highlands. Loblolly, however, does not grow naturally in the Mississippi River flood plain. Because of its ability to grow quickly on a variety of sites, loblolly is extensively planted in other parts of the world for timber and pulp.

This tree grows best in moist sites, but it can grow in drier areas and compete with other pines. For example, although longleaf pine (*Pinus palustris*) originally dominated the Atlantic Coastal Plain before the European settlers arrived, two factors helped establish the dominance of *Pinus taeda* in this area. First, eroded abandoned farm fields were quickly colonized by loblolly, an aggressive pioneer on disturbed land; thus the name "oldfield pine." Secondly, fire exclusion helped loblolly pines to regenerate in areas where longleaf, a tree highly adapted to frequent fire, was dominant. Without fire, loblolly thrived and outcompeted longleaf pines.

Climate

The loblolly pine range includes a warm-temperate, humid climate. The summers are long and hot,

while the winters are short, and fairly mild. Mean temperatures range from 13 to 24 degrees C (55 to 75 degrees F). Average July temperature is about 27 degrees C (80 degrees F) and average January temperature ranges from 4 to 16 degrees C (40 to 60 degrees F). Average yearly rainfall is between 1020 to 1520 mm (40 to 60 in).

The frost-free period ranges from 5 months in the northern areas to 10 months in the southern states. Colder winter temperatures may limit the growth of loblolly in the north, while lack of precipitation during the growing season inhibits its occurrence in the west.

Soils and Topography

The term "loblolly" literally means "mudhole" which can be used to describe the wet soil conditions on which this tree occurs naturally. Their best growth is on moderately acid soils in areas of poor surface drainage which consists of a thick, medium-textured surface layer and fine-textured subsoil. They do not grow well, however, on very wet or water-logged sites, or in areas with shallow or eroded soils.

Loblolly is mostly found on Ultisol soils, although small areas of Entisols, Spodosols, and Alfisols are scattered throughout its range. Productivity is sensitive to soil fertility; if poorly drained soils have low fertility, usually there is a decrease in productivity. Also, the presence of a spodic horizon along the root zone causes a decline in productivity. This tree is planted on Histosols following artificial drainage and site preparation.

Pinus taeda can be found on a variety of topographies, ranging from the flat Coastal Plain, to rolling Piedmont hills, to fringes of the Interior Highlands.

Bark	Back to <i>Pinus taeda</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus taeda L.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots in middle and lower crown
- 2.5 to 3.8 cm (1.0 to 1.5 in) long
- pinkish-purple to light greenish-yellow
- release pollen February through April

Female cones

- occur near the tip of new shoots, mostly on higher branches
- pinkish-red to yellowish-green at time of pollination
- appear February through April
- 10 to 15 cm (4 to 6 in) long at maturity
- dull brown to yellowish-brown

- oblong-conic
- sessile
- apophysis swollen or flattened
- umbo armed with a sharp prickle
- mature and release seed September through early December of second season
- persist on branch 1 to 4 years

Seeds

- 6 to 7 mm (0.2 to 0.3 in) long
- reddish to blackish-brown
- wing 25 to 28 mm (1.0 to 1.1 in) long; light brown

According to Baker and Langdon (1990): "Staminate flowers on a given tree tend to mature before the pistillate flowers, which helps to reduce self-pollination. Fertilization of the pistillate strobili takes place in the spring of the following year.

"Despite fluctuations in seed production, loblolly usually produces some seeds every year and good seed crops normally occur at intervals of 3 to 6 years."

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus taeda</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Additional Readings

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***Contortae*, The Fire Pines**

Contortae includes 4 species occurring in the United States and Canada. Leaves are usually 2 per fascicle and short. The seed cones are small, and symmetrical or oblique in shape. These cones are normally serotinous, remaining closed or opening late in the season, and often remaining for years on the tree. Cone scales may or may not be armed with a persistent prickle, depending upon species.

***Contortae* includes 2 species in the southeastern North America:**

Pinus virginiana
Virginia pine



Pinus clausa
sand pine



Glossary

Interactive Comparison Tool

Back to *Pinus* - The Pines

Pinus virginiana Mill.

Virginia pine

(Jersey pine, scrub pine, spruce pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 15 to 23 m (56 to 76 ft)
Maximum: 37 m (122 ft)
- **Diameter at breast height at maturity:**
Typical: 30 to 50 cm (12 to 20 in)
Maximum: 80 cm (32 in)
- **Crown shape:** open, broad, irregular

- **Stem form:** excurrent
 - **Branching habit:** thin, horizontally spreading; dead branches persistent
-

Virginia pine regenerates prolifically, quickly and densely reforesting abandoned fields and cut or burned areas. This pine is a source of pulpwood in the southeastern United States on poor quality sites.

Human uses: pulpwood, Christmas trees. Because of its tolerance to acidic soils, Virginia pine has been planted on strip-mine spoil banks and severely eroded soils.

Animal uses: Old, partly decayed Virginia pines are a favorite nesting tree of woodpeckers. Serves as habitat for pine siskin (*Spinus pinus*) and pine grosbeak (*Pinicola enucleator*). A variety of songbirds and small mammals eat the pine seeds. Deer browse saplings and young trees.

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus virginiana Mill.

Bark



Bark characteristics:

- young bark thin, smooth; dark brown
 - mature bark thin; separated into broad, flat, scaly plates
 - 0.8 to 1.3 cm (0.3 to 0.5 in) thick
 - brownish-orange to light brown
-

Bark	Back to <i>Pinus virginiana</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus virginiana Mill.

Leaves and Buds



Bud Characteristics:

- 8 to 12 mm (0.3 to 0.5 in) long
- conical, acuminate
- dark brown scales
- resinous

Leaf Characteristics:

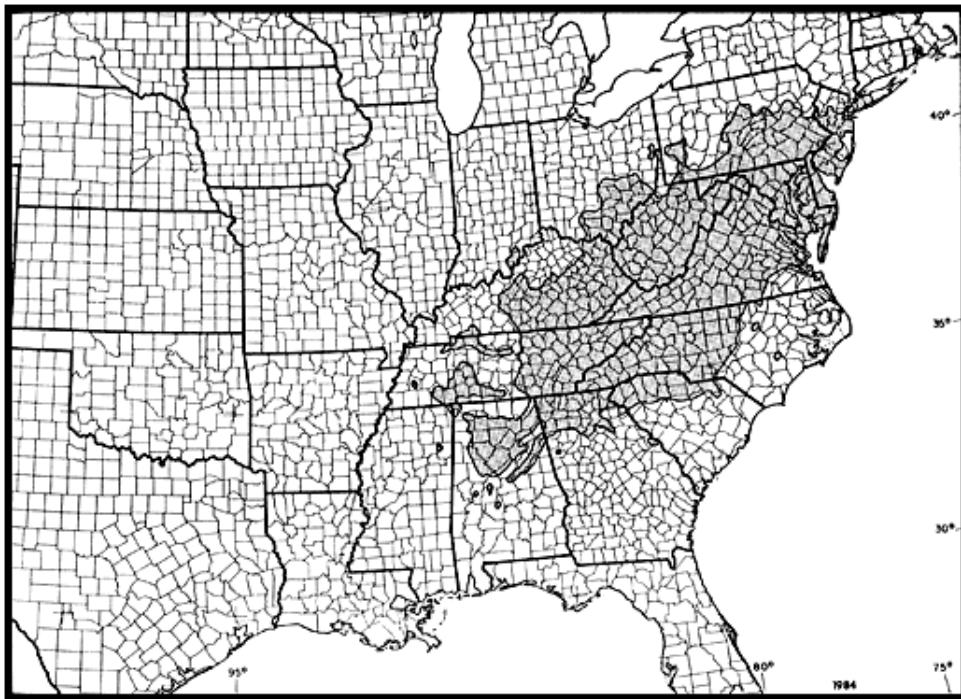
- 4 to 7 cm (1.6 to 2.8 in) long
- 2 needles per fascicle
- dark green to grayish-green
- acicular; rigid, often twisted
- persist 3 to 4 years

- fascicle sheath 10 mm (0.4 in) long; persistent
-

Bark	Back to <i>Pinus virginiana</i> title page	Range and Habitat
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Glossary		Interactive Comparison Tool

Pinus virginiana Mill.

Range and Habitat



The native range of Virginia pine. (From Little, 1971.)

Geographic Range

According to Carter and Snow (1990): "Virginia pine generally grows throughout the Piedmont and at lower elevations in the mountains from central Pennsylvania south-westward to northeastern Mississippi, Alabama, and northern Georgia. It is also found in the Atlantic Coastal Plain as far north as New Jersey and Long Island, NY, and extends westward in scattered areas into Ohio, southern Indiana, and Tennessee."

Climate

According to Carter and Snow (1990): "The annual precipitation in the native range of Virginia pine averages 890 to 1400 mm (35 to 55 in) and is fairly well distributed throughout the year. Rainfall generally is greatest in the southwestern portion of the range. The climate throughout most of this area is classified as humid."

"Summer temperatures average about 21 to 24 degrees C (70 to 75 degrees F); winter temperatures range from -4 to 4 degrees C (25 to 40 degrees F); and the average number of frost-free days varies from more than 225 on the eastern and southern edge of the Piedmont to 160 days on the more mountainous areas to the west and north."

Soils and Topography

According to Carter and Snow (1990): "Virginia pine grows well on a variety of soils derived from marine deposits, from crystalline rocks, sandstones, and shales, and from limestone to a lesser extent. These are classified as Spodosols and Inceptisols. After harvesting or fire, these soils are subject to moderate sheet and gully erosion; erosion can become severe on shale soils. On many areas that now support Virginia pine, much of the A horizon is gone because of past erosion under intensive agricultural use.

"The species grows best on clay, loam, or sandy loam; it generally does poorly on serpentine soils, shallow shaly soils, and very sandy soils. It thrives only in moderately well drained to well drained soils and is less tolerant of wet sites and impeded drainage than pitch and loblolly pines (*Pinus rigida* and *P. taeda*). Virginia pine generally tolerates soil acidities ranging from pH 4.6 to 7.9. Soil beneath a Virginia pine stand was more acidic and contained more organic matter than soil under shortleaf (*P. echinata*), loblolly, or white (*P. strobus*) pine stands.

"Virginia pine usually is found at elevations of 15 to 760 m (50 to 2,500 ft). It comes in freely on abandoned farmland throughout its range."

Bark	Back to <i>Pinus virginiana</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus virginiana Mill.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots in lower crown
- 1 to 2 cm (0.4 to 0.8 in) long at maturity
- orangish-brown at maturity
- release pollen March through May

Female cones

- occur singly, in pairs, or in clusters near the tips of new shoots throughout crown
- pale green at time of pollination
- 3 to 6 cm (1.2 to 2.4 in) long at maturity
- reddish brown, glossy
- ovoid-conic
- usually sessile, but also pedunculate
- apophysis reddish-brown with inner tip of scale covered by a purple band

- umbo armed with a sharp, slender, persistent prickle
- mature and release seed September through November of second season
- persist on branch up to 15 years

Seeds

- 3 to 6 mm (0.1 to 0.2 in) long
- dark brown to black
- triangular to oval
- wing 7 to 9 mm (0.3 to 0.4 in) long; light brown

Fertilization takes place in June, usually 13 months after pollination of the female cones. The cones are mature in late September or early November. Virginia pine can produce cones as early as age 3 and as late as age 80, depending on site conditions. Unlike most other pines, this pine produces seed cones in all parts of the crown, not just the upper portion. Seeds are produced every year with large cone crops every 3 or 4 years. Seeds require exposed mineral soil for successful seedling establishment, as Virginia pine is intolerant of vegetative competition and overstory shade.

Bark	Back to <i>Pinus virginiana</i> title page	Range and Habitat
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Additional Readings

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-

Pinus clausa (Chapm. ex Engelm.) Vasey ex Sarg.

sand pine

(Ocala sand pine, Choctawhatchee sand pine, scrub pine, spruce pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 9 to 24 m (30 to 80 ft)
Maximum: 31 m (103 ft)

- **Diameter at breast height at maturity:**
Typical: 30 to 50 cm (12 to 20 in)
Maximum: 63 cm (24 in)
 - **Crown shape:** rounded or flattened, open
 - **Stem form:** excurrent
 - **Branching habit:** short, coarse, spreading limbs; persistent dead branches
-

Sand pine is found almost exclusively in Florida. Two geographic races are recognized, the Ocala race and the Choctawhatchee race. The Ocala race, *P. clausa* var. *clausa*, occurs from northeastern to southern Florida. This race is distinguished from the other variety by its serotinous cones, which either remain closed for many years, or open after high-intensity fires. This variety grows in dense, even-aged stands. The best development is in the "Big Scrub" in north-central Florida. The Choctawhatchee race, *P. clausa* var. *immuginata*, occurs in northwest Florida and extreme southeastern Alabama. This variety has non-serotinous cones.

Human uses: Pulpwood, construction lumber, fuelwood, Christmas trees.

Animal uses: Seeds eaten by wild turkey (*Meleagris gallopavo*), bobwhite quail (*Colinus virginianus*), fox squirrel (*Sciurus niger*), gray squirrel (*Sciurus carolinensis*), and mourning dove (*Zenaidura macroura*).

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus clausa (Chapm. ex Engelm.) Vasey ex Sarg.

Bark



Bark characteristics:

- young bark thin, smooth; pale gray
- mature bark furrowed into scaly, narrow ridges
- dark gray to reddish-brown

The thin bark and poor pruning of sand pine allow wildfires to quickly consume entire trees, spreading from crown to crown in the dense stands. However, the hot temperatures cause the closed cones to open, and the newly exposed mineral soil below is suitable for seed germination.

Bark		Range and Habitat
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Glossary		Interactive Comparison Tool

Pinus clausa (Chapm. ex Engelm.) Vasey ex Sarg.

Leaves and Buds



Bud Characteristics:

- 2 mm (0.1 in) long
- oblong or cylindrical
- reddish-brown scales
- non-resinous

Leaf Characteristics:

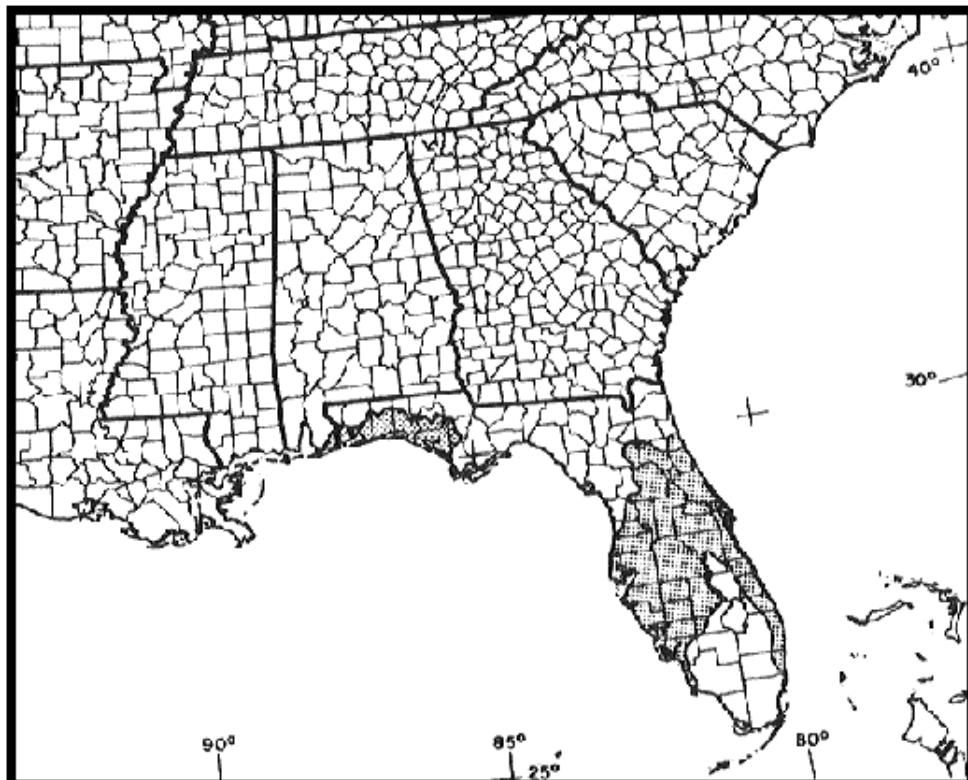
- 5 to 9 cm (2 to 3.6 in) long
- 2 (rarely 3) needles per fascicle
- dark green

- acicular, slender, slightly twisted
 - fascicle sheaths 5 mm (0.2 in) long; persistent
-

Bark	Back to <i>Pinus clausa</i> title page	Range and Habitat
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Glossary		Interactive Comparison Tool

Pinus clausa (Chapm. ex Engelm.) Vasey ex Sarg.

Range and Habitat



The native range of sand pine. (From Little, 1971.)

Geographic Range

According to Brendemuehl (1990) : "Sand pine is one of the minor southern pines with a natural range limited almost entirely to Florida. The largest sand pine concentration is a block of the Ocala variety covering about 101 170 ha (250,000 acres) in north-central Florida, and area often referred to as the "Big Scrub." This variety of sand pine also grows in a narrow strip along the east coast of Florida from St. Augustine southward to Fort Lauderdale. On the Gulf Coast small tracts of Ocala sand pine can be found scattered from a few kilometers north of Tampa southward to Naples. The less abundant Choctawhatchee variety is found growing along the coast in western Florida from Apalachicola to Pensacola and extending westward into Baldwin County, AL. Natural stands of Choctawhatchee sand pine are most abundant in Okaloosa and Walton Counties, FL, covering an area of about 40 470 ha (100,000 acres). Scattered stands of this variety of sand pine can be found 32 to 40 km (20 to 25 mi) inland from the coast in this section of Florida. Sparse stands of sand pine are also found on many of Florida's offshore islands."

Climate

According to Brendemuehl (1990) : "The climate of north-central Florida is characterized by hot summers with abundant precipitation and mild, rather dry winters. Precipitation varies from 50 to 75 mm (2 to 3 in) per month from October until April to as much as 200 to 230 mm (8 to 9 in) per month in June, July, and August. About 55 percent of the average rainfall of 1350 mm (53 in) occurs in the 4 months from June through September. Temperature extremes of -11 degrees and 41 degrees C (12 degrees and 105 degrees F) have been recorded. A frost-free period of 290 days is normal.

"Choctawhatchee sand pine thrives in western Florida under climatic conditions that are somewhat different from those of north-central Florida. Rainfall from December through May averages 100 to 110 mm (4 to 4.5 in) per month. It is hot and humid from June through September but slightly less so than in the north-central area. About 43 percent of the average annual rainfall of 1520 mm (60 in) occurs during this period of the year. October and November are the driest months, with rainfall averaging about 75 mm (3 in) per month. Temperature extremes of -17 degrees and 42 degrees C (2 degrees and 107 degrees F) have been recorded. Average temperature for January is 11 degrees C (52 degrees F) and 27 degrees C (81 degrees F) for July. A frost-free period of 265 days is normal."

Soils and Topography

According to Brendemuehl (1990) : "Sand pine grows on well-drained to excessively drained, infertile, acid to strongly acid sandy soils of the order Entisols. This sand is of marine origin, much of which was deposited in terraces developed during the Pleistocene epoch.

"Most Ocala sand pine grows in the division of Florida known as the Central Highlands. Elevations range from less than 6 m (20 ft) above sea level near Lake George to nearly 61 m (200 ft) in the highest areas of this region. Numerous lakes dot this area and are indicative of the presence of soluble limestone not far below the surface. Gentle rolling hills characterize the terrain. The major soils on which Ocala sand pine grow, in order of importance, are the Astatula, Paola, and St. Lucie series.

"In west Florida, scattered stands of Choctawhatchee sand pine grow on the excessively drained soils of the Coastal Lowlands; however, the majority of such stands are in the division of Florida known as the Western Highlands. Elevations range from near sea level to nearly 90 m (295 ft) above sea level. The terrain of this area is typified by long, gentle slopes and broad, nearly level ridgetops. Sloping to steep hillsides border most of the streams and small lakes of the area. The waterlevel of the rivers, lakes, and intermittent ponds of the area fluctuates considerably according to the amount of rainfall and seepage from the surrounding deep, sandy soils. Soils common to this region include the Kershaw and Lakeland series".

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Glossary		Interactive Comparison Tool

Pinus clausa (Chapm. ex Engelm.) Vasey ex Sarg.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots in lower crown
- 10 mm (0.4 in) long at maturity
- pinkish or purplish at maturity
- *P. clausa* var. *clausa* matures and releases pollen from late December through mid-January
- *P. clausa* var. *immuginata* matures and releases pollen from late January through February

Female cones

- occur in clusters of 2 to 5 near tip of new shoots
- yellowish-green at time of pollination

- 5 to 9 cm (2 to 3.6 in) long at maturity
- serotinous or non-serotinous
- dark brown to yellowish-brown
- ovoid-conic
- short-stalked
- apophysis dark brown
- umbo armed with short, sharp prickles
- persistent on branch 1 to many years
- *P. clausa* var. *clausa* bears both serotinous and non-serotinous cones
- *P. clausa* var. *immuginata* bears mostly non-serotinous cones

Seeds

- 5 mm (0.20 in) long
- dull black to gray
- triangular to oval
- wing 15 mm (0.6 in) long; glossy brown

According to Brendemuehl (1990) : "Sand pine bears cones at an early age. It is not unusual to find mature cones on 5-year-old trees. Occasionally flowers, usually pistillate strobili, are produced by 9- to 10 month old seedlings growing under nursery conditions. The two varieties of sand pine differ appreciably in cone production, cone size, seed size, and several other characteristics. An abundant crop of cones is produced by Ocala sand pine almost annually. Choctawhatchee cone crops of similar size are produced at 4- to 6-year intervals, with light crops in intervening years.

"The majority of Ocala sand pine cones are serotinous: they remain closed when mature and require heat to open. Consequently, seed dispersal is minimal. The cones are very persistent and may accumulate in large numbers on a single tree.

"Seed dissemination of Choctawhatchee sand pine differs from that of Ocala sand pine. The majority of Choctawhatchee cones open when mature and most of the seeds are disseminated during September, October, and November. In western Florida the prevailing winds during the fall are from the west and northwest, and consequently seeds are distributed more evenly and to a greater distance on the eastern and southeastern sides of stands of seed-bearing age."

Bark	Back to <i>Pinus clausa</i> title page	Range and Habitat
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Additional Readings

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-

***Strobi*, The White Pines**

Strobi includes 14 species; 6 in North America and 8 in Eurasia. Leaves are 5 per fascicle. Seed cones open at maturity, releasing seeds with a long or rudimentary wing. Cones have terminal umbos.

***Strobi* includes one species in the eastern North America:**



Pinus strobus - eastern white pine

Glossary	Interactive Comparison Tool	Back to <i>Pinus</i> - The Pines
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Pinus strobus L.

eastern white pine

(white pine, northern white pine, Weymouth pine, soft pine)



Tree Characteristics:

- **Height at maturity:**
Typical: 25 to 33 m (80 to 100 ft)
Maximum: 48.2 m (158 ft)
- **Diameter at breast height at maturity:**
Typical: 90 to 120 cm (36 to 48 in)
Maximum: 170 cm (68 in)

- **Crown shape:** broadly conical with open spaces between branches, producing a layered appearance.
 - **Stem form:** excurrent
 - **Branching habit:** horizontally spreading; one tight spiral formed each year along the main bole (uninodal). Thus tree age may be estimated by counting the spirals.
-

Eastern white pine is the only naturally occurring white pine tree in eastern North America. Of the pines in the United States, this tree is second only in size to sugar pine (*Pinus lambertiana*) which occurs on the west coast. Considered a long lived tree, this pine commonly lives to 200 years of age, and selected individuals may live to 450 years.

Human uses: Furniture, interior trim, window framing, shelving, and Christmas trees. Also grown for landscaping and stabilization of strip-mine spoils.

Animal uses: Songbirds, such as the yellow-bellied sapsucker (*Sphyrapicus varius*), pine warbler (*Dendroica pinus*), and red crossbill (*Loxia curvirostra*), eat the seeds. A few mammals like the beaver (*Castor canadensis*), porcupine (*Erethizon dorsatum*), white-tailed deer (*Odocoileus virginianus*), and snowshoe hare (*Lepus americanus*) may also consume seeds, bark and foliage. Favorite tree for bald eagle (*Haliaeetus leucocephalus*) nests.

Bark	Additional Readings	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus strobus L.

Bark



Bark characteristics:

- young bark grayish to grayish-black; smooth
 - mature bark thick, rough; deeply furrowed ridges on the bole
 - 2.5 to 5 cm (1 to 2 in) thick
 - gray to black
-

Bark	Back to <i>Pinus strobus</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus strobus L.

Leaves and Buds



Bud Characteristics:

- 5 to 7 mm (0.2 to 0.3 in) long
- cylindrical
- thin, reddish to orangish-brown scales

Leaf Characteristics:

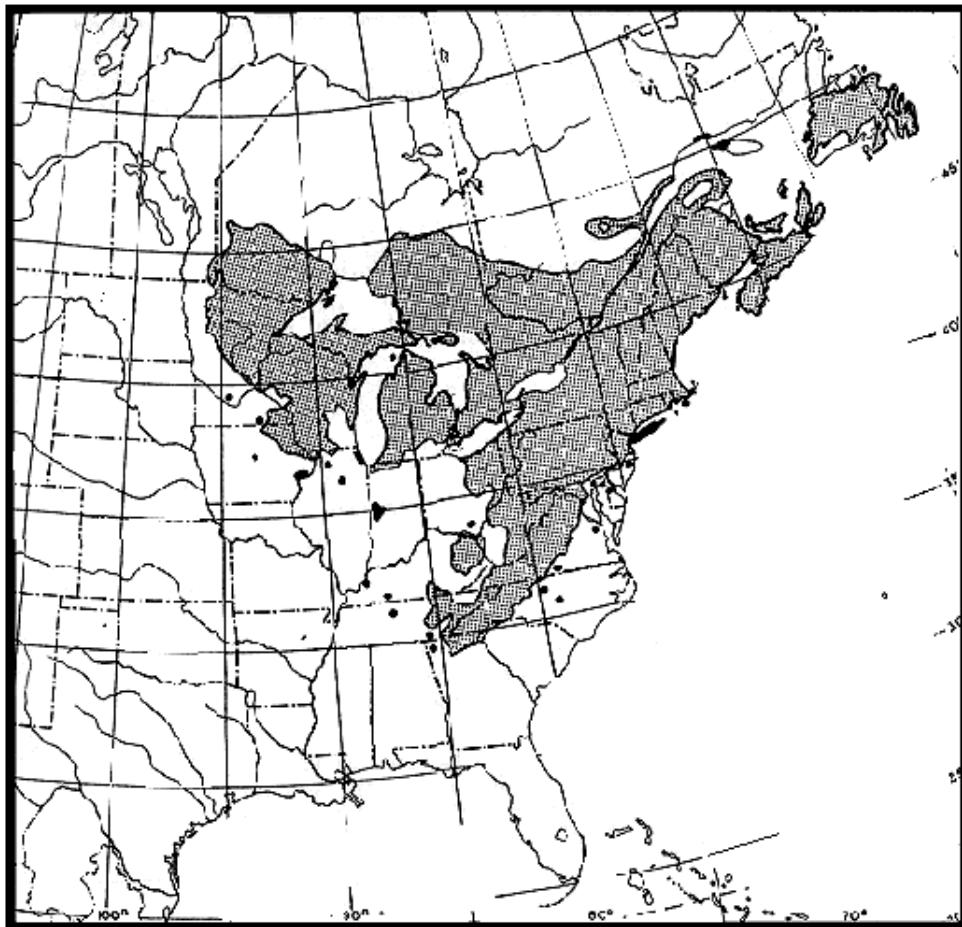
- 6 to 13 cm (2.5 to 5 in) long
- 5 needles per fascicle
- bluish-green

- acicular; straight, slender, flexible
 - persist 1 to 3 years
 - fascicle sheath 1 cm (0.4 in) long; quickly deciduous
-

Bark	Back to <i>Pinus strobus</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus strobus L.

Range and Habitat



The native range of eastern white pine. (From Little, 1971.)

Geographic Range

According to Wendel and Smith (1990): "Eastern white pine is found across southern Canada from Newfoundland, Anticosti Island, and Gaspe peninsula of Quebec; west to central and western Ontario and extreme southeastern Manitoba; south to southeastern Minnesota and northeastern Iowa, east to northern Illinois, Ohio, Pennsylvania, and New Jersey; and south mostly in the Appalachian Mountains to northern Georgia and northwestern South Carolina. It is also found in western Kentucky, western Tennessee, and Delaware. The variety *chiapensis* grows in the mountains of southern Mexico and Guatemala."

Climate

According to Wendel and Smith (1990): "The climate over the range of white pine is cool and humid.

The distribution of white pine coincides reasonably with that part of eastern North America where the July temperature averages between 18 and 23 degrees C (65 and 74 degrees F).

"Annual precipitation ranges from about 510 mm (20 in) in northern Minnesota to about 2030 mm (80 in) in northwestern Georgia. In the area surrounding the Great Lakes, about two-thirds of the precipitation occurs during the warm seasons. The length of the growing season ranges from 90 to 180 days.

"Average depth of frost penetration ranges from more than 178 cm (70 in) in parts of central and northern Minnesota. Average annual snowfall ranges from 13 cm (5 in) in northern Georgia to more than 254 cm (100 in) in New England and southern Canada."

Soils and Topography

Inceptisols, Ultisols, Spodosols, Entisols, and Alfisols are the major soil orders in which *Pinus strobus* grows.

According to Wendel and Smith (1990): "White pine grows on nearly all the soils within its range, but generally competes best on well drained sandy soils of low to medium site quality. The soils permit fair growth of white pine but not hardwoods. On these sandy sites, white pine regenerates naturally, competes easily, and can be managed most effectively and economically. On medium-textured soils (sandy loams), it will out-produce most other native commercial species in both volume and value. White pine also grows on fine sand loams and silt-loam soils with either good or impeded drainage when there is no hardwood competition during the establishment period - as on old fields and pastures, burns, and blowdowns. It has been found on clay soils and on poorly drained or very poorly drained soils with surface mounds. It can be very productive on these sites but usually occurs as individual trees or in small groups. This pine should not be planted in heavy clay soils. Poorly drained bottom land sites and upland depressions are also poor choices for planting.

"At various places within white pine's range, site quality has been related to combinations of soil and topographic characteristics such as texture and thickness of the A and B horizons, depth and permeability of the underlying rock or pan, depth to the water table, natural drainage class, topographic position, slope percent, and aspect.

"In the southern part of its range, white pine grows best on soils along rivers and streams and grows somewhat more slowly on well drained sites. The growth of white pine in plantations in eastern Tennessee was found to decrease with increased plasticity of the B horizon.

"In New England and New York, white pine generally grows at elevations between sea level and 460 m (1,500 ft) occasionally higher. In Pennsylvania, the elevation ranges from 150 to 610 m (500 to 2,000 ft). In the southern Appalachians, white pine grows in a band along the mountains between 370 and 1070 m (1,200 and 3,500 ft) above sea level, occasionally reaching 1220 m (4,000 ft). In Pennsylvania and the southern Appalachians, most white pine is found on northerly aspects, in coves, and on stream bottoms. Elsewhere, aspect seldom restricts its occurrence."

Bark		Range and Habitat
Leaves and Buds	Back to <i>Pinus strobus</i> title page	Reproductive Structures
Glossary		Interactive Comparison Tool

Pinus strobus L.

Reproductive Structures



Male cones

- occur in clusters at base of new shoots in lower crown
- 8 to 10 mm (0.3 to 0.4 in) long at maturity
- yellowish to light brown
- release pollen April through June

Female cones

- occur singly or in clusters near the tips of main branches in upper crown
- 5 to 38 mm (0.2 to 1.5 in) long at time of pollination
- pink with purple margin at time of pollination
- appear between May and June
- 10 to 20 cm (4 to 8 in) long at maturity

- yellowish-brown to dark brown
- narrowly oblong-conic; slightly curved
- pendulous on a stalk
- apophysis mostly smooth
- umbo unarmed and terminal
- mature and release seed August through September of second season
- sheds from branch at maturity, usually during winter or following spring

Seeds

- 5 to 8 mm (0.2 to 0.3 in) long
 - grayish-brown
 - wing 18 to 25 mm (0.7 to 1.0 in) long; light brown
-

Bark	Back to <i>Pinus strobus</i> title page	Range and Habitat
Leaves and Buds		Reproductive Structures
Glossary		Interactive Comparison Tool

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Grass Stage Development



Grass stage in longleaf pine.

Both *Pinus palustris* and *Pinus elliottii* var. *densa* have a fire-adapted seedling stage, aptly named a "grass stage." The grass stage occurs because height growth is extremely slow for a period of years and the needles appear similar to clumps of grass.

During the grass stage, which generally lasts from 2 to 10 years, the pine seedling develops an extensive root system, which stores food. The needle clusters around the bud provides insulation from fire, and even if needles are burned, new ones will arise from the protected bud. No annual growth rings are formed during the grass stage, but once emerged from the grass stage, distinct growth rings develop.

Site conditions are an important factor in determining time spent in the grass stage. If soil fertility is low, or there is loss of needles due to fire or brown-spot needle blight, *Scirrhia acicola*, the stage may be extended, sometimes as much as 15 to 20 years. Also, surrounding vegetation affects growth. If other plant species shade trees during the grass stage, growth will be slow.

Glossary

Naval Stores



Former trees used for naval stores. Note the cavities at the base of each tree and the herring-bone pattern due to chipping.

The term ‘naval stores’ refers to products made from the resin of pine trees. Naval stores originated when wooden ships were waterproofed using pitch, tar, and other resinous pine products. The French first utilized pine resin in the northeastern United States from pitch pine, *Pinus rigida*. Later, the production of naval stores switched to longleaf pine, *Pinus palustris*, and slash pine, *Pinus elliottii*.

Resin is naturally produced in all pines in resin ducts. Resin was obtained by progressively removing the bark and a small amount of wood by chipping in a herring-bone pattern. Bark and wood removal allowed resin to flow from existing ducts into cavities chipped in the base of the trees. Later, clay pots and metal tins replaced the cavities. Today, resin is obtained as a byproduct from papermills.

Glossary

Glossary

- **Acicular:** Needle-like.
- **Apex:** Tip; as in tips of leaves.
- **Apical:** Located at the tip or apex.
- **Apophysis:** Outer portion of a cone scale which is exposed on a closed cone.
- **Armed:** Bearing prickles, spines, or thorns.
- **Bark:** All tissue external to the vascular cambium; includes phloem and periderm.
- **Bract:** Modified leaf; bracts often subtend reproductive structures, such as a flowers or an ovuliferous cone scale.
- **Bole:** The main stem or axis of a tree; merchantable portion of a tree stem.
- **Bud:** An embryonic shoot.
- **Bud scales:** Modified leaves surrounding a bud.
- **Cambium:** Layer or zone of dividing cells that produce xylem in the inner portions of the plant, and phloem in the outer portions of the plant. Also called vascular cambium.
- **DBH:** Diameter at breast height (1.4 m or 4.5 ft above ground level).
- **Deciduous:** Not persistent; dropping or falling off.
- **Dioecious:** Having unisexual cones or flowers with only one sex per plant, thereby having separate male and female plants.
- **Endemic:** Restricted to a narrow, limited geographic area.
- **Excurrent:** A tree form in which the bole or main axis is clearly defined; the main stem outgrows the secondary, lateral branches due to strong apical dominance, usually resulting in a cone-shaped crown.
- **Fascicle:** A bundle or close cluster of leaves or flowers.
- **Fascicle sheath:** A tubular structure, often made of leaves or bracts, which surround a stem or other plant organ.

- **Fertilization:** Fusion of egg and sperm.
 - **Glabrous:** Smooth; without hairs.
 - **Glaucous:** Covered with white wax.
 - **Leaf:** Plant organ located directly below a lateral bud; lateral foliage appendages originating at nodes of the stem, usually responsible for photosynthesis.
 - **Megastrobilus:** Female cone of some gymnosperms like cycads and conifers. Plural: megastrobili.
 - **Microstrobilus:** Male cone of some gymnosperms like cycads, ginkgo, and conifers. Plural: microstrobili.
 - **Monoecious:** Having unisexual cones or flowers with female and male reproductive structures on the same plant.
 - **Needle:** Long, slender leaf; as in *Pinus*.
 - **Pollen:** The male gametophyte. Minute, powdery grains produced by anthers and male cones of seed plants; collective term for pollen grains.
 - **Pollination:** Transfer of pollen from pollen sac to stigma or conelet.
 - **Pubescent:** Covered with soft hairs.
 - **Reflexed:** Turned or curved downward or backward.
 - **Resin canal:** Ducts in bark or wood lined with resin-secreting cells, especially in conifers.
 - **Scale:** 1) A reduced, appressed leaf. 2) A woody appendage on a cone which bears ovules.
 - **Seed:** A ripened ovule consisting of an embryo, food store, and protective coat.
 - **Serotinous:** Remaining closed at maturity.
 - **Sessile:** Not stalked.
 - **Umbo:** Protuberance or swollen part of a cone scale.
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DISCUSSION

This project created an information-rich computer database for southeastern pines. Much tree data was quoted directly from non-copyrighted government documents (e.g., Burns and Honkala, 1990; Little, 1971). The advantage to this approach was the inclusion of large amounts of information without considerable rewriting. With additional data researched and compiled by me from other sources, each tree species Web page within the database contained informative descriptions. The quality and size of photographs and figures enhanced the program. My teaching experience indicates that people often have difficulty pronouncing scientific names and terms. Thus, audio of correctly pronounced names ends this problem and adds to the interactivity of the program, serving other learning pathways.

User-friendly pathways accessing this information were developed. A key to successfully creating these pathways was formatting the program for the World Wide Web. From a technical standpoint, HTML served as a user-friendly Web programming language and made creating and updating information pages simple. With networked computers, graphical and textual information created on one computer were easily transferred to other computers. From a user standpoint, the information could be accessed simply by pointing and clicking the cursor on desired information, avoiding the need to learn programming languages or commands. This information collected into one computer database has made a useful and convenient program for researching southeastern pines.

During early phases of the project, photographic problems plagued the creation of the GUI's. Some pictures were under-exposed and appeared too dark on the computer screen. Other photos were too large, too small, or not angled correctly. Thus, many photographs had to be retaken and rescanned into the database. Because of the numerous highlighted pathways within the program, occasionally one would be linked to an incorrect page or not linked at all. Further, when information was updated, each linked page had to be changed, and with the intricacy of the database structure, performing these modifications was tedious. To minimize these problems, links were constantly checked and all necessary information additions were performed at a single programming session to reduce inconsistencies in the database.

Some limitations in this program exist. Most pages display only one picture of a tree or characteristic. Ideally, all pages would contain multiple images that would load randomly, like the *Pinus palustris* title page. This way, users would be exposed to different views of the same species, and not memorize just one image. Currently, the interactive comparison tool does not allow for common or scientific name misspellings, but with programming modifications, this limitation could be addressed.

Finally, more information could be added to the database by future projects. For example, sections on silviculture, diseases, insects, and forest associates could be included. Additional species could be incorporated into the existing database, expanding it to include all naturally-occurring woody plants. The rapid technological changes that have occurred during the development of this program have allowed for easier data entry and Web page creation. Videos explaining tree identification and virtual walks through eastern

forests could also be included. Software, particularly image-enhancing software, has and will continue to improve, allowing sharper images. The future holds great potential for the expansion of this database.

CONCLUSIONS

This thesis has 2 conclusions:

- (1) the database provides an information-rich and convenient mechanism for researching southeastern pines, and
- (2) the database could be expanded to include many more species.

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