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SILVICAL
Characteristics
OF . . .

ROCK ELM

(*Ulmus thomasii*)

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U.S. DEPARTMENT OF AGRICULTURE

THE SILVICAL REPORT SERIES

During 1907 and the following several years the U. S. Forest Service issued a series of silvical leaflets which covered the broad characteristics of a considerable number of major timber species. Since then much new knowledge has accumulated--some of it published in a variety of sources. There is also a considerable store of unpublished silvical information in the files of the forest experiment stations, the forest schools, and some other agencies. To compile this information systematically and make it available to foresters generally, the Lake States Forest Experiment Station is preparing reports on 15 individual species. Similar reports are being prepared by the other Federal forest experiment stations. When completed, these individual species reports will provide the basis for a comprehensive manual of silvics for the important trees of the United States, to be published by the U. S. Forest Service.

This report is one of the series being prepared by the Lake States Station. A preliminary draft was reviewed by several members of our own Station staff and by a number of well qualified staff members of other forest experiment stations, colleges, and universities; Federal, State, and Provincial forestry organizations; and forest industry. Their comments helped the author to make this report more complete, more accurate, and more up to date. Especially helpful reviews were submitted by R. U. Swingle, Ornamental Crops Field Station, Agricultural Research Administration; and R. W. Merz, Central States Forest Experiment Station.

Every effort has been made to ensure the accuracy and completeness of the information concerning the silvical characteristics of each species consistent with a brief treatment of the subject. We shall appreciate it, however, if any errors or omissions of important information are brought to our attention.

M. B. Dickerman

M. B. Dickerman, Director

Cover design: The photograph shows a 20-inch rock elm; the shape of the crown and form of branching are characteristic of mature trees. Drawing shows typical leaves.

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SILVICAL CHARACTERISTICS OF ROCK ELM

(*Ulmus thomasii* Sarg.)

by

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DISTRIBUTION

Rock elm is one of seven species or varieties of this genus indigenous to the United States (18).[2/] Its botanical range includes the extreme western portions of New Hampshire and Vermont; the southern fringe of Quebec along the St. Lawrence River; that part of Ontario lying north of Lake Ontario and Lake Erie and east of Lake Huron; the western half of New York State; the northwestern third of Pennsylvania; most of Ohio, Indiana, Wisconsin, and Iowa; the southern half of the Lower Peninsula of Michigan; that part of Minnesota lying east of the prairie fringe and just south of the headwaters of the Mississippi River; and the northern half of Missouri and the northern half of Illinois. The species also has been reported from isolated areas in southeastern South Dakota, north-central and east-central Nebraska,[3/] eastern and south-central Kansas, southeastern Missouri; west-central and southeastern Kentucky; north-central and east-central Tennessee; and west-central West Virginia (18) (fig. 1).

The commercial range[4/] for rock elm is substantially the same as its botanical range. Because of its scattered occurrence and the valuable physical properties of the wood, the species has been drastically overcut in many localities. Currently, the highest quality sawtimber trees are found in the mixed hardwood forests of north-central Wisconsin and the Lower Peninsula of Michigan.

1/ Maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minnesota, in cooperation with the University of Minnesota.

2/ Underlined numbers in parentheses refer to literature cited, page 14.

3/ There are no herbarium specimens available to authenticate occurrence in Nebraska according to a communication from Dr. J. Davidson, Botany Department, University of Nebraska.

4/ Commercial range is defined as that portion of the botanical range within which the species grows to commercial size and is a major or important species in the type.

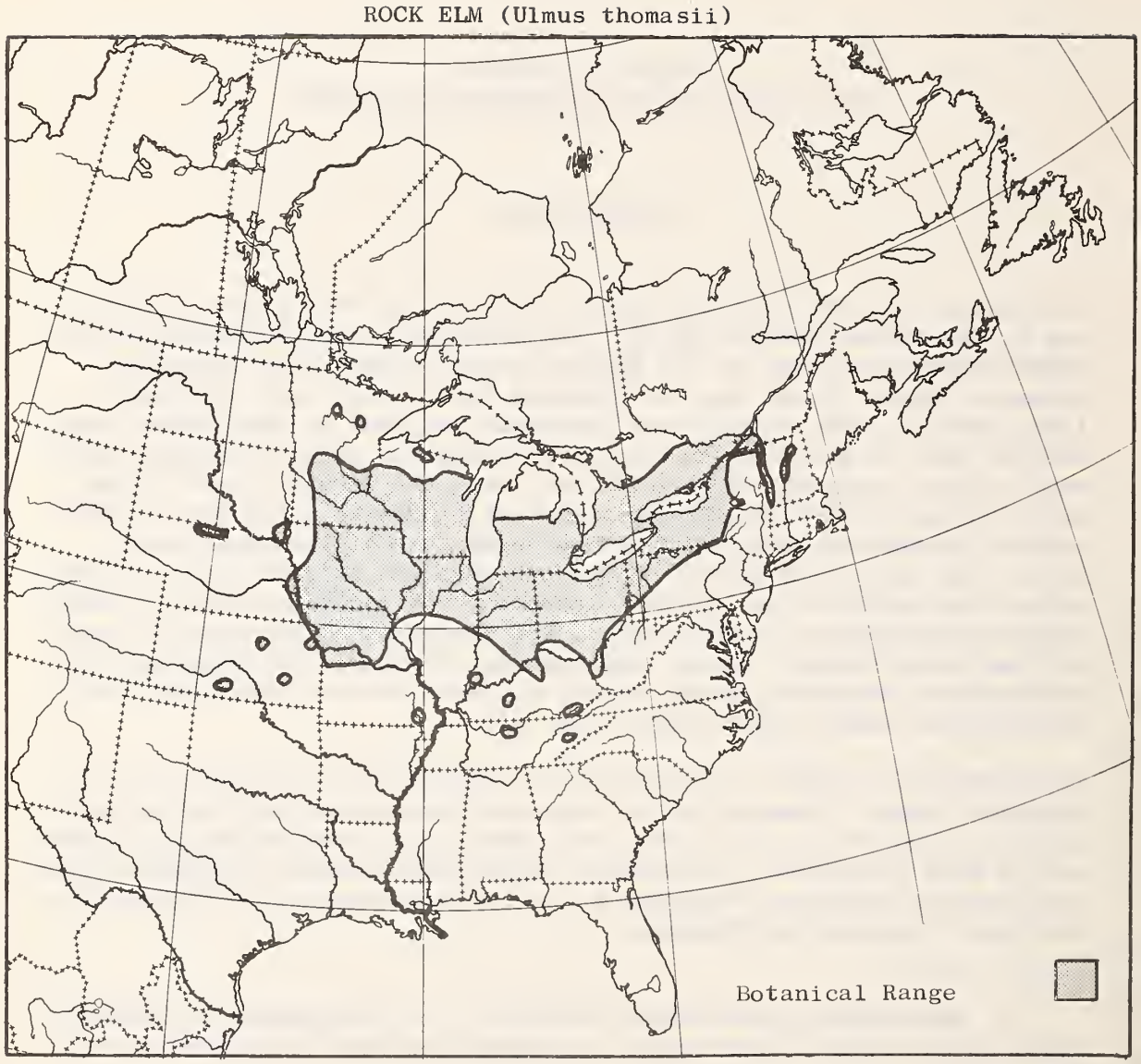

Figure 1.--Botanical and commercial range of rock elm.

Other common names for this tree include cork elm, corkbark elm, hickory elm, and cliff elm (9, 12, 13, 17, 22, 24).

HABITAT CONDITIONS

Climatic Factors

For the rock elm range as a whole, maximum temperatures of 100° F. or higher are not uncommon. Minimum temperatures vary from -25° in the southern part of the area to -50° or lower in the extreme northern part. The main body of rock elm's range lies between the 70° and 75° mean July isotherms.

Annual precipitation may be as low as 25 inches in southwestern Minnesota or as high as 40 or 50 inches in the extreme southern and eastern portions of the territory. From 50 to 75 percent of the total moisture for a year falls during the "warm-weather months" (April through September). The average annual snowfall is 20 to 80 inches depending on the geographic location and the physiographic peculiarities of any particular area.

The length of the growing season or frost-free period averages 100 to 200 days in the various parts of the region over which rock elm occurs; it falls between 120 and 160 days where the species develops best (30, 31).

Edaphic Factors

The soils lying within the botanical range of rock elm include the Northern Prairie, the Gray-Brown Podzolic, and the Podzol groups (19, 33). They vary from slightly alkaline or neutral to strongly acid in pH.

While rock elm often occurs on rocky ridges, limestone outcroppings, stream banks, and on other inhospitable sites (12, 13, 22, 25), it does not make its best growth under such conditions. In Lower Michigan and north-central Wisconsin, where rock elm attains optimum development, it almost invariably is found in mixture with the better hardwoods on moist but well-drained sandy loam, loam, or silt loam soils.

Physiographic Factors

Most of the region occupied by rock elm lies north and west of the main ridge of the Appalachian Mountains at elevations which vary from 200 to possibly 2,500 feet above sea level (30). There may be even an occasional tree which becomes established higher than this in the mountains of the East.

Locally, the occurrence of rock elm appears to be associated more with differences in the moisture regime than with topography. Thus, the species may be absent on a glacial outwash plain of droughty sand occupied by jack pine (Pinus banksiana), but relatively common on a well-drained loamy hardwood "flat" a few miles away.

Biotic Factors

Rock elm is a minor component of several forest types in the eastern part of the United States (26). The species has numerous hardwood, but few coniferous associates (4, 10, 12, 13, 34). Those of first importance are: sugar maple (Acer saccharum), American basswood (Tilia americana), white ash (Fraxinus americana), American elm (Ulmus americana), and eastern hemlock (Tsuga canadensis). Other, but less common, mixtures may include butternut (Juglans cinerea), American beech (Fagus grandifolia), slippery elm (Ulmus rubra), black cherry (Prunus serotina), northern red oak (Quercus rubra), white oak (Q. alba), eastern hophornbeam (Ostrya virginiana), yellow birch (Betula alleghaniensis), paper birch (B. papyrifera), shagbark hickory (Carya ovata), green ash (Fraxinus pensylvanica), red maple (Acer rubrum), silver maple (A. saccharinum), balsam fir (Abies balsamea), and white spruce (Picea glauca). The specific combination of rock elm with other tree species depends mainly on the grographic location of the stand.

Some of the woody shrubs commonly associated with rock elm include common pricklyash (Zanthoxylum americanum), beaked hazelnut (Corylus cornuta), blackberry (Rubus spp.), American red raspberry (R. idaeus var. strigosus), roundleaf dogwood (Cornus rugosa), pagoda dogwood (C. alternifolia), redosier dogwood (C. stolonifera), gray dogwood (C. racemosa), gooseberry (Ribes spp.), Atlantic leatherwood (Dirca palustris), common ninebark (Physocarpus opulifolius), American bittersweet (Celastrus scandens), creepers (Parthenocissus spp.), grape (Vitis spp.), hawthorn (Crateagus spp.), American and scarlet elders (Sambucus canadensis and S. pubens), and nannyberry viburnum (Viburnum lentago) (9, 20).

LIFE HISTORY

Seeding Habits

Flowering and Fruiting

Rock elm flowering takes place about 2 weeks before the leaves appear from March to May, depending on locality and site. The fruit, a samara measuring from ½ to 1 inch in length, matures during May or June when the leaves are about half grown. Leaf fall takes place from late September to late October (12, 16, 24, 25, 32).

Clean, fully ripened seed, with wings intact, number 5,000 to 9,000 per pound (32). Their germinative energy ranges from 61 to 90 percent in 4 to 10 days and their germinative capacity from 64 to 100 percent. Rock elm seeds apparently have little embryo dormancy and should be sown for nursery use as soon as possible after ripening as they lose their viability very rapidly (32).

Seed Production

Trees 20 years old will mature viable seed, but the optimum yields of fruit are obtained from trees 45 to 125 years in age (32). Good crops of the winged samara occur every 3 to 4 years. Dispersal of the ripe seed takes place from May to early July.

Throughout the botanical range of rock elm, killing frosts are common during the flowering period. It is possible that these sub-freezing temperatures prevent the development of viable seed in certain years. As far as is known, the immature fruit is seldom damaged or destroyed on the tree by insects, diseases, or animals.

The seed and buds of elm, presumably including rock elm, comprise ½ to 2 percent of the seasonal diet of the wood duck (Aix sponsa), sharp-tailed grouse (Pedioecetes phasianellus), prairie chicken (Tympanuchus cupido), ring-necked pheasant (Phasianus colchicus), and certain song birds. The seed, buds, and wood also are consumed by beaver (Castor canadensis), muskrat (Ondatra zibethica), cottontail rabbit (Sylvilagus floridanus), white-tailed deer (Odocoileus virginianus), fox squirrel (Sciurus niger), red squirrel (Tamiasciurus hudsonicus), and gray squirrel (Sciurus carolinensis) (23, 33).

Smaller rodents such as chipmunks, ground squirrels, and mice apparently relish the filbert-like flavor of the rock elm seed, and frequently will eat the major part of the crop within a matter of days after it reaches the ground.5/

Seed Dissemination

The rock elm fruit is a compressed nutlet surrounded by a membranous wing. It is, therefore, ideally constructed for dissemination by the wind. The writer estimates that the preponderance of seed falls within 100 to 150 feet of the parent tree, although thunder squalls and other forms of air turbulence undoubtedly carry some of it much farther than this. Rodents may play a minor role in distributing the seed.

The "normal" seeding radius may be increased, especially on slopes, by the movement of surface water during heavy rains. This fruit also can be carried long distances by creeks or rivers. Its large size and extremely light weight provide the necessary buoyancy. Elm seed often can be collected along the banks of streams or lakes where it has been concentrated by surface eddies (29).

5/ Unpublished observations by E. I. Roe, Lake States Forest Experiment Station, St. Paul 1, Minn.

Figure 2.--Small groups of rock elm saplings and poles such as this one are common in Lincoln Co., Wis.

Figure 3.--This 17-inch rock elm is at neast a mile from the nearest seed tree of the same tree species. Langlade Co., Wis.

One of the unexplained silvical peculiarities of rock elm is its occurrence in thickets of sapling-size trees (fig. 2 on preceding page), or as scattered larger individuals (fig. 3), often several miles from the nearest source of seed. Such isolated trees or small patches are a common sight along roadsides and fence rows, in open pastures, and in farm woodlots of north-central Wisconsin.

Vegetative Reproduction

Rock elm regenerates vegetatively by means of root suckers (21, 25), and from stump sprouts (8), but this method of reproduction is believed to be of minor importance in the natural spread of the tree.

Seedling Development

Establishment

Observations made in southeastern Minnesota (8) and elsewhere (12, 25) indicate that this species perpetuates itself largely by reproduction from seed.

If laboratory tests can be used as a criterion (32), the fruits of rock elm germinate under favorable moisture conditions within a week or two after they have fallen from the tree. Mineral soil provides an ideal seedbed, but does not seem to be a requisite for the successful establishment of the seedlings. The young trees occur commonly in north-central Wisconsin in fully stocked woodlands, on open pastures and old burns, and along roadsides where forest humus layers or sod has mantled the soil for decades.

Despite the characteristically high viability of its seed (32), rock elm is described as a species of poor natural reproduction (12, 25). Another worker states: "In the relatively little experience we have had with U. thomasii we have found it rather difficult to propagate from seed, cuttings, or by grafting. Seed, though well filled and planted immediately after collection, failed to germinate. Attempted propagation failed from root and branch cuttings and by budding to U. americana and U. pumila root stocks. Best results were by whip or cleft grafts of dormant scions on active root stocks."[6/]

Early Growth

Information on the early growth of rock elm is rather meager. Seedlings raised on sandy soil at the Hugo Sauer Nursery near Rhinelander, Wis., averaged 0.9 inch in height as 1-0 stock and 4.1 inches as 1½-0 stock.[7/] Another lot of nursery stock attained a mean height of about 8 inches 2½ years from seed (23). Under field conditions, 1½-0 nursery stock grew from 0.5 foot to 1.7 feet in height during the first decade (27). When conditions for their development are favorable, wildlings become 2 or 3 inches tall by the end of the first summer.

During its seedling and presapling stages this tree appears to be quite tolerant of shade (8). Nevertheless, one case study in northern Wisconsin showed that various natural factors reduced the survival of planted rock elm from 85 percent at the end of the first year to 32 percent at the end of the tenth season (27).

The browsing and trampling of wooded areas by domestic livestock are serious obstacles to securing and maintaining practically all tree regeneration including rock elm in farming regions.

6/ Roger U. Swingle, Agricultural Research Service. Personal communication to Director, Lake States Forest Experiment Station, in 1956.

7/ Unpublished data, Lake States Forest Experiment Station, St. Paul 1, Minn.

Sapling Stage to Maturity

Growth and Yield

Few species have rock elm's capacity for recovering from prolonged suppression and subsequently making "normal" growth. An analysis of 153 trees showed that "a large proportion...have survived for 50 years or more in such a state" (8). These studies also showed a striking relationship between the crown class and the number of rings per radius inch, namely, about 50 for the suppressed stems, 30 to 40 for the intermediate class, 20 to 30 for the codominants, and 10 to 20 for the dominants.

The following height-diameter values are averages based on a 30-tree sample of rock elm saplings, poles, and small sawtimber taken in the spring of 1956 in Lincoln and Langlade Counties, Wis.[8/]

D.b.h. (Inches)	Total height (Feet)	D.b.h. (Inches)	Total height (Feet)
1	9	7	32
2	14	8	34
3	18	9	36
4	22	10	37
5	26	11	38
6	29	12	39

It is extremely difficult to estimate the age of rock elm saplings or pole-sized stems on the basis of diameter alone because of the possible effect of suppression. The following tabulation (8) shows why such correlations are unreliable:

8/ Unpublished data, Lake States Forest Experiment Station, St. Paul 1, Minn.

Crown class	Diameter class of trees -- inches				
	1	3	5	7	9
	Average number of years				
Dominant	14	26	39	51	63
Codominant	22	50	72	93	-
Intermediate	30	64	97	-	-
Suppressed	48	99	-	-	-

Rock elm is a medium- to large-sized tree. On average sites, its total height at maturity varies from 50 to 80 feet and its diameter from $1\frac{1}{2}$ to 2 feet (20, 25). However, in the virgin hardwood stands of the east and north, this species grew to magnificent dimensions: 90 to 100 feet in height and 3 to 5 feet in diameter (12, 13, 15, 24, 25). In well-stocked forests, such trees often were free of limbs to a height of 50 or 60 feet (22, 24).

Its straight columnar bole, its tendency to be single-stemmed even in the open, its comparatively short, slender, strongly drooping lateral branches, and its oblong cylindrical crown (see cover picture) are some of the characteristics which distinguish this species from other elms and other hardwoods (12, 21). The maximum life of the tree is estimated at 250 to 300 years (8, 32).

Since rock elm occurs only as scattered individuals or in small clumps with other hardwoods, yield tables are impracticable for this species. Single tree volumes vary from less than 100 board-feet for small sawtimber stems to well over 2,500 board-feet for the 4-log, $3\frac{1}{2}$- to 4-foot-d.b.h. monarchs of the past.

Reaction to Competition

Some tree species are more tolerant of shade at certain periods in their life cycle than at others (11). Rock elm belongs in this category. Ring counts for mature stems show that they often recover successfully from 50 years' suppression during their seedling and sapling stages (8).

As the tree grows older it apparently becomes more light demanding. In fact, the majority of foresters rate it as intermediate in a scale of tolerance which includes very tolerant, tolerant, intermediate, intolerant, and very intolerant (1). Recently rock elm was assigned a tentative numerical score (climax adaptation number) of 7.0 in an ecological classification wherein aspen rated 1.0 and sugar maple 10.0 (6). These climax adaptation numbers roughly parallel the shade tolerance ratings of foresters.

Rock elm usually occupies a dominant position in the stand (25). These individuals seem to owe their competitive advantage to the fact that they grew in well-lighted openings from the start.

Limiting Factors

Insects attacking rock elm usually are leaf-feeders or wood-borers, although this species also is the host for various sucking insects (5).

The defoliators ordinarily do not kill the trees except in prolonged infestations, but they may weaken their hosts sufficiently so they fall prey to other insects, diseases, droughts, etc. Some of the important leaf-eating insects which attack the elms are: Spring cankerworm (Paleacrita vernata), fall cankerworm (Alsophila pometaria), forest tent caterpillar (Malacosoma disstria), and elm leaf beetle (Galerucella xanthomelaena).

The borers usually attack trees of low vigor although they occasionally infest, but seldom kill, healthy individuals. Their main effect is to down-grade the quality of the products harvested from such timber. The elm borer (Saperda tridentata) is one of the more common representatives of this group.

Three insects also are known vectors of serious diseases of elm. They are: The smaller European elm bark beetle (Scolytus multistriatus) and the native elm bark beetle (Hylurgopinus rufipes), which spread Dutch elm disease (Ceratocystis ulmi), and a small leaf hopper (Scaphoideus luteolus) which is the vector for the virus Morsus ulmi causing elm phloem necrosis.

Trees infected by either of these diseases die from progressive wilting and loss of their normal physiological functions. The most effective means of combating the Dutch elm disease is to control the insect vectors (28). No effective control has been found for elm phloem necrosis (3).

Several of the rot fungi are known to attack various species of elm, but their relative importance on rock elm has yet to be determined. Five of these wood-decaying diseases are (3, 14): (1) The elm fungus (Pleurotus ulmarius)--causes a brown cubical rot, mostly of heartwood, in living trees. Decayed material separates easily along annual rings. (2) The oyster mushroom (P. ostreatus)--a white, flaky rot which attacks both heartwood and sapwood of live timber. (3) spongy white rot (Fomes connatus)--causes a white heart rot of living hardwoods. (4) White spongy heart rot (F. igniarius)--this (the false tinder) fungus reportedly causes more loss in living hardwoods than any other rot. (5) Ustulina butt rot (Ustulina vulgaris)--"causes a brittle white heart rot with prominent black zones in the butts of living hardwoods" (3).

SPECIAL FEATURES

Rock elm presumably refers to the physical properties of the wood, which weighs about 44 pounds per cubic foot when in an air-dry condition; it is nearly equal to white oak in strength and hardness and superior to it in shock-resisting ability (2). Its interlaced fibers, resistance to splitting, and durability under water led British shipbuilders to export rock elm in quantities in the latter part of the 19th and early part of the 20th centuries (22). Even hickory scarcely surpassed this wood for toughness, and ax handles made from it were considered "tops" by northern woodsmen.

Twigs more than 2 years old ordinarily have 3 or 4 conspicuous corky ridges. This identifying characteristic is particularly eye-catching on trees of sapling or small pole size (fig. 4).

RACES, HYBRIDS, AND OTHER GENETIC FEATURES

As far as is known, rock elm has not developed any recognized races, but Dr. J. T. Curtis of the University of Wisconsin Botany Department, reports that this species forms an apparent natural cross with slippery elm (Ulmus rubra).[9/]

9/ Personal communication to Director, Lake States Forest Experiment Station, March 8, 1956.

Figure 4.--The conspicuous ridges of corky bark on the branches and older twigs of this 7-inch rock elm are one of its identifying features. This characteristic is especially noticeable in winter. Lincoln County, Wis.

Artificial crosses have been tried between U. thomasii and U. pumila by the Agricultural Research Service. It is reported that "All attempted crosses failed with the exception of three seedlings... These...were hybrids without question but all were lost while still 1-0 stock."[10/] The number of chromosomes in normal vegetative cells of rock elm is 14 pairs, or 28 (diploid number) (7).

10/ Roger U. Swingle, Agricultural Research Service. Personal communication to Director, Lake States Forest Experiment Station, in 1956.

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SPECIES COVERED IN SILVICAL REPORTS

This report on rock elm is the third of the silvical report series to be published by the Lake States Forest Experiment Station. Reports on red pine (Station Paper 44) and on black spruce (Station Paper 45) have already appeared. Ensuing reports will cover the following species:

Bigtooth aspen	Sugar maple
Quaking aspen	Jack pine
Basswood	Balsam poplar
American elm	White spruce
Slippery elm	Tamarack
Black maple	Northern white-cedar

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