

green for driveway planting and as ornamental shade tree.

Mango. Tall, broad evergreen for ornamental shade and, where selected strains are used, for fruit also.

Cajeput-tree. Medium-tall, yellow-flowered, slender evergreen for wind-break, beach, driveway, ornamental shade.

Cuban royalpalm. Tall palm with decorative, smooth trunk, for driveway and as large landscape ornamental on moist soils.

African tuliptree, or Bell flambeau-tree. Tall, rapid-growing, semideciduous, conspicuously flowered tree for ornamental and shade.

West Indies mahogany. Tall, slender evergreen that gives light shade for

lawn, driveway, and general planting.

The authors are forest pathologists in the Bureau of Plant Industry, Soils, and Agricultural Engineering of the Department of Agriculture.

RALPH M. LINDGREN is in charge of the field headquarters of the Division of Forest Pathology in New Orleans. Dr. Lindgren is a graduate of the University of Minnesota.

R. P. TRUE is stationed in Lake City, Fla. Dr. True is a graduate of the University of Pennsylvania.

E. RICHARD TOOLE is stationed in Asheville, N. C. He has been working for several years on mimosa wilt and other diseases of shade trees. Dr. Toole is a graduate of Duke University.

SHADE TREES FOR THE PLAINS

ERNEST WRIGHT, T. W. BRETZ

Good care is doubly important for shade trees in the Plains States.

Trees planted on shallow soil underlain with clay or other hardpans have little chance of survival unless watered artificially and, even then, growth is generally unsatisfactory. The best and deepest soil available should be chosen so tree roots can develop unhindered.

Cultivation, following planting, is necessary to help the trees compete with prairie grasses and other native vegetation. Cultivation should be shallow to avoid unnecessary injury to tree roots near the surface. After the crowns of the trees are well developed, particularly in group plantings, they tend to shade out competing vegetation, and cultivation may no longer be necessary. The tree also must be protected from injury by livestock and sometimes from damage by rodents.

At best, most of the trees planted in the Plains States are relatively short-lived as compared to the same species growing in more favorable regions.

Coarse and droughty gravels, claypan soils, the undrained alkaline basins

(buffalo wallows), and shale-derived upland soils generally are unsuited for trees. Furthermore, the western third of the Plains States, from Texas to the Dakotas, have areas where the soil is deficient in iron or where iron or other essential nutrients are unavailable to growing trees.

Unavailability of iron causes chlorosis, or yellowing, of the leaves of some tree species, reduces growth, and frequently brings on premature death. Also, in Texas and Oklahoma along the Red River and southward east of the high plains, certain large areas are infested with the cotton root rot fungus, an indigenous soil fungus that infects the roots of many kinds of trees and eventually kills them. A few species, however, are highly resistant to the disease and will usually survive satisfactorily. The susceptibility of several of the more important tree species to cotton root rot is indicated later.

Adequate artificial watering of the shade and street trees is frequently not practicable in the Plains. In such cases their survival depends largely on rain

and snow. Furthermore, isolated individual shade trees do not have the advantage of gaining additional moisture by stopping drifting snow, as do shelterbelt or block plantings. Because of the reduction in annual precipitation from east to west in the midcontinental section of the United States, there is a corresponding reduction in the choice of usable tree species. Survival and growth are usually poor, even for the hardiest species, where annual precipitation is less than 16 inches in the extreme northern part and 20 inches in the more southern part of the Plains States.

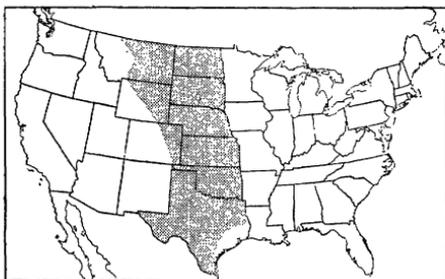
Low winter temperatures can likewise endanger the survival of trees. Even worse are freezes in early fall and late spring. Consequently, the choice of species becomes more restricted the farther north one goes.

In the following discussion of trees for the Great Plains, we have separated broadleaf species from the conifers and describe in greater detail the trees that can be used in all parts of the Plains.

The broadleaf species include the ash, cottonwood, elms, oaks, birch, poplars, and others.

GREEN ASH, a native species, develops spreading branches and makes a medium-sized, round-topped tree up to 50 feet in height. Its trunk may grow 1½ feet thick. It makes a moderate growth and the light-green foliage, turning golden yellow in autumn, gives dense shade. The greenish flowers develop in late spring. Green ash develops best in deep, rich, lowland soil, but it also does well on heavier upland soil. It is one of the best broadleaf trees for streets and yards in the Plains States. It is moderately drought-resistant, but it will stand wet as well as dry sites. Borers damage it, especially on droughty sites. Several relatively unimportant leaf spot diseases and a rust affect it. Green ash is moderately susceptible to cotton root rot.

White, blue, or red ash are important locally, principally on the extreme eastern edge of the Plains.



THE PLAINS COTTONWOOD was widely planted by early settlers. This native tree quickly develops an open crown and it reaches a height of 80 or 90 feet. The trunk gets to be as large as 6 feet in diameter at the base. It affords light shade. Flower catkins appear in early spring before the leaves. The leaves become a colorful yellow in autumn. The trees may attain an age of 60 years or more on the better sites. Although they prefer rich, moist soil and thrive particularly well in the lowlands, they will also grow in drier, sandier locations of the uplands. They do poorly on soils with clay hardpan near the surface, and should not be planted on sand dunes. The life of the plains cottonwood on such soil is short, usually 10 years or less. The tree is susceptible to borers, especially on the drier sites.

Poplars and cottonwoods are highly susceptible to cotton root rot. Bacterial limb galls, not uncommon, cause considerable branch dying in older trees. Fungus stem cankers are destructive to young trees, especially on unfavorable sites where growth is slow. Leaf rusts are common but of little consequence to thrifty trees. Cottonwoods are subject to attack by gall insects, which make them unsightly but cause little harm. They are moderately drought-resistant when well established on good upland sites. They are also susceptible to chlorosis and grow poorly on alkaline soils. They are mainly usable as farmstead trees. When used for street plantings, only male trees should be selected, to avoid the nuisance from cottony seed. Roots of the cottonwood often clog sewer and drain pipes. The wood is weak and subject to breaking

in storms. Large, old trees near houses are often dangerous. The cottonwood should not be planted on streets, except where more suitable species will not grow.

Other species, such as Lombardy poplar and the hybrid Carolina poplar, have also been used widely but are better suited to the eastern edge of the Plains area where rainfall is greatest.

THE AMERICAN ELM, perhaps the most beautiful broadleaf tree, sometimes reaches 90 feet in this region. This elm has a symmetrical, vase-shaped crown that frequently attains a width of 60 feet or more. It lives to an age of 75 to 100 years on the better sites, provides moderately dense shade, and grows moderately fast. Its small, brown flowers appear in early spring before the tree leafs out. It prefers deep, rich, moist loam, but it will stand adverse soil and weather conditions and does fairly well even on sandy exposed sites.

In the Plains States, American elm is often seriously attacked by the elm leaf beetle and European elm scale. The elm sawfly causes defoliation at times. The woolly elm aphid is also abundantly present, especially during wet seasons. A fungus leaf spot disease is common. Phloem necrosis has been found in eastern Nebraska, Kansas, and Oklahoma and is a serious menace to the existence of the American elm throughout the Plains. We fear that phloem necrosis will progress rapidly westward; until a method of control is discovered for this destructive disease, we advise against planting the American elm. Trunk rot due to a fungus is fairly common in planted street trees. American elm is susceptible to cotton root rot and should not be planted on soils infested by this fungus. Rabbits are another enemy.

THE SIBERIAN ELM, often sold under the name of Chinese elm, has been planted perhaps more widely than any of the other introduced species. It grows rapidly to a height of 50 to 60

feet. The main branches tend to grow upward and form sharp crotches that are easily broken by wind. Slime flux commonly develops in such wounds. The species provides moderately dense shade. Small purplish flowers appear in early spring before the leaves show. It does best on sandy loam soils, but it will also grow on sandy sites of low fertility. It lives about 50 years or less. It is drought-hardy, but, because it develops its leaves early in the spring and retains them later than most trees in the fall, it is in constant danger of severe damage by unseasonable freezes. Cytospora fungus cankers cause further damage to frost-injured trees. Siberian elm is highly susceptible to cotton root rot and cannot be used on soil infested by the fungus. Rabbits often damage it severely. This species is used for both street and yard planting, but is now in general disfavor because of its susceptibility to frost damage.

COMMON HACKBERRY makes a moderate growth up to 50 to 70 feet, and develops a large, rounded crown. Its spreading branches provide moderate shade. The small, greenish flowers appear in late spring. It prefers a rich, moist, and well-drained soil, but it will grow successfully on practically all types. The common hackberry is frost-hardy and withstands heat well. It attains an age of 60 to 70 years.

Webworms commonly cause defoliation, especially of young trees. This species is subject to rabbit damage. Witches' brooms are a distinguishing feature of older trees and are regarded as undesirable, but they do not seriously affect the health of the trees. Several minor leaf diseases occur on this species. It resists cotton root rot, and is drought-hardy when once established. It will not stand extensive flooding.

The common hackberry is a good street tree and should be used more extensively in this region.

THE BUR OAK, a large, slow-growing native tree, reaches a height of 80

feet on the best sites. Its life expectancy is 75 years or more. It has a short trunk and a broad, massive top that gives moderately dense shade. The slender flower catkins and the leaves appear in midspring. The bur oak does well on many soils but prefers rich bottom lands. Drought-resistant and frost-hardy, it should be planted more extensively despite its slow growth.

Twig galls are common, but few insects attack the tree. Leaf rollers are observed frequently and red spider occurs in dry years. Foliage diseases usually are not serious. Powdery mildew and leaf scorch sometimes do damage. Cronartium rust is common on oak leaves in some localities. Rabbit damage is severe to the young seedlings in the western part of the area. Bur oak is susceptible to the cotton root rot fungus.

Other species more limited in use are pin oak, black oak, and the chinquapin oak. In the uplands of Nebraska, the trunks of pin oaks often have vertical cracks that are the result of freezing injury.

Several broadleaf species have a more restricted use.

AILANTHUS, or tree-of-Heaven, can be planted in the eastern part of the central and southern Plains. It grows rapidly, gives moderate shade, and lives 30 to 50 years. It develops best in light, moist soil but tolerates fairly heavy soils. It stands smoke and dust better than most trees and it is, therefore, adapted to street planting in factory districts. Only the female plants should be used, because the flowers of the male trees have a disagreeable odor and the pollen is said to cause catarrhal troubles. The brown seeds hang on the trees until late winter. Some persons may consider them unsightly. Ailanthus suckers so readily that it is objectionable in some locations. Webworms frequently defoliate the young trees. Ailanthus is moderately resistant to cotton root rot. Moderately drought-hardy, it does not stand flooding, and it is subject to wind damage.

EUROPEAN WHITE BIRCH, which has drooping branches, can be used in the easternmost part of the northern Plains. This widely used ornamental has several horticultural varieties. It gives moderate shade, prefers moist soil, and is not frost-hardy on dry soil sites. On favorable sites its life expectancy is 25 to 35 years. It is not drought-resistant. Bronze birch borer causes serious injury and is perhaps the main factor that limits survival. The young trees sunscald readily.

Yellow birch is better suited to dry sites. The best use for the birch species is as ornamentals.

THE BOXELDER, a native, is mainly a yard tree in the northern and central Plains. It develops best on deep, rich, moist soil but survives surprisingly well on the dry and droughty sites. It gives moderate shade. It is short-lived, 20 to 40 years, depending on site quality. All in all, it deserves wider use in this zone.

One reason why it is in disfavor for planting near dwellings is that the boxelder bug, which breeds on the female trees, enters houses or cellars in search of hibernating places. Because the insect lays its eggs on the fruit, only male trees should be planted as a yard tree in the northern and central Plains.

NORTHERN CATALPA can be planted in the eastern part of the central and southern Plains. It commonly lives 35 to 40 years and is not especially drought-hardy. The large leaves are frequently affected by a *Phyllosticta* leaf spot disease, which, however, is not ordinarily serious. An insect known as a midge causes a leaf scorch. Decay fungi commonly invade the wood through wounds; the rot often advances rapidly and shortens the life of the tree. The species is not resistant to cotton root rot but it is moderately frost-hardy. The leaves sometimes turn yellow because of iron deficiency. Catalpa is not particularly popular because its blooms and seed pods can be a nuisance. Rabbits damage it.

KENTUCKY COFFEETREE, a native, is used as a street or yard tree in the central and southern Plains. It prefers a deep, moist soil but adapts itself to drier sites as well. The trees may grow as tall as 50 feet and may live 40 to 50 years. The leaves give light shade and are said to possess an ingredient poisonous to flies. The coffeetree is susceptible to cotton root rot and should not be used on infested soils.

THE CHINESE ELM has much the same habit of growth as the Siberian elm, but the flowers open late in the summer. It is small and half-evergreen from Oklahoma southward. It is like the Siberian elm in adaptation to soil conditions.

Other species of elm, such as the Scotch elm and English elm, and such native species as rock elm and slippery elm, can be used especially in the eastern part of the Plains. The first two, however, are almost as readily susceptible to frost injury as Siberian elm, and the latter two are considerably less drought-resistant. None of these has been widely used as street trees.

SUGARBERRY, or sugar hackberry, a native tree, is useful in the southern Plains. It is a smaller tree than the common hackberry but grows up to 25 feet tall. It is not so frost-hardy as common hackberry. It will grow on dry soil and is drought-resistant. It is not widely used.

Netleaf hackberry, also a native, is not widely planted. It grows up to 35 feet in height. It is drought-hardy but not especially frost-hardy. It grows naturally on rocky or gravelly soil.

THE BLACK LOCUST is suitable for parks and lawns in the central and southern Plains. A native, it does well on sandy soils and is moderately frost-hardy and drought-resistant, and long-lived, 40 to 60 years. The trunk is commonly attacked by wood-rotting fungi that follow borer injury. The wood rots materially reduce the length of life of the tree and are especially

common in the southern Plains. Black locust is highly susceptible to chlorosis and to cotton root rot. The wood makes good fence posts.

COMMON HONEYLOCUST is valuable in the central and southern parts of the Plains. It grows well in most kinds of soils but prefers deep and rich loam. It lives 40 to 50 years. It is not so subject to borer injury as black locust, but trees on droughty soils are commonly attacked. Twig girdlers are common on this native species in the southern localities. It is susceptible to cotton root rot, but is drought-resistant and frost-hardy. It is less susceptible to chlorosis than the black locust. Its seed pods make good cattle feed. It grows well in street or yard plantings; in fact, it is one of the best trees for the central West.

A thornless variety of the common honeylocust is gaining favor. It has most of the desirable characteristics of the common honeylocust.

SILVER MAPLE can be used in the eastern part of the northern and central Plains, but is not recommended where better trees will grow. Under most favorable conditions this native tree may reach an age of 70 years. Not particularly drought-hardy, it prefers rich bottom-land soil but will do fairly well on fertile upland soil. Silver maple is subject to a number of insect attacks, mostly foliage destroyers such as bagworm, green worm, and bladder gall mites. Foliage is frequently infected with various leaf spot fungi, which are generally of minor importance. Twig borers are also common and may cause considerable damage. Trunk rots are common but occur most frequently in drought-weakened trees. A fungus disease, *Verticillium* wilt, occurs occasionally and sometimes kills the trees. Silver maple is susceptible to chlorosis, which is caused by lack of iron. It is best suited to growth in the eastern third of the area but will grow farther west when it is artificially watered. It often is subject to

wind damage, but it is commonly used as a shade and street tree. Its roots commonly plug drain pipes.

Other species—sugar maple, Norway maple, black maple, red maple—are usable only in the extreme eastern border of the Plains area where rainfall is heaviest.

THE RUSSIAN-OLIVE, an introduction from southern Russia, usually attains less than 30 feet in height. It survives well on many sites, from sandy to alkaline soils, but prefers moist, rich soil in open sunlight. It is drought-hardy and moderately frost-resistant. The dry, cast-off leaves sometimes are eaten by sheep, goats, and cattle. Although it is but little troubled with insect or fungus attacks, it is susceptible to cotton root rot.

The Russian-olive merits wide use, especially in the drier and more alkali sections from the Dakotas southward. It is not especially desirable as a street tree, but if it is used in streets the lower branches should be pruned when the tree is young.

THE AMERICAN SYCAMORE prefers rich, moist soil, but it can adapt itself to drier sites. It is not frost-hardy enough for planting in the northern Plains, but can be used in the eastern part of the central and southern Plains. Leaf blight, a fungus disease, is often prevalent and causes considerable defoliation, disfigurement, and reduction in growth. It is moderately resistant to cotton root rot, and is the best of the fast-growing tall trees for use on soil infested with the disease. It is susceptible to chlorosis, however, on alkaline sites. It is recommended for street planting in places free of blight. The American sycamore is widely planted as an ornamental.

THE LONDON PLANETREE is less susceptible than the American sycamore to leaf blight, but is more restricted in range. It is best suited to the extreme eastern edge of the Plains where rainfall is highest. It is excellent in parks.

THE EASTERN BLACK WALNUT grows moderately fast and reaches a height of 60 feet or more. On favorable sites it will live 75 years. It thrives best on moderately friable soil that has good fertility and moisture. It will stand some flooding but will not live long on the swampy sites. Because its leaves and fruit hulls contain tannic acid and stain objects with which they come in contact, the tree should not be planted too close to walks or clotheslines. Several insects attack the leaves and fruit but do not endanger the health of the tree. Fungus diseases are also of little consequence. It is susceptible to cotton root rot and is not drought-hardy. It is used as a street and shade tree, but the fruits are objectionable on streets.

WEeping WILLOW and black willow are sometimes used as shade trees. The European white willow appears to be more drought-resistant than the other species, but it should not be planted on dry sites.

The willows are all fairly short-lived and subject to insect damage and fungus diseases.

Desertwillow, native to the Southwest, develops into a small tree 20 to 30 feet high under favorable conditions. Often, however, it is shrublike, especially in hedge plantings. It is extremely drought-hardy and prefers a sandy soil. It will not tolerate flooding and is short-lived—probably about 20 years—but withal it is an excellent tree that can well be planted more widely in the Southwest. Its principal advantage over other species there is its high resistance to cotton root rot.

Other broadleaf species of local importance that do well on sandy soils and are usable principally in the southern parts of the Plains are the western soapberry (which is resistant to cotton root rot), and Osage-orange and eastern redbud, both of which are prey to cotton root rot.

The principal value of evergreens on the Plains is as ornamentals and for protection from wind. They do provide much shade, particularly when they

are in groups. The most desirable species are eastern redcedar, Rocky Mountain juniper, ponderosa pine, common Douglas-fir, and some spruces.

THE EASTERN REDCEDAR, a medium-sized tree, forms a pyramidal or conical crown, grows 30 to 40 feet tall, and reaches an age of 100 years or more. Flowers are produced in small cones in midspring. It prefers loamy soil in open sunlight, but it will grow successfully on almost any soil. It is drought-resistant and frost-hardy but will not stand flooding. It is sometimes damaged by grasshoppers and hail, but it makes rapid recovery. It is subject to attack by red spider. The main objection to its use is that it is a bridging host for a rust that also attacks apple and related trees. Eastern redcedar should not be grown where apples are grown commercially, because of the possibility of damage by the rust. The rust galls cause relatively minor damage to the cedar except when infections are numerous on young trees.

Ornamental eastern redcedar is also damaged by a needle blight. It is the best evergreen for use on soil infested with the cotton root rot because it is highly resistant to the disease. Mice often damage young plants.

Rocky Mountain juniper resembles eastern redcedar, but it is perhaps even more drought-hardy. It is particularly suited for the western Plains area.

PONDEROSA PINE, a native, can be used in the Black Hills and vicinity. It grows slowly to a height of 50 to 75 feet. The broad, conical crown gives moderate shade. It is long-lived. It does well on various upland soils in full sunlight but it will not stand permanent shading. Ponderosa pine is susceptible to cotton root rot but it is frost-resistant and drought-hardy. It is used mainly as an ornamental and occasionally in street planting.

THE DOUGLAS-FIR: The Rocky Mountain strain of the common Doug-

las-fir makes a particularly good ornamental shade tree for the eastern part of the northern Plains. It is best adapted to a moist, deep, porous soil but it is moderately drought-hardy and fairly long-lived.

Common Douglas-fir here is practically free of serious pests. It is not recommended for use in the central part of the area, but it does fairly well in eastern Colorado and Wyoming. The common Douglas-fir grown from Pacific coast seed should not be used in any part of the Plains area.

WHITE FIR is one of the most beautiful of the coniferous ornamentals. It is about as drought-hardy as the Rocky Mountain Douglas-fir and does surprisingly well even on poor to dry, shallow sites after it has become well established.

AUSTRIAN PINE is similar to ponderosa pine but less adapted to poorer sites. It is subject to a fungus twig blight that causes some dieback of branches and is less drought-resistant than ponderosa pine.

SCOTCH PINE is a widespread tree with somewhat scant foliage. It is well adapted to upland soil but less drought-hardy than either ponderosa pine or Austrian pine.

Several other pines also are useful in the region. Among them are jack pine, in the north-central part, on the lighter soils; loblolly pine and shortleaf pine, which can be grown in the southern parts, but are susceptible to cotton root rot; and the eastern white pine, which frequently makes an excellent tree in the eastern central Plains.

THE SPRUCES: Several species of spruces can be grown, particularly in the northern Plains. Colorado blue spruce, black spruce, and western white spruce are examples. As a class the spruces are fairly drought-resistant and frost-hardy. The spruces are somewhat shorter-lived than the pines, but are fine ornamental shade trees.

In the southern Plains the Arizona cypress is of limited value.

ERNEST WRIGHT worked in the Great Plains region 7 years before he was transferred to the field headquarters of the Division of Forest Pathology in Portland, Oreg. In his work on the Great Plains, Dr. Wright studied the survival of trees in relation to climate and disease.

T. W. BRETZ, a forest pathologist, conducts investigations on methods of controlling the phloem necrosis of elm in Missouri and nearby States. Dr. Bretz' experience includes searching for plant diseases in Iowa and Missouri on the Emergency Plant Disease Survey and teaching and research work in Texas, where he became familiar with conditions in the southern part of the Great Plains.

SHADE TREES FOR THE ROCKIES

LAKE S. GILL

Getting trees to grow along with the settlements and cities of the southern Rocky Mountain region has been all the more impressive because trees are naturally absent from most of the area.

The region—Arizona, Colorado, New Mexico, and Utah—is largely a high plateau 4,000 to 8,000 feet in elevation and broken by mountain ranges that often exceed 10,000 feet. In southern Arizona and southwestern New Mexico, roughly the area drained by the Gila River and its tributaries, the plateau is 1,000 to 4,000 feet in altitude. The plateau is largely treeless, although a few species occur along stream banks, and usually the foothills support an open woodland forest of low pinyons and junipers. Coniferous forests, broken occasionally by stands of quaking aspen, cover the sides of the mountains.

Normal precipitation is less than 16 inches a year, only about half of which falls during the growing season. In the Gila Basin the average annual rainfall is less than 12 inches, although there is proportionally more rain in the winter than in other parts of the region below 8,000 feet elevation. Precipitation is 20 to 30 inches in the mountains. Cold winters and hot summers are the rule except in the Gila drainage, where winter temperatures are usually mild. Wide changes in daily temperatures occur throughout the region, especially

during the winter months. Late frosts are the rule. Scaring winds are common. Most of the soil is alkaline; much of it is low in nitrogen and poor in physical characteristics. Often an impervious layer of hardpan lies close to the surface.

Under such conditions, the early settlers deserve great credit for introducing new trees. Today Salt Lake City, Denver, and Phoenix are outstanding examples of large cities that have been beautified by shade trees despite natural odds against them.

At first the plains poplar and the common hackberry, both native, were commonly planted. More recently, the plains poplar has lost favor because of its space requirements, its expansive and high water-consuming root system, and its untidy habit of shedding "cotton." The common hackberry is still widely used in difficult locations.

The black locust and boxelder were among the first introductions to survive the vicissitudes of climate and soil with minimum care. Later the Siberian elm joined them. These three cannot be surpassed in their ability to produce quick shade, stand abuse, and endure unusually unfavorable climatic and soil conditions.

Today the list of shade trees that can be grown successfully in the southern Rocky Mountains is indeed impressive. Most of them require supplemental ir-