A selected and annotated

BIBLIOGRAPHY of Eastern White Pine

(Pinus strobus L.), 1890-1954

compiled by

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BIBLIOGRAPHY of Eastern White Pine

Contents

Introduction

IN both North America and Europe, the growth, management, and use of white pine *(Pinus strobus* L.) has long attracted intense interest; and a great mass of literature — some of it dating from the 17th Century — has been published about this valuable species.

No one has ever made a thorough compilation and organization of this great mass of literature about white pine, and much of the literature has been inaccessible to the forestry profession. Therefore it was felt that the reduction of this material to a more accessible and usable form would be extremely helpful to practicing foresters, research workers, lumbermen, teachers, students, and laymen interested in white pine.

This bibliography is an outgrowth of a literature review prepared by the senior author as part of a problem analysis for the white pine region of New England and New York. The authors' objective was to make available — to the layman and professional alike — the results of observations and experiments with white pine that could contribute toward its culture and use. With this broad objective in mind, all known literature on the subject as well as illustrative material was examined and given consideration.

More than 3,000 references have been collected. Of these, 944 that were published between 1890 and 1954 are included in this bibliography. The year 1890 was selected for the starting date because the publications of Gifford Pinchot, Henry S. Graves, C. S. Sargent, V. M. Spalding, and B. E. Fernow during the 1890's marked the beginning of the modern era of scientific investigations into the properties of eastern white pine. The closing date, 1954, was the latest year for which a reasonably thorough literature search could be made at the time the bibliography was being prepared.

Selections were based primarily on the originality of the work or the ideas presented. However, it was necessary to modify our selections in several ways. First, the limitation of space prevented the inclusion of all the original material available. Second, some publications not notable for originality were included because they are comprehensive in scope or contain literature reviews that supplement this bibliography, or clearly present information on which action can be based. Third, references such as textbooks that are widely available but contain only scattered or incidental material on eastern white pine have been omitted. Finally, only published material is included because the cost of tracing unpublished material proved prohibitive in relation to its overall value.

The bulk of the references included deal directly with the silvics, phytosociology, silviculture, protection, and management of white pine. In addition, many of the significant publications in taxonomy, morphology, physiology, genetics, wood anatomy, wood technology, logging, manufacturing, end uses and marketing, and resource and economic statistics are included.

Each of the titles is annotated. In most, the important conclusions about white pine are given, together with the author's basis for these conclusions. In some cases the subject matter and scope of the publication are described. The latter type of annotation was used mainly for comprehensive publications covering a number of subjects for information-type publications, and for some publications giving detailed and lengthy treatment to one subject not directly related to the culture or use of white pine.

The search for white-pine literature was made through a number of channels. The catalogs of these libraries were consulted: U. S. Department of Agriculture (including Forest Service and Departmental libraries), Yale University School of Forestry, Harvard Forest, New York State University College of Forestry at Syracuse University, and the Library of Congress. The indices to all volumes of Forestry Abstracts, Biological Abstracts, Journal of Forestry, Forestry Quarterly, Ecology, and Ecological Monographs were checked. The publication lists of the Canada Forestry Branch and the U. S. Forest Service were also checked.

Special mention must be made of the inclusion of two publications that appeared after completion of this bibliography. One (Hirt, 1959) is an exhaustive annotated bibliography of the fungus diseases of eastern white pine. The other (Horton and Bedell, 1960) not only contains an extensive bibliography but is the first monograph involving the ecology, silviculture, and management of eastern white pine to appear in many years. Both are of extraordinary value.

Many people gave encouragement or help in various ways. Glenn R. Allison and F. H. Eyre, of the U. S. Forest Service; T. T. Kozlowski, University of Wisconsin; D. M. Smith, Yale University; and J. W. Wright, Michigan State University, contributed lists of references they had collected. Adrian M. Gilbert, of the Forest Service, gave valuable assistance with translations of foreign articles. Their aid is gratefully acknowledged.

General

FORest POLICY : RESOURCE STATISTICS

Anonymous. 1934. **White pine *(Pinus strobus* Linnaeus).** Amer. Forests 40: 360-361, illus.

A botanical description of the species, its range, uses, sites and pests. Illustrations of form, needles, cones, and bark.

Adkin, B. W. 1916. **Weymouth pine in the Surrey Desert.** Quart. Jour. Forestry 10: 185-193.

A 6-acre, 70-year-old plantation on wet sandy soil in a heather barren in England yielded 4,000 cubic feet per acre in trees averaging 53 feet high and varying widely in diameters. Calculations show that the stand yielded 4% interest on the investment in land and planting. The land was good for little else.

Albert, A. 1914. **El pino blanco Americano, *Pinus strobus*.** Bol. Bosque, Pesca i Caza 2: 428-433, illus.

Reviews American species planted in Chile, and concludes that white pine should be planted only on the best sites. On other sites it is equalled or exceeded in growth by *P. excelsa*, which produces timber equally good.

Badoux, Henri. 1920-21. **Le pin Weymouth *(Pinus strobus)* en Suisse.** Jour. Forest. Suisse 71: 221-227; 72: 86-89; 131-135, 148-152, 165-173.

Known plantations of white pine in France and Switzerland are discussed in relation to sites, growth, and pests. Recommends that white pine be widely planted on public forests.

Badoux, H. 1929. **Le pin Weymouth en Suisse.** Sta. Fed. de Rech. Ann. 15 (1): 105-183.

Describes distribution of white pine in Switzerland and the experimental plots being used to study the species. Chapters on height and volume growth, site requirements, uses and prices of the wood, and enemies of the species. Although attacked by many diseases (especially blister rust) and insects, white pine is recommended for cultivation because of its rapid growth and fine quality.

Betts, H. S. 1954. **Eastern white pine.** U. S. Dept. Agr. Amer. Wood Ser. 8 pp., illus.

A brief account of the history, distribution, growth, supply, properties, and uses of eastern white pine as a timber tree.

Borchers (first name not given). 1952. Folgerungen aus den bisherigen Anbauergebnissen mit fremdlandischen Holzarten im Gebiet des Landes Niedersachsen für die kunstige waldbauliche Planung. Mitt. der Deut. Dendrol. Gesell. Jahrb. 1951-52 (57): 69-81.

Notes on various species, with an indication of the total area planted to each, and a few growth data. White pine, despite losses from blister rust, has done better than the native *Pinus sylvestris*.

Canada Forestry Branch. 1923. White pine. Canada Forestry Branch Tree Pamphlet 1, 8 pp., illus.

A description of white pine, including brief notes on its place in the lumber industry, quality, uses of the wood, habit and form of growth, natural reproduction, propagation, and planting.

Canada Lumberman. 1934-43. (Annual white pine number.) Canada Lumberman vols. 54-63.

The annual white pine issues of this lumber trade journal contain many brief articles and editorials on new uses and markets for white pine. Also included are articles on price and supply trends, annual cut, protection from blister rust, and occasional notes on management. In substance, the articles tell what is being done to promote the use of white pine and to perpetuate the industry.

Cary, Austin. 1923. The future of New England forests. Jour. Forestry 21: 15-24.

The author discusses the place and form of private enteprise in the forestry business and the over-riding importance of location, species, site, and growth rate in the future. Intensive management is appropriate for the white pine region of central New England, in the author's opinion, but extensive management will probably continue to be appropriate for northern New England.

Chapman, H. H., and William P. House. 1952. Forest practice survey report. Pulpwood Res. Center, 191 pp., illus. Gorham, N. H.

A survey of cutting practices in New England, New York, and Pennsylvania, together with discussion of the condition of the major forest types and recommendations for improvement of current practices. In the white pine type the recent cutting was reported to be poor, with only about 40% of the cuttings being of a nature to keep the land productive.

Collingwood, G. H., and Warren D. Brush. 1947. White pine. *In* Knowing your trees. ed. 3, pp. 8-9, illus. Washington, D. C.

A brief natural and economic history of white pine.

Cook, H. O. 1929. A forest survey of Massachusetts. Jour. Forestry 27: 518-522.

A survey of Massachusetts forests made between 1914 and 1929, showed that the total area of the State, 5.3 million acres, included 2.8 million acres of woodland and 400,000 acres of agricultural land reverting to woodland. Of the woodland, 10.6% was in white pine type and 11.3% was pine-hardwood.

Cope, J. A. 1932 **Northern white pine in the southern Appalachians.** Jour. Forestry 30: 821-828.

In the southern part of white pine's natural range, lumbering, fire, and insects have greatly reduced its distribution and it meets strong competition for abandoned fields from southern pine in some localities. Its excellent growth rate and little real danger from weevils or blister rust should make it an important species for forestry

Corhin, A. 1927. **Le pin Weymouth dans la foret communale d'Epinal (Vosges).** Bul. Trimest. Soc. Forest. Franche-Comte 17 (1): 19-22.

White pine planted 40-60 years ago on low, wet, peaty areas of the Vosges Mountains has grown tall and straight and the stands now have volumes of 200-400 cubic meters per hectare. The trees produce good crops of seed almost every year and reproduce themselves naturally. They appear to have attained maturity at about 60 years.

Cunningham, R. N., and others. 1950. **Forest resources of the Lake States region.** U. S. Dept. Agr. Forest Resource Rpt. 1, 57 pp.

Gives an inventory of the Lake States forests and the timber growth and drain on them. White pine, once extensive, occupied only 2% of the forest land. Of the 40 billion board feet of sawtimber in the Lake States, 2.4 billion was white pine. Total cordwood volume was 180 million cords, of which 4 million was white pine, 2.7 million red pine, and 7 million jack pine.

Dallimore, W., and A. Bruce Jackson. 1948. ***Pinus strobus* Linnaeus. White pine or Weymouth pine. *In* A Handbook of Coniferae, including Ginkoaceae,** pp. 551-554, illus.

Briefly gives synonymy, identification, distribution, size and habit, wood properties, uses, and silvical characteristics. Planting, growth, and protection of the species are discussed.

Delevoy, G. 1938. **Les resineux au champ d'essais de belle-etiole (Foret de Soignes).** Soc. Cent. Forest. Belgique Bul. 45: 283-295, illus.

White pine was among the exotic conifers established in small plantations between 1906 and 1915 in the Forest of Soignes, Belgium. Growth in height, diameter, basal area (at breast height, mid-height, and 7 cm. top), volume, and form coefficients are shown in tables and graphs with corresponding figures for *P. silvestris*. All the exotics surpassed the native pine in some or all respects.

Federal Reserve Bank of Boston. 1950. **Eastern white pine — Nature's gift to New England.** Fed. Reserve Bank Boston Mo. Rev. 32 (9): 1-2.

A popular history of white pine as a timber tree and a statement of its importance in the New England economy.

Fisher, Richard T. 1928. **Pine plantations and New England forestry.** Jour. Forestry 26: 790-793.

During the first quarter of the century, forestry in New England has meant primarily the planting of white pine. White pine should not be planted in pure stands because white pine growth drops fast at 50-60 years, red rot is frequent, and health, quality, and market value are all poor.

Giordano, Guglielmo. 1934. **Il pino strobo *(Pinus strobus* L.).** L'Alpe 21: 342-348, illus.

A brief note on the suitability of white pine for growth in Italy. Botanical characteristics, origin of the species, and its culture in central Europe and in Italy are discussed. The growth attained by some older plantations at several places in Italy is recorded and natural regeneration is discussed.

Grumbine, A. A. 1941. **Natural range does not limit white pine.** U. S. Forest Serv. Plant. Quart. 10 (1): 10-11.

White pine seedlings obtained from Michigan were planted in 1910 on the Ouachita national Forest in Arkansas. By 1940 the trees were producing cones, seeds, and seedlings. Mean annual growth was satisfactory, in spite of suppression during most of the 30-year period.

Guidaudeau, C. 1942. **Etude sur le pin Weymouth dans les Vosges.** Rev. des Eaux et Forets 80: 457-460, 507-511.

Pinus strobus was introduced into the Vosges about 1850 and was used principally from 1860 to 1869 for planting moist sites. It has grown well and produces abundant regeneration, but is seriously threatened by attacks of *Peridermium strobi.* Notes on the location and condition of white pine plantations in the region, and a special study of plantation growth and development in the Epinal Communal Forest.

Hatt, G. 1912. **Plantations de pin Weymouth dans les Terrains Marecageux.** Rev. des Eaux et Forets 51: 193-195.

An 8-acre plantation was planted in 1873 in a poor, open coppice stand on marshy ground near Epinal. In 1911 the stand, which bore seed annually, contained 150 trees per acre, 8 to 20 inches in diameter, and grew nearly 72 cubic feet per year for a total of 3,300 cubic feet. Average diameter was less than 12 inches. It is figured that the stand paid 5% interest on original costs and improved the site fourfold.

Heiberg, Svend O. 1953. **White pine research.** N. Y. Forester 10 (2): 1-7.

Since the beginning of forestry practice in the Northeast, white pine has been severely damaged by blister rust and the weevil. As a result the species has fallen into disrepute. But white pine is still a profitable and a highly desirable species to manage. The key to success is intensive management practice.

Horton, K. W., and G. H. D. Bedell. 1960. **White and red pine: ecology, silviculture and management.** Canada Forestry Branch Bul. 124, 185 pp.

This monograph deals with the ecology, silviculture, and management of white pine and red pine throughout their ranges but with particular emphasis on their behavior in the Great Lakes-St. Lawrence Forest Region of Canada. Because of the relationship between the two species in that region, the monograph is both a treatment of the white pine-red pine forest type and a comparative study of the two species. An extensive bibliography is used in documenting the material presented.

Ionov, M. I. 1939. **(Weymouth pine plantations.)** Lesnoe Khozyaystvo (Moscow) 11: 34-37. (In Russian.)

The Weymouth pine plantations of the Tamtov-Ryazan region, now over 30 years old, show good growth and health and have almost twice as large a standing volume per unit area as comparable Scots pine woods in the same region.

Lake States Forest Experiment Station. 1935. **The forest situation in the central pine district, Minnesota.** U. S. Forest Serv. Lake States Forest Expt. Sta. Econ. Note 3, 19 pp.

This was a highly productive unit with large local markets, but after 80 years of lumbering most of the area had been cut over and was still suffering from forest fires. There were approximately 2½ billion board feet of sawtimber standing, nearly half of it scattered on cut-over land. Roughly 1 billion board feet was of pine and other softwoods.

Litscher, B. 1908. **Die Weymouthskiefer in den Stadtwaldungen von Rapperswil.** Schweiz. Ztschr. f. Forstw. 59: 7-14, illus.

In the 1850's a mixed planting of white pine and six other species was made at elevations between 1,200 and 1,500 feet in St. Gallen Canton. It grew rapidly and practically eliminated the other species. Seed production began 20 years after planting and regeneration has taken place on both dry and wet ground, in openings and under considerable shade. At 52 years some trees were 25 inches in diameter and 90 feet tall.

McGuire, John R., and Robert D. Wray. 1952. **Forest statistics for Vermont.** U. S. Forest Serv. Northeast. Forest Expt. Sta., 47 pp.

A report on the ownership and condition of forest areas, timber volumes, and growth and drain, by species, major types, and watersheds. White pine types comprise 11% of the commercial forest area. White pine accounts for about 5% of the primary growing stock and 7% of the sawtimber volume of the State. Most of the white pine area is in the Champlain Valley.

Morey, H. F. 1939. **Research problems in the management of northern white pine in the northeastern United States.** Iowa State Col. Forester 27: 41-47. Ames.

A brief description of the pine region is followed by an outline of the major research problems of the region. The selection system of cutting in pine-hardwood stands appears to offer possibilities that have been little explored.

Northeastern Forest Experiment Station. 1950. **Forest statistics for New Hampshire.** U. S. Forest Serv. Northeast. Forest Expt. Sta. Forest Survey Release 9, 56 pp.

A report of the ownership and condition of forest areas, timber volumes, and growth and drain, by species, major forest types, and counties. White pine types comprise 29% of the commercial forest area. White pine accounts for about 22% of the primary growing stock and about one-third of the sawtimber volume of the State. Most of the white pine area lies in the southern half of the State.

Northeastern Forest Experiment Station. 1954. **The forest resources of New Hampshire.** U. S. Dept. Agr. Forest Resource Rpt. 8, 39 pp., illus.

A summary of the resource situation in New Hampshire, where 29% of the commercial forest area is in white pine or related forest types. The total volume of white pine is 870 million cubic feet, of which roughly ¾ is in sawtimber stands. The sawtimber volume is 3.8 billion board-feet. The annual drain of all softwood sawtimber (¾ of which is white pine) exceeds the annual growth by about 10 million cubic feet.

Northeastern Forest Tree Improvement Conference. 1954. **Northeast. Forest Tree Improve. Conf. Proc.** 1, 107 pp.

Contains papers and discussions of need for and progress in research in genetics of white pine and other species. See Foster (1954), Hansbrough (1954), Brown (1954), Wright (1954), Doran (1954), Rhodes (1954), and Johnson (1954).

Pinchot, Gifford. 1897. **White pine (and) white pine forests.** *In* **Timber Trees and Forests of North Carolina.** N. C. Geol. and Econ. Survey Bul. 6: 123-125, 215-219, illus.

A brief description of the species, its growth, its enemies, and its uses. Discusses the condition and occurrence of merchantable stands in North Carolina on the southern and eastern slopes of the Blue Ridge and on the low hills to the west.

Pourtet, J., and P. Duchaufour. 1946. **Possibilities d'utilisation en France de quelques essences Canadiennes.** Rev. des Eaux et Forets 84: 128-152.

White pine is one of many Canadian species considered for silvicultural and utilization possibilities in France. Results so far obtained there are outlined. Notes on its economic value and natural history in North America provide a background for discussion.

Rohmeder, E. 1931. **Anbauflache und Gefahrdungen der Strobe im bayerischen Staatswald.** Forstwiss. Centbl. 53: 325-339, illus.

In the State forest area in Bavaria, white pine suffers from many enemies. Deer are especially destructive to young saplings, on which they rub their antlers. Blister rust attacked 1,677 hectares in 1926, and the fungus *Agaricus melleus*, severely damaged the stand on 1,121 hectares. White pine is relatively free from snow breakage at low altitudes, but is badly damaged above 600-750 meters. Scale insects, weevils, mice, woodpeckers, and drought caused some damage locally.

Ruzicka, Jaroslav. 1939. **Vejmutovka.** *(Pinus strobus.)* Lesnická Práce 18 (3): 126-148.

White pine, introduced into central Europe in 1755, is one of the most valuable exotic trees planted there. Its site requirements and growth habits and the quality and uses of the wood are outlined. (German summary.)

Sakss, K. 1949. **Sveszemju koku sugu ieaudzesanas meginajumi dazas Latvijas PSR vietas. (Researches on acclimatization of some foreign tree species in different regions of the Latvian S.S.R.)** Mezsaimniecibas Problemu Instituta Raksti, Latvijas PSR Zinatnu Akademija Riga 1: 7-36, illus.

An account in some detail, with numerous illustrations and graphs, of exotics that have established themselves in some numbers in various parts of Latvia. Some, including white pine, appear to have become completely acclimatized. They survived even the hard winter of 1939-40 without much damage and have regenerated naturally.

Society of American Foresters, New England Section. 1952. **Important tree pests of the Northeast.** Ed. 2, 191 pp., illus.

White pine is listed as one of the hosts of 12 insects (4 of them sawflies) and 5 diseases (3 of them rots) important in the forests of the Northeast. The distribution, hosts, symptoms, damage, life history, and control of these pests are briefly described.

Spalding, V. M.; revised by B. E. Fernow; with contributions by F. H. Chittenden and Filbert Roth. 1899. **The white pine *(Pinus strobus* Linnaeus).** U. S. Div. Forestry Bul. 22, 185 pp., illus.

This early monograph deals primarily with the natural history, distribution and associated species, botanical description, morphology, and wood anatomy; measurements of size, volume, and growth of trees from seedling stage to maturity (based on detailed measurements of 700 widely scattered trees); and insects attacking the species. The white pine lumber industry, available supplies of timber, and the qualities and uses of the wood are also described.

Takahashi, N. 1951. **Silvicultural value of white pine in Hokkaido.** Tokyo Univ. Forest Misc. Inform. 8: 1-11.

White pine is recommended in preference to *Picea jezoensis, Abies sachalinensis,* Japanese larch, or Norway spruce because it is suited to the climate, grows fast, is rarely damaged by rats, is suitable for a wide variety of sites and is easy to raise from seed, and because the wood has many uses. Data for these conclusions are drawn from literature and from 66 hectares of white pine, pure and in mixture, in the Tokyo University Forest.

TAXONOMY : PLANT STRUCTURE : GENETICS

Anonymous. 1890. **A bit of forgotten history.** Garden and Forest 3: 536.

Presents reasons for believing that a young pine at Fontainbleau, identified in 1553 by Pierre Belon as *Pinus cembra*, was really *Pinus strobus*. This would antedate Lord Weymouth's first cultivation of white pine in England by about 150 years.

Abbe, Lucy B., and A. S. Crafts. 1939. **Phloem of white pine and other coniferous species.** Bot. Gaz. 100: 695-722, illus.

In white pine, cambial division may start as early as February and is rapid during May. Phloem differentiation may lag until late summer or early fall, and daughter cells may remain in various stages of maturity through the winter. The structural and physiological changes that accompany sieve-tube differentiation, functioning during maturity, and approach to senility are described.

Bailey, I. W. 1920. **The cambium and its derivative tissues. II. Size variations of cambial initials in gymnosperms and angiosperms.** Amer. Jour. Bot. 7: 355-367.

The dimensions of cells in and near the cambium differed greatly in the wide variety of species studied. In white pine the lengths of cambial initials ranged from 2.3 to 4.0 mm., with an average of 3.2 mm. The length of tracheids varied from 2.2 to 4.6 mm., with a mean of 3.4 mm. The means were from 50 measurements.

Bailey, I. W. 1920. **The cambium and its derivative tissues. III. A reconnaissance of cytological phenomena in the cambium.** Amer. Jour. Bot. 7: 417-434, illus.

Using white pine material primarily, it was determined that cambial initials may attain a length of 9,000 microns or more — several hundred times the width. They are uninucleate, and the nucleo-cytoplasmic ratio may be relatively constant in ray initials but is highly variable in fusiform initials. All initials have the diploid (24) number of chromosomes, which are as large in small ray initials as in large fusiform initials.

Bailey, I. W. 1923. **The cambium and its derivative tissues. IV. The increase in girth of the cambium.** Amer. Jour. Bot. 10: 499-509.

Measurements of the number and size of fusiform initials in white pine sections of various ages are used to illustrate that, in species with nonstratified cambia, increase in the girth of the cambium is caused primarily by the elongation and consequent crowding of the fusiform initials in any given section.

Bailey, I. W. 1930. **The cambium and its derivative tissues. V. A reconnaissance of the vacuome in living cells.** Ztschr. f. Zellforsch. u. Mikros. Anat. 10: 651-682, illus.

In all species studied (hardwoods and softwoods, including white pine) the cambial cells were conspicuously vacuolated but the form differed with species and season. Changes in the vacuole appear to be due to a complex of varying physio-chemical factors, affecting both the protoplasm and the content of the vacuoles, rather than solely to hydration and dehydration of vacuolar colloids. Describes technique for studying living cells.

Baker, Lillian V. 1920. **Vestigial centripetal xylem and transfusion tissues in the leaf of *Pinus strobus*.** Roy. Soc. Canada Trans. vol. 3, ser. 5, soc. 14: 51-69, illus.

Morphological studies of cotyledonary, primordial, normal, and polyphyllus adult leaves of white pine have given evidence on the origin of transfusion elements — the parenchyma-shaped tracheids bordering the fibrovascular bundle. Author concluded that these elements originate from parenchyma rather than from centripetal xylem, the secondary wood, or the fossil sheaths as claimed by various other investigators.

Brown, H. P. 1921. **White pine, Weymouth pine. *In* Trees of New York State, Native and Naturalized.** N. Y. State Col. Forestry Tech. Pub. 15: 76-77.

A brief description of the silvics and distinguishing characteristics of eastern white pine.

Burt, L. B. 1939. **The bearing of Zalanski's law on conifer leaves.** Kansas Acad. Sci. Trans. 42: 113-121.

Investigations on leaves of white pine and eight other conifers showed that photosynthetic cells decreased in size and increased in frequency from the basal to the apical parts. The stomatal frequency increased in the same direction. This bears out the observations made by Zalenski and others on plants in general.

Delisle, Albert L. 1942. **Histological and anatomical changes induced by indoleacetic acid in rooting cuttings of *Pinus strobus* L.** Va. Jour. Sci. 3: 118-124, illus.

Cuttings and brachyblasts from 4-year-old seedlings of white pine root readily after auxin treatment, but brachyblasts are not able to survive unless a terminal bud is also formed. Anatomical changes in response to the auxin take place first in the cortex and then in the cambium. These changes and the resulting root anlagen are associated by position with rays and leaf traces.

Duffield, J. W., and F. I. Righter. 1953. **Annotated list of pine hybrids made at the institute of forest genetics.** U. S. Forest Serv. Calif. Forest and Range Expt. Sta. Forest Res. Note 86, 9 pp.

Among the hybrids produced at Placerville, Calif., were three with eastern white pine parents. Western white x eastern white, 1939, was produced from several geographic races of each parent. All individuals have hybrid vigor and some seem resistant to blister rust. Western white x (Balkan white x eastern white), 1946, grows as fast as the one above and is being tested for blister rust resistance. Eastern white x Himalayan white, 1940, has shown good blister rust resistance and grows faster than eastern white pine.

Ferguson, Margaret C. 1901. **The development of the pollen-tube and the division of the generative nucleus in certain species of pines.** Ann. Bot. 15: 193-223, illus.

Pollination took place from late May to early June. The pollen grain germinated soon after and the vegetative nucleus moved immediately into the pollen tube, which grew very slowly during the first season. Shortly before fertilization the stalk cell moved into the pollen tube and the generative nucleus divided. Fertilization of the egg took place 10 days after nuclear division and 13 months after pollination. Development was essentially the same in the five species studied.

Ferguson, Margaret C. 1904. **Contribution to the knowledge of the life history of pinus with special reference to sporogenesis, the development of the gametophytes and fertilization.** Wash. (D. C.) Acad. Sci. Proc. 6: 1-202, illus.

The standard reference on the subject. Three trees each of *Pinus strobus, P. rigida, P. austriaca, P. montana* var. *uncinata* and *P. resinosa* provided the study material, collected periodically from November 1897 to July 1899. The development of staminate and pistillate flowers was followed from their first appearance until fertilization. The results are covered under the chapter headings: microsporogenesis; the male gametophyte; macrosporogenesis; the female gametophyte; fertilization and related phenomena.

Fielding, J. M. 1951. **The chiapas white pine.** Austral. Forestry 15: 114.

A note on a variety of white pine found in Mexico and Guatamala, that makes very rapid growth and apparently produces wood of good quality.

Grahle, Annelise. 1933. **Vergleichende Untersuchungen über strukturelle und osmotische Eigenschaften der Nadeln verschiedener Pinus-Arten.** Jahrb. f. Wiss. Bot. 78: 203-294, illus.

Among 29 pine species studied, the needles of white pine had the greatest ratio (87) of surface area to volume and ranked among the species whose needles had the greatest percentage of assimilatory (56%) and epidermal (25%) tissue and the smallest percentage of conducting tissue (19%). The needles of white pine had the greatest number of stomata per unit volume (311 per cubic mm.) but were intermediate in number per unit surface (37 per square mm.).

Harlow, W. M. 1931. **The identification of the pines of the United States, native and introduced, by needle structure.** N. Y. State Col. Forestry Tech. Pub. 32, 21 pp., illus.

Discusses morphology and anatomy of the needles and gives a key to identification of the species, based on needle structure. Includes photomicrographs and an index to the common and scientific names.

Heimburger, C. C., and L. P. V. Johnson. 1946. **Preliminary report on interspecific hybridization in forest trees.** Canad. Jour. Res. Sec. C. 24: 308-312.

A report on work from 1938 to 1945 at Chalk River, Ontario, and the Dominion Arboretum, Ottawa. Successful crossing of *P. strobus* and *P. peuce* is reported, with 55% seed set, 6% germination, and 62 seedlings produced with a survival of 70%. There were sufficiently large trials in crossing *P. strobus* with *P. koraiensis* and *P. resinosa* to make these failures worth reporting.

Huet, M. 1933. **Determination de differentes especes de pins par l'etude anatomique de l'aiguille.** Soc. Cent. Forest. de Belg. Bul. 40: 66-75, 107-139, illus.

White pine is one of 36 species of pine classified and keyed according to anatomical characteristics of the needles. The transverse section of a white pine needle is illustrated and described in detail. The differences between white pine and closely related species are emphasized.

Johnson, Albert G. 1952. **Spontaneous white pine hybrids.** Jour. Arnold Arbor. 33: 179-187, illus.

A small hybrid group of *Pinus strobus parviflora* is described, and the type individual is designated X *P. hunnewelli*. It displays marked heterosis and is promising as an ornamental because of its attractive foliage. The hybrid is at least partially fertile and is readily propagated by common grafting techniques. A second hybrid between *P. peuce* and *P. parviflora* is also referred to.

Johnson, L. P. V. 1939. **The breeding of forest trees.** Forestry Chron. 15: 139-151.

A brief review of the techniques available for improving forest trees, and the possible applications of these techniques. One white pine at Petawawa has been observed to be exclusively female. In white pine there is a definite tendency for the female flowers to mature before the male flowers, which are borne on the lower branches.

Johnson, L. P. V. 1943. **The storage and artificial germination of forest tree pollens.** Canad. Jour. Res., Sect. C. 21: 332-342.

Pollen from the pines and spruces proved to have the greatest longevity in storage. The best physical and nutrient conditions for pine pollen was 10% sucrose in 0.75% agar. Incubation in light or dark made no significant difference in germination, but pollen-tube growth was stimulated by light. After 1 year of storage, white pine pollen held in the dark at 2° C. and at 35-75% relative humidities gave best germination (more than 90%).

Johnson, L. P. V. 1945. **Reduced vigor, chlorophyll deficiency and other effects of self-fertilization in *Pinus*.** Canad. Jour. Res., Sect. C. 23: 145-149, illus.

Selfed white pine seeds showed no appreciable difference from open-pollinated or hybridized seed in seed set or in seedling emergence but in seedlings 4 years old, those from selfed seed were significantly smaller and had pronounced chlorophyll deficiency in 11 out of 46 seedlings. Other detrimental effects of selfing are shown for other pines.

Kelsey, Harlan P., and William A. Dayton. 1942. **Standardized plant names.** Ed. 2, 675 pp. Harrisburg, Pa.

A revised and enlarged listing of approved scientific and common names of plants and plant products in use in America. *Pinus strobus* and *eastern white pine* are the approved scientific and common names. Scientific variety names and lumber trade names associated with white pine are also listed.

Kerr, Thomas, and I. W. Bailey. 1934. **The cambium and its derivative tissues. X. Structure, optical properties, and chemical composition of the so-called middle lamella.** Jour. Arnold Aboretum 15: 327-349, illus.

A study in which most of the work was done with white pine and later checked with other species has shown that the middle lamella, commonly considered a single isotropic homogeneous membrane, is two lignified anisotropic cambial walls and an intervening, truly isotropic layer of lignified material.

Kozlowski, Theodore T., and Francis X. Schumacher. 1943. **Estimation of stomated foliar surface of pines.** Plant Physiol. 18: 122-127, illus.

The surface area of a population of pine needle fascicles may be readily calculated through its correlation with volume, a value more easily determined by displacement. The methods are described, and expressions suitable for loblolly and eastern white pine are given.

Little, Elbert L., Jr. 1953. **Check list of native and naturalized trees of the United States (including Alaska).** U. S. Dept. Agr., Agr. Handbk. 41, 472 pp.

White pine, which was named by Linnaeus in 1753 from the Latin *strobos* (pine cone), ranges from Newfoundland west to southeastern Manitoba. In the east it ranges south to northern Georgia and in the west to northeastern Iowa.

Meyer (first name not given). 1953. **Der Bastard *Pinus strobus* x *excelsa.*** Cong. Internatl. Union Forest Res. Organ. Proc. Sect. 22 (13). 2 pp.

A 16-year-old hybrid from the arboretum at Hanover Munden shows signs of hybrid vigor and of resistance to attack by *Cronartium ribicola.* A good seed yield with 82% viability was obtained from experimental crosses in 1951.

Meyer, H. 1954. **Zur Blasenrostresistenzzüchtung mit Pinus strobus.** Ztschr. f. Forstgenetik 3: 101-104, illus.

Of 32 healthy older trees selected for blister rust resistance, 4 clones have proved non-resistant. The hybrid *Pinus strobus* x *P. griffithii* can be successfully produced and has proved resistant. One such hybrid, now 17 years old, has shown remarkable growth and vigor.

Nieuwland, Julius A. 1913. **The generic name of the white pine.** Amer. Midland Nat. 3: 68-70.

It is argued that the white pine should be separated taxonomically from the other pines. The generic name *Leucopitys,* from the Greek words meaning "white" and "pine," is proposed for *Pinus strobus* and *P. excelsa.* the specific names to remain the same.

Perry, G. S. 1940. **Keys to the pines of the Tennessee Valley.** Rev. ed., 12 pp. T.V.A. Dept. Forest Relat.

Three keys to the pines are given: (1) needle and twig, (2) cone, and (3) natural occurrence. White pine is one of the six native species, and five introduced species are also included.

Righter, F. I. 1945. **Pinus: the relationship of seed size and seedling size to inherent vigor.** Jour. Forestry 43: 131-137, illus.

The results of a series of tests with several species and species hybrids show that seed size and seedling size are controlled more by environment than by heredity. In one test *Pinus monticola* x *P. strobus* was compared with natural progeny of *P. strobus*. Data indicated that selection for inherent vigor based on height at 1 or 2 years would be unreliable because at 3 years the height of *P. strobus* expressed as a percentage of the hybrid height is considerably greater than it was at 1 and 2 years. Early height was primarily an expression of seed size and other non-heritary factors.

Riker, A. J., and R. F. Patton. 1954. **Breeding of *Pinus strobus* for quality and resistance to blister rust.** Wis. Univ. Forestry Res. Note 12, 2 pp.

A resumé of the white pine improvement program at the University of Wisconsin. Since 1938 more than 200 selections for blister rust resistance have been made from natural stands in Wisconsin and Minnesota; some 40 of them show great promise after tests in the blister rust nursery. Since 1949, 185 successful intra-specific crosses have been made and are being tested for resistance. Some interspecific crosses have been made and some of these between resistant eastern and western white pine have shown marked hybrid vigor when 2 years old.

Sargent, Charles Sprague. 1902. ***Pinus strobus*, white pine. *In* The silva of North America 11: 17-22, illus.**

In his principal work, Sargent has compiled information on synonymy; distribution; size, habit, and other dendrologic characteristics; properties of the wood; products of the tree; and economic history. Excellent plates illustrate details of twigs and cones. Copious footnotes cite early authors on distribution, size, and other historical items.

Sax, Karl, and Hally Jolivette Sax. 1933. **Chromosome numbers and morphology in the conifers.** Jour. Arnold Arboretum 14: 356-375, illus.

A highly technical paper reporting the chromosome numbers of 53 species in 16 genera of conifers and the chiasma frequency and behavior of the chromosomes at meiosis of 22 species in 10 genera. White pine has a chromosome number of 12 and an average number of chiasmata per bivalent of 2.4.

Schreiner, E. J., and M. A. Huberman. 1940. **Induced flowering — a tool for mass selection, progeny tests, and forest management.** Jour. Forestry 38: 491-492.

Describes ways by which flowering may be induced in forest trees. Induced flowering should prove useful to the practicing forester, because harvest cuttings can be made to coincide with seed years and seed need be collected only from trees of known superior quality.

Shaw, G. R. 1914. ***Pinus strobus. In*** The genus pinus. Arnold Arboretum Pub. 5, 96 pp., illus.

White pine was originally described by Linnaeus in 1753. Three synonyms are given, and botanical features and general characteristics are described. Classification is based on the evolution of cones and seeds. White pine is placed in *Section Haploxylon, Subsection Cembra, Group Strobi.*

Small, John Kunkel. 1913. **Flora of the southeastern United States.** 1370 pp. New York.

Primary generic differences among pine species are the number of needles per fascicle and the number of fibro-vascular bundles per needle. White pine is the only species described in the genus that has five needles per fascicle and one fibro-vascular bundle per needle.

Spurr, Arthur R. 1949. **Histogenesis and organization of the embryo in *Pinus strobus* L.** Amer. Jour. Bot. 36: 629-641, illus.

Describes the later stages of embryogeny of white pine, with particular regard to the origin of the parts and tissue systems.

Spurr, Arthur R. 1950. **Organization of the procambium and development of the secretory cells in the embryo of *Pinus strobus* L.** Amer. Jour. Bot. 37: 185-197, illus.

Well-defined patterns of organization occur in each of the two portions (xyloic and phloic) of the procambium. They are distinguished by rather consistent differences in general cell form and size. Two categories of secretory cells are also recognized — vascular and subdermal.

Thomson, Robert Boyd. 1914. **The spur shoot of the pines.** Bot. Gaz. 57: 362-385, illus.

Argues that spur shoots in pines are specialized, not primitive, characters and that they are wholly vegetative, not vestigial reproductive, in function. The lack of definiteness in the number of leaves in a fascicle, and the occurrence of supernumerary needles in the recognized primitive region and after wounding, are evidence of the branch character of the spurs.

Wright, Jonathan W. 1951. **Tree-breeding technique: some effects of continuous bagging.** U. S. Forest Serv. Northeast. Forest Expt. Sta., Forest Res. Note 5. 4 pp.

Describes the case of one white pine at Philadelphia, which normally matured only 5% of its cones and yielded no viable seed but after continuous bagging yielded 49 seeds from the 2 cones that matured from the 5 strobili pollinated.

Wright, J. W. 1952. **A directory of forest genetics research in the United States and Canada.** U. S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 53. 7 pp.

Gives location, personnel, and nature of work on 10 projects with white pine.

Wright, Jonathan W. 1953. **Summary of tree breeding experiments by the Northeastern Forest Experiment Station, 1947-1950.** U. S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 56, 47 pp., illus.

Cone mortality and low seed yield were generally common in the pines, especially white pine. The following true hybrids were bred: *Pinus griffithi* x *P. strobus* and reciprocal, *P. strobus* x *P. flexilis*, *P. strobus* x *P. ayacahuite*, *P. strobus* x *P. parviflora*. A probable hybrid *P. peuce* x *P. strobus* was also obtained.

Wright, Jonathan W. 1954. **Racial variation and individual tree selection in the Northeast.** Northeast. Forest Tree Improve. Conf. Proc. 1:

Notes that the possibility of there being more than one geographic race in white pine has not been investigated. Work in Wisconsin has shown that there are individual white pines sufficiently resistant to blister rust to make possible the breeding of a resistant strain.

Zirkle, Conway. 1931. **Nucleoli of the root tip and cambium of *Pinus strobus*.** Cytologia 2: 85-105, illus.

The root tip and cambium were fixed in several different fluids to preserve the chromatin plastin and mitochondria in several different combinations. It was thus possible to follow the plastin through the mitotic phases and to distinguish between plastin and mitochondria in the cytoplasm. The organization of nucleolar material and its behavior during karyokinesis are described.

CHEMISTRY AND PHYSIOLOGY : CYTOLOGY

Bailey, I. W. 1930. **The cambium and its derivative tissues. V. A reconnaissance of the vacuome in living cells.** Ztschr. f. Zellforsch. u. Mikros. Anat. 10: 651-682, illus.

A technique was perfected for studying living cells of the cambium and its derivative tissue. Cambial initials could be kept alive and actively streaming for 500 hours after sections were cut. A study was made of cell vacuoles in a number of softwoods (including white pine) and hardwoods. In all species the cambial cells were conspicuously vacuolated but the form differed with species and with season.

Burkholder, Paul R., and Ilda McVeigh. 1945. **The b vitamin content of buds and shoots of some common trees.** Plant Physiol. 20: 276-282.

The content of eight vitamins in the needles of eastern white pine and eastern hemlock and in the buds of a number of hardwood trees and shrubs is given. It is suggested that vitamins are among the specific substances making up plant auxins.

Burns, George P. 1926. **Relation of the moisture content of the soil to the sensitiveness of the chloroplast to light.** Vt. Agr. Expt. Sta. Bul. 257, 16 pp., illus.

One potted white pine seedling and a few of other species were used to determine the relation between soil moisture content and rate of photosynthesis as measured by the gain or loss of carbon dioxide in the air.

Burns, G. Richard. 1936. **Further studies of the limits of photosynthesis.** Vt. Agr. Expt. Sta. Bul. 402, 16 pp.

Describes results of a study of the limits of photosynthesis of white pine and Norway spruce under short- and long-wave light. Seedlings grown under red, blue, and white light for various periods were placed under red and blue light and the rate of photosynthesis was determined. It appears that these species cannot use light in the blue-violet portion of the spectrum as well as they can the light near the center of the spectrum.

Burns, G. Richard. 1937. **Photosynthesis and the absorption spectra of plant pigments.** Amer. Jour. Bot. 24: 257-265.

The primary absorption spectrum of a plant is defined as the incident radiation minus the reflected radiation minus the radiation transmitted by a solution of the plant pigments in 85% acetone similar in concentration to that in the leaf. On the assumption that only light thus primarily absorbed was effective in photosynthesis, that the quantum yield did not change, and that the long-wave limit of photosynthesis was 7800 A, the relative amounts of photosynthesis in various portions of the spectrum down to 5000 A were calculated for white pine. The observed values agreed with the calculated values within a few percent.

Burns, G. Richard. 1942. **Photosynthesis and absorption in blue radiation.** Amer. Jour. Bot. 29: 381-387.

Data on the relative photosynthetic efficiencies of white pine, Norway spruce, and Marquis wheat in monochromatic radiation at several wave lengths.

Chandler, R. F. 1939. **The calcium content of the foliage of forest trees.** Cornell Agr. Expt. Sta. Mem. 228, 15 pp., illus.

In white pine the calcium content of the needles increased through each growing season (to about 0.5% of dry weight during the first season and to about 0.9% during the second season) but remained fairly constant during the winter. By the end of the third growing season the mature white pine leaves had a calcium content of 1.2% — about the same as mature leaves of white oak, red oak, chestnut oak, yellow birch, and balsam fir.

Dole, Eleazer J. 1924. **Studies on the effects of air temperature and relative humidity on the transpiration of *Pinus strobus*.** Vt. Agr. Expt. Sta. Bul. 238, 39 pp., illus.

Experiments with a few white pine seedlings in the greenhouse and in the field demonstrated that transpiration was very responsive to environmental changes. Transpiration loss could not be correlated with relative humidity, temperature, or vapor pressure; but the product of loss and vapor pressure was correlated with temperature. This indicates an additional effect of temperature which may be interpreted in terms of diffusion.

Doyle, Joseph, and P. O'Connor. 1930. **Seasonal change in the catalase content of conifer leaves.** Ann. Bot. 44 (176): 907-915.

Measurements of catalase activity of conifer leaves in summer, fall, and winter are reported. In white pine and seven other conifers, catalase activity was invariably greater in October than in July, and in January than in October.

Duffield, John W., and Albert G. Snow, Jr. 1941. **Effect of storage conditions on pollen longevity of *Pinus strobus* and *Pinus resinosa*.** Jour. Forestry 39: 410-411, illus.

After 1 year's storage at 50% relative humidity and 0 to 4° C., pollen of both pine species had 80% germinability — definitely greater than pollen stored under warmer and more humid conditions.

Ehlers, John Henry. 1915. **The temperature of leaves of *Pinus* in winter.** Amer. Jour. Bot. 2: 32-70.

As an adjunct to the main experiments reported, leaves of white pine and several other conifers were collected throughout January, February, and March in southern Michigan. There was no evidence of starch formation in white pine during the period, although there was in the other species.

Fraser, D. A. 1949. **Production of spring wood with B-indole-acetic acid (heteroauxin).** Nature 164: 542.

Applications of heteroauxin tended to cause production of spring wood tracheids with large radial measurements and narrow walls; in contrast, the controls formed thicker and narrower tracheids typical of summerwood. White pine was used as the test material.

Fraser, Donald A. 1952. **Initiation of cambial activity in some forest trees in Ontario.** Ecology 33: 259-273.

Cambial activity in white pine, *Larix laricina,* and *Picea mariana* was studied by sectioning samples of bark and outer wood and by daily measurements of radial increment with a dendrometer. Cambial activity proceeded from the apex to the base of the tree. Experiments with heteroauxin and a lengthened photoperiod substantiated the theory of a stimulus not associated with food, proceeding from the buds and developing leaves in the spring and being responsible for the apical initiation of cambial activity.

Fraser, D. A., and C. A. Mawson. 1953. **Movement of radioactive isotopes in yellow birch and white pine as detected with a portable scintillation counter.** Canad. Jour. Bot. 31: 324-333, illus.

Calcium-45 chloride and calcium chloride were introduced in bore-holes in two bifurcated white pines on July 10. One stem received the chemical and the other was used as a control. The isotope moved upward from the point of injection in a relatively narrow channel. Only two branches contained appreciable activity. Monitering on August 22 indicated an accumulation of isotope in the main stem at a point where the upper active branch had its origin, and from here most of the radioactive calcium was carried out into this branch.

Freeland, R. O. 1952. **Effect of age of leaves upon the rate of photosynthesis in some conifers.** Plant Physiol. 27: 685-690, illus.

Under uniform conditions of light, temperature, and CO_2 concentration, apparent photosynthetic rate of leaves 1 to 3 years old of white pine and four other conifers was measured by the difference in CO_2 content of air passed over the needles. Rate of photosynthesis decreased with increase in age; in white pine the decrease was small and in 3-year-old needles photosynthesis was still appreciable.

Gibbs, R. Darnley. 1939. **Studies in tree physiology. I. General introduction. Water contents of certain Canadian trees.** Canada Jour. Res. Sect. C. 17: 460-482.

Water content of entire 2-year-old twigs, 1-year-old twigs, and needles from old white pine in Quebec was determined at different times during the winter. In November, December, and January water content was apparently constant, roughly 110-140% of dry weight. By mid-March, water content dropped to 96-130%. By mid-April it had increased to 117-142%.

Koblet, Rudolf. 1937. **Über die proteolytisene Aktivität von Weymouthskiefern-und Weizensamen unter besonderer Berudksichtigung des Einflusses der Vorkühlung.** Internatl. Seed Testing Assoc. Proc. 9: 228-253.

In tests with embryos and endosperms (white pine and wheat seeds) it was shown that low temperatures had no beneficial influence on proteolytic activity, which in turn could not be the factor influencing germination. The rapid breaking down of reserve proteins during germination is connected with the removal of the products of hydrolysis due to the growth processes in the embryo, as well as with the rise in the activity of proteolytic enzymes.

Kozlowski, Theodore T. 1943. **Transpiration of some forest tree species during the dormant season.** Plant Physiol. 18: 252-260, illus.

An experiment with potted trees in the open at Durham, N. C., established differences in transpiration per unit of transpiring surface with season and species. The average transpiration of white pine in October and November was more than three times the maximum transpiration in December and January.

LaRue, Carl D. 1936. **Cell outgrowths from wounded surfaces of plants in damp atmospheres.** Mich. Acad. Sci. Arts and Letters Paper 22: 123-139.

When 1- to 3-year-old white pine twigs were cut into short sections, split, and placed in damp chambers, outgrowths developed between the cambium and the xylem, between the cambium and the cortex, and in the cortex itself.

Loewenberg, J. B., and F. Skoog. 1952. **Pine tissue cultures.** Physiol. Plant. 5: 33-36.

A method and media for obtaining callus and maintaining growth of tissue cultures of red and white pine are described. A heat labile factor present in malt and pine seed appears to be essential for the growth of red pine cultures.

Lorenz, R. W. 1939. **High temperature tolerance of forest trees.** Minn. Agr. Expt. Sta. Tech. Bul. 141. 25 pp., illus.

The cortical parenchyma cells in microscopic sections from seedlings of white pine and four other species were killed in 30 minutes when exposed to temperatures between 57 and 59° C. by immersion in a water bath, and in 1 minute at 65 to 69° C. The five species did not vary markedly in their relative heat resistance.

Maki, T. E., and H. Marshall. 1945. **Effects of soaking with indolebutyric acid on root development and survival of tree seedlings.** Bot. Gaz. 107: 268-276.

Preliminary experiments in 1942 showed no beneficial responses to root soaking of white pine.

Parker, Johnson. 1952. **Dessication in conifer leaves: anatomical changes and determination of the lethal level.** Bot. Gaz. 114: 189-198.

Gives results of studies of the changes in needles of *Pinus nigra* var. *austriaca* and white pine during gradual drying and rehydration, including rate of CO_2 release from drying needles. Usefulness of the tetrazolium chloride test as a measure of viability is discussed.

Riou, Paul, Gerard Delorme, and (Le Frere) Hormisdas. 1936. **De la distribution du manganese et du fer dans les pins du Quebec.** Acad. de Sci. Compt. Rend. 202 (21): 1811-1812.

Report on an investigation of the distribution of manganese and iron in the bark, branches, leaves, sapwood, heartwood, and seeds of Quebec-grown *Pinus strobus, P. resinosa,* and *P. banksiana.* Amounts of iron and manganese varied inversely. The metals were found in leaves and branches, and seem to accumulate in the bark.

Struckmeyer, B. Ester, and A. J. Riker. 1951. **Wound periderm formation in white-pine trees resistant to blister rust.** Phytopath. 41: 276-281, illus.

Cortex and phloem tissues of normal white pines and of susceptible and resistant white pines that had been artificially inoculated with blister rust 4 years earlier were examined. Resistant trees were not immune to attack; but the infected cells were effectively walled off from healthy tissue by wound periderm of suberized cork cells and lignified stone cells. In susceptible trees there was little or no evidence of wound periderm, so the mycelium easily penetrated the phloem to the cambium, eventually killing the tree.

Voight, G. K. 1953. **The effects of fungicides, insecticides, herbicides, and fertilizer salts on the respiration of root tips of tree seedlings.** Soil Sci. Soc. Amer. Proc. 17: 150-152, illus.

Studies with excised root tips in nutrient solutions and with seedlings in quartz sand and the A_1 horizon of outwash sand indicate that biocides (calomel, spergon, thiosan, Stoddard oil, and chlordane) influence the oxygen uptake in root tips of white pine and several other species. Results vary with species, chemical, and fertilization. The manometric technique is suitable for such studies.

Wallace, R. H. 1932. **The photosynthetic activity of evergreens in winter.** Ecol. Soc. Amer. Bul. 13, item 35.

Tests showed that some photosynthetic activity occurred in white and red pine, hemlock, and a number of other softwoods at temperatures below 10° C.

White, Donald P. 1954. **Variation in the nitrogen, phosphorus, and potassium contents of pine needles with season, crown position and sample treatment.** Soil Sci. Soc. Amer. Proc. 18: 326-330.

Plantations in New York were systematically sampled and analyzed by standard chemical procedures. Data on magnitude of variations in red and white pine confirm the percentage decline of K, N, and P in needle tissue from an early summer maximum to a fairly constant base level during winter months. Late fall and winter sampling from mid-crown is recommended for foliar analysis. Stripping of needles from branches and immediate oven-drying (70° C.) after collection is necessary.

Zeeuw, Carl de. 1941. **Influence of exposure on the time of deep cork formation in three northeastern trees.** N. Y. State Col. Forestry Tech. Pub. 56, 10 pp., illus.

In studies of white pine (red ash and yellow-poplar were also used) it was found that the mean age of deep cork formation in open-grown trees was 20 years whereas the mean age in trees that had grown in stands with full crown closure was 35 years, whether the trees were dominants, codominants, or suppressed.

SILVICAL CHARACTERISTICS

Anonymous. 1941. **Seed dissemination of native tree species.** Canada Forestry Branch Silvic. Leaflet 2, 2 pp.

A preliminary report on seed dissemination at the Petawawa Station (Ontario) shows that most white pine seed falls inside the stand between October 3 and November 11.

Anonymous. 1950. **Effective pollination distances. *In* U. S. Forest Serv.** Northeast. Forest Expt. Sta. Ann. Rpt. 1949: 12-13.

Pollen counts made at varying distances from heavily pollinating trees corroborated observations on the degree of fruitfulness of isolated trees. For white pines near Philadelphia, production of viable seed averaged only 0.3 to 1.8 per cone on trees isolated from pollinating neighbors by 200 feet or more. Distances as short as 100 feet between seed trees may reduce pollination below the requirements for effective seed production.

Badoux, H. 1930. **Recherches sur l'accroissement du pin Weymouth en Suisse.** Jour. Forest. Suisse 81: 14-18.

Report of white pine studies in Switzerland. Describes soil profile in a 36-year-old plantation in Canton Argovie, as well as rooting habits, thinning practices, attack by blister rust, and stand conditions in regard to numbers, basal area, diameter, total height, and volume. Recommends thinning at 2- to 3-year intervals to remove trees infected by blister rust.

Baldwin, Henry I. 1931. **The period of height growth in some northeastern conifers.** Ecology 12: 665-689, illus.

The period of white pine height growth began April 26 - June 20 and lasted till August 7 - September 5. Rapid growth began early in June and continued through most of the month. Temperature seemed to be the major determinant. White pine always followed the grand-period type of growth, but the curves varied somewhat with place and time; for example, some were double-peaked.

Baldwin, H. I., and M. A. Holden. 1939. **Phenological observations.** N. H. Forestry and Recreation Comn. Fox Forest Notes 17, 1 p.

Records taken at Hillsboro, N. H., over a 5-year period show that for white pine the average date of bud bursting is April 12, the beginning of flowering June 15. Fruit ripens about September 2 and the seed begins to disperse about September 12.

Belyea, R. M., D. A. Fraser, and A. H. Rose. 1951. **Seasonal growth of some trees in Ontario.** Forestry Chron. 27: 300-305.

A brief report on results with a new dial-gage dendrometer used on white pine at Chalk River, Ont., and on other species at Chalk River and Cedar Lake, Ont. White pine growth began about May 25 and was complete by August 25.

Brown, H. P. 1915. **Growth studies in forest trees. 2. *Pinus strobus* L.** Bot. Gaz. 59: 197-241, illus.

A detailed record of seasonal growth was obtained from sections taken periodically, and other measurements. Stages of growth are described in detail. Since moisture conditions and food reserves are at optimum in spring, it appears that awakening and rapidity of growth are directly proportional to prevailing temperatures.

Buckhout, W. A. 1907. **The formation of the annual ring of wood in the European larch and the white pine.** Forestry Quart. 5: 259-267.

Careful measurements of circumference on one tree of each species over a period of 4 years showed that the period of cambial activity in white pine at State College, Pa., was from the last week of April to the first week of September. The trees were in an ornamental setting comparable to an open forest stand.

Burger, Hans. 1930. **Mitteilunge die Weymouthsfohre.** Schweiz. Central-anst. f. Forstl. Versuchsw. Mitt. 15: 243-292.

Data obtained from 24 white pine trees, aged 21 to 70 years and growing in 8 different situations, were used to show relationships among wood quality, growth, and quantity of foliage. To produce a cubic meter of wood per year, 600 to 1,500 kilograms of green needles, or a foliage area of 6,000 to 15,000 square meters, are required.

Cousins, M. 1938. **White pine monarch.** Wis. Mag. Hist. 22: 44-45.

A large white pine cut in Wisconsin in 1937 was about 426 years old, 4 feet 10½ inches in diameter at the butt, and had a total height of 140 feet. Merchantable log length was 92 feet and the logs scaled 5,078 feet board measure.

Deen, J. Lee. 1933. **Some aspects of an early expression of dominance in white pine *(Pinus strobus,* L.).** Yale Univ. School Forestry Bul. 36, 34 pp., illus.

White pine has the inherent ability to express dominance. Good sites and variation of age within the stand favor expression of dominance; dense stocking is detrimental on the poorer sites only. Low density of stocking acts against expression of dominance on all sites but does not cause stagnation. Silvicultural treatment can either favor or check this expression of dominance.

Deen, J. L. 1934. **The expression of dominance after twenty years in a nursery seed bed.** Jour. Forestry 32: 485-486.

Studies of white pine trees in a 20-year-old seedbed indicate strongly that the species possesses inherent characteristics that enable it to show an acceptable expression of dominance on a good site regardless of original density or lack of variation in age.

Friesner, R. C. 1942. **Elongation of the primary axis in four species of pines.** Ind. Acad. Sci. Proc. 1941: 51.

Measurements of terminal internodes in 50 specimens each of white pine, *P. banksiana*, *P. silvestris*, and *P. resinosa* were made weekly during the period April 1 to September 25, 1941. *P. banksiana* and *P. silvestris* reached their peak growth early in May; white pine and *P. resinosa* showed maximum growth somewhat later in the month.

Friesner, Ray C. 1942. **Vertical growth in four species of pines in Indiana.** Butler Univ. Bot. Studies 5: 145-159, illus.

Elongation was measured weekly on 50 individuals each of jack, Scotch, red, and white pine. Terminal growth began in most individuals the week ending April 13, but in the majority of the white pines it began a week later. All individuals showed a grand-period type of growth with nine different curve-types being displayed. Most of the white pines showed a single peak of growth that was fairly regular. Maximum growth was reached in white pine 4 to 7 weeks after initiation.

Friesner, Ray C. 1943. **Correlation of elongation in primary, secondary, and tertiary axes of *Pinus strobus* and *P. resinosa*.** Butler Univ. Bot. Studies 6: 1-9, illus.

Careful measurements of the elongation of the terminal axis and 30 secondary axes on a single eastern white pine in Indiana at 1- to 3-day intervals verified that the elongation of white pine follows the grand-period type of growth. Growth of all axes began at the same time but the terminal axis grew faster and for a longer period than the secondary axes. The younger secondary axes (near the top of the tree) grew somewhat faster and for a longer period than older ones.

Friesner, Ray C., and Gershon Walden. 1946. **A five-year dendrometer record in two trees of *Pinus strobus*.** Butler Univ. Bot. Studies 8: 1-23.

Weekly measurements taken on two trees at Camden, Maine, throughout a 5-year period showed that true radial enlargement began between April 15 and May 26. The data coincided within a few days with the date on which the mean daily air temperature was continuously above 50° F., and closely followed the start of bud swelling. Temperature seems to be the most important factor controlling the starting date of radial enlargement.

Gevorkiantz, S. R., and N. W. Hosley. 1929. **Form and development of white pine stands in relation to growing space.** Harvard Forest Bul. 13. 83 pp., illus.

Reports on a study that was based on 50 sample plots and detailed measurements on 377 trees. Because of weevil damage and persistent branches, white pine should be grown in dense stands (2,200 + stems per acre) during early life to produce good lumber. Cubic-foot and board-foot form-class volume tables are included.

Haddow, W. R. 1948. **Distribution and occurrence of white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) at the northern limit of their range in Ontario.** Jour. Arnold Arboretum 29: 217-226, illus.

The distribution of red and white pine is described with reference to a datum line which is the northern boundary of the common occurrence of these species in Ontario. It runs southwest from below Lake Abitibi to Sudbury, then west to Lake Superior, follows the north shore to Black Bay and then northwest and west to the Manitoba border. Red pine occurs farther north than white pine.

Haddow, W. R. 1948. **Checklist of stations for white pine and red pine at the northern limit of their range in Ontario.** Ontario Dept. Lands and Forests, 32 pp.

A supplement to the report cited above. Source of the information and remarks concerning the stands at each station are included.

Hastings, George T. 1900. **When increase in thickness begins in our trees.** Plant World 3: 113-116.

In white pine and five other species, the course of radial growth was studied at Ithaca, N. Y., in sections of branches and stems taken at weekly intervals during April to June. White pine radial growth began on May 19. The buds were still unopened. Twigs 2 and 3 years old were the first parts of the tree to start growth.

Kienholz, Raymond. 1934. **Leader, needle, cambial, and root growth on certain conifers and their inter-relations.** Bot. Gaz. 96: 73-92, illus.

The 1931 seasonal growth of the terminals, needles, and stems of white pine and red pine sample trees was measured at Keene, N. H. Leader growth began May 13, reached a peak on June 10, and ceased about August 15. Needles elongated at the base, reached maximum elongation on July 15, and ceased growth September 2. Data on cambial growth of both pines were similar. The interrelation between time and growth rates of the various growing regions of pine are discussed.

Kramer, P. J. 1942. **Species differences with respect to water absorption at low soil temperatures.** Amer. Jour. Bot. 29: 828-832.

Study of the effects of gradually cooling the soil on water absorption by certain plants including elm, and red, white, loblolly, and slash pines. Absorption was reduced in all species, but more in loblolly and slash pines, which normally grow in warm soil, than in white and red pine, which normally grow at least part of the year in cold soil. Reduction in water absorption caused by cold soil is of considerable ecological and practical importance because it often produces winter injury.

Kramer, Paul J. 1943. **Amount and duration of growth of various species of tree seedlings.** Plant Physiol. 18: 239-251, illus.

Eleven species of tree seedlings were grown together for 3 years at Durham, N. C., and their height growth was measured at intervals during the growing season. The red and white pine (from New York) had only one-sixth the yearly height growth of loblolly, which was by far the fastest growing conifer.

LaRue, Carl D. 1934. **Root grafting in trees.** Amer. Jour. Bot. 21: 121-126, illus.

Root grafting in white pine was studied in Michigan stump fences. Grafts were seen in every stump examined. Removal of the bark at the point of contact by friction is not necessary to produce root grafts.

Lownes, Albert E. 1935. **The King's pine.** Amer. Bot. 41: 17-19.

Describes a large white pine near Hiram, Maine, and various other white pines that had been reserved in Colonial days by royal marking.

Lutz, H. J. 1939. **Layering in eastern white pine.** Bot. Gaz. 101: 505-507, illus.

Reports an instance of layering at Keene, N. H. A low branch on the south side of the mother tree became covered with eroded mineral soil and organic material. The branch developed an independent root system and assumed an upright habit at the point of rooting. The upright branch was 2.4 meters tall and the roots had a horizontal spread of 1.8 meters.

Lyon, N. F. 1951. **Seed dispersal test.** Ont. Dept. Lands and Forests Proj. Rpt. 1950-51: 75-76.

Seed traps placed around two white pine trees caught 2,000 and 3,652 seeds per acre. Seed traveled at least 200 feet. It was dispersed October 3-30.

Morey, H. F. 1935. **The average date of maturity of white pine *(Pinus strobus* L.) seed.** U. S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 22, 1 p., illus.

Maturity dates of white pine seed ranged from August 1 in northern Connecticut to September 15 in Vermont, New Hampshire, and southern Maine. Based on observations over a 5-year period.

Munns, E. N. 1938. **The distribution of important forest trees of the United States.** U. S. Dept. Agr. Misc. Pub. 287, 176 pp., illus.

Map shows botanical range of northern white pine as extending from southeastern Manitoba, northern and eastern Minnesota, eastward to the Atlantic Coast and Newfoundland. The area is roughly rectangular except for a southern extension that includes northeastern Ohio, all of Pennsylvania, and continues south to Georgia along the Appalachian Mountains.

Page, Frederick S. 1927. **Living stumps.** Jour. Forestry 25. 687-690.

Living hemlock and white pine stumps were reported from Hanover, N. H., and living hemlock stumps from Ithaca, N. Y. On the larger living stumps in a thinned stand of white pine at Hanover, root grafts were easily found. The living stumps had large numbers of living rootlets, which, linked by root grafts to living trees, may have been a factor in increasing the rate of tree growth after thinning.

Paul, Benson H. 1938. **Knots in second-growth pine and the desirability of pruning.** U. S. Dept. Agr. Misc. Pub. 307, 35 pp., illus.

Branch persistance and the value of pruning were studied in six eastern pine species. Complete natural pruning was slowest in white pine. In plantations, little or no clear lumber could be expected in rotations of less than 80 years. Even in fully-stocked stands, artificial pruning of white pine is essential for the production of any of the best grades of lumber in a reasonable time.

Reineke, L. H. 1941. **Fruiting of 10-year-old conifers.** U. S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 47, 3 pp.

A comparison of cone production on 10-year-old planted white spruce, red pine, and white pine trees. Cone production on all three species was related to height growth. Trees less than 3 feet high generally did not produce cones. Number of cones varied according to height growth.

Righter, F. I. 1939. **Early flower production among the pines.** Jour. Forestry 37: 935-938, illus.

Average minimum age of flowering among 55 species and varieties of pine was 5.2 years for ovulate flowers and 4.4 years for pollen production, at Placerville, Calif. The minimum record there for white pine was 5 years for ovulate flowers; no record for staminate flowers.

Sinnott, Edmund W. 1952. **Reaction wood and the regulation of tree form.** Amer. Jour. Bot. 39: 69-78, illus.

Using white pines 5 to 10 years old and branches from older trees, the author repeated and extended experiments by Hartmann on the formation and function of compression wood. Main axes and lateral branches were tied into a series of positions different from their natural ones and the distribution of reaction wood after 1 or 2 years of growth was diagrammed from sections.

Stevens, Clark-Leavitt. 1931. **Root growth of white pine.** Yale Univ. School Forestry Bul. 32. 62 pp., illus.

In spring and fall, root growth was rapid. In mid-summer, when height growth was almost complete, the more vigorous roots grew at a slower rate; the less vigorous roots ceased growth altogether. From November 15 to April 1 roots normally did not grow, but greenhouse experiments gave no evidence that the winter rest period was inherited or necessary. Rate of root growth was highly variable but did not appear to be correlated with weather or with the amount of top growth.

Svenson, H. K. 1925. **The white pine in middle Tennessee.** Rhodora 27: 27-28.

The presence of about a dozen full-grown white pines at the summit of a high bluff in the hills west of Nashville is reported. This new station extends the known distribution of white pine some distance to the southwest.

Tarbox, E. E., and P. M. Reed. 1924. **Quality and growth of white pine as influenced by density, site and associated species.** Harvard Forest Bul. 7, 30 pp., illus.

The relationship of lumber quality — based on knot size and current leader growth — to stand density and associated species influencing pine development was studied in 20- to 90-year-old stands of pure pine, pine-hemlock and pine-hardwoods on site I and II on or near the Harvard Forest. Density had little or no effect on height or leader growth but was inversely correlated with knot size in the first 12-foot log. For a given site, lumber quality is determined by knot size, which varies with the years of open growth before crown closure. Thus dense and uniform pine reproduction is desirable.

Toumey, James W. 1929. **Some observations on the importance of early dominance in pure stands of white and red pine in New Hampshire.** Mich. Agr. 8 (8): 5, 21.

Early expression of dominance in pure red and white pine stands prevents stagnation that would require costly early thinnings; as a result, some trees will have two or three times as much volume as the average tree in the stand as well as good form and quality. Dominance is better expressed in natural stands than in plantations. Seeds and seedlings should not be sorted into grades in the nursery because this reduces the ability of trees in the resulting stands to express dominance.

Weck, H. 1944. **Kronenausmasse and Zuwachsleistung.** Forstarchiv. 20: 73-78.

Results of growth studies of several conifer species growing under a variety of conditions (including white pine in strictly even-aged stands of several ages). Crown-surface area, expressed as the product of crown length and maximum width, was correlated with basal-area increment, but less so in even-aged than in irregular stands.

Wheeler, C. F. 1898. **A sketch of the original distribution of white pine in the Lower Peninsula of Michigan.** Mich. Agr. Expt. Sta. Bul. 162: 5-6, illus.

Eastern white pine was originally found throughout the Lower Peninsula, but the southern limit of white pine logging is sketched on a map as beginning on Lake Michigan near the southern boundary of Van Buren County and extending northeastward into northern Gratiot County, thence turning south of east and terminating on the Lake Huron shore in central Saint Claire County.

Wojczynski, Wladyslaw. 1932. **Proba ustalenia zaleznosci przyrostu od zwarcoa dla kedmek klasy biologicznej w drzewostanie sosnowyn. (Relation between growth and stand density for a biological tree class in pine stands.)** Roczniki Nauk Rolnicz i Lesnych (Polish Agr. and Forest. Ann.) 27 (2): 227-262, illus.

Subdominant white pine trees were investigated. The author concludes that average radial distance can be used as a measure of stand density instead of the more expensive crown-projection method, and the comparatively easy sample-tree method can be substituted for the sample-plot method to determine degree of stocking as a guide in management.

Wright, Jonathan W. 1953. **Notes on flowering and fruiting of northeastern trees.** U. S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 60, 38 pp.

For specimen trees of white pine and other species in the Philadelphia area, the author recorded the position in the crown and on branches of the female and male flowers, tree height at first appreciable flowering, the degree of maleness and femaleness of young and older trees, and dates of pollen-shedding and female-cone receptivity. Self-pollination is possible in white pine. White pine tends to produce flowers and fruit year after year, but cone weevils cause heavy losses of the developing cones and are the chief cause of seed-crop periodicity.

ATMOSPHERIC AND BIOTIC RELATIONS (including fire)

Adams, W. R. 1935. **Studies in tolerance of New England forest trees. XII. Effect of thinning in plantations on some of the physical factors of the site and on the development of young northern white pine and Scotch pine (*Pinus silvestris* L.).** Vt. Agr. Expt. Sta. Bul. 390, 147 pp., illus.

Detailed results from removal of 45% of basal area in a 20-year-old white pine plantation. Trees of largest diameter and best form showed an increase in diameter growth and total volume production but no change in quality of wood, as indicated by specific gravity. Conditions continued beneficial to tree growth 4 years after treatment.

Baker, F. S. 1949. **A revised tolerance table.** Jour. Forestry 47: 179-181.

In a canvass of American foresters on the question of the tolerance of American timber species, 72% of 55 respondents expressed opinions that eastern white pine is intermediate in tolerance.

Bartholomew, W. V., and A. G. Norman. 1947. **The threshold moisture content for active decomposition of some mature plant materials.** Soil Sci. Soc. Amer. Proc. 11: 270-279.

Alfalfa, Sudan grass, oat straw, hemp bark, and white pine needles were studied. The moisture content at which decomposition of pine needles began, at temperatures of 25 and 37° C., was 15-17%, and the relative humidity required was 80-86%. Increased temperature shortened the length of time before the peak rate of CO_2 evolution was reached.

Bates, C. G. 1925. **The relative light requirements of some coniferous seedlings.** Jour. Forestry 23: 869-879.

Grown for 11 months under artificial light comparatively rich in the longer wavelengths, the seedlings of eight species survived under very low light intensities. White pine survived in less than 1% of noon September sunlight. Height of the seedlings was not visibly affected by the light intensity, but root length and branching were markedly reduced in weak light, which suggests that seedlings may succumb to unfavorable soil conditions under low light intensities rather than to failure of photosynthesis.

Bates, C. G., and Jacob Roeser, Jr. 1928. **Light intensities required for growth of coniferous seedlings.** Amer. Jour. Bot. 15: 185-194, illus.

White pine was among 12 species in this test of survival and growth under artificial light with an intensity of less than 1% to more than 18% of full sunlight. Poor germination and low survival made the number of surviving white pine seedlings too few for conclusive results, but the theoretical minimum light in which growth could be made was set at 2% — lower than other pines but nearly four times the minimum for redwood and nearly twice the minimum for Douglas-fir. The pines appear to be rather inefficient photosynthetically.

Burns, George P. 1915. **The relative transpiration of white pine seedlings.** Plant World 18: 1-6.

As determined through measurements of evaporation from a black atmometer, seasonal transpiration of first-year white pine seedlings grown in a nursery bed was 21 times greater under no shade and 8 times greater under half shade, than when the seedlings were grown under full shade. Study data indicate that size of plant must be related to photosynthesis and assimilation rather than absorption and transpiration of water.

Burns, George P. 1923. **Studies in tolerance of New England forest trees. IV. Minimum light requirement referred to a definite standard.** Vt. Agr. Expt. Sta. Bul. 235, 32 pp., illus.

Minimum light requirements of a number of species was determined by measurement of the amount of CO_2 given off in respiration at different light intensities. Eastern white pine required a minimum of 10.4 milliamperes, compared to 28.7 for Scotch pine, 13.3 for red oak, 8.7 for Norway spruce, 8.4 for hemlock, 7.5 for beech, and only 3.4 for sugar maple.

Candy, R. H. 1939. **Discussion on the reproduction and development of white pine.** Forestry Chron. 15: 88-92.

White pine has disappeared from many parts of central and eastern Canada because of natural agencies such as invasion of spruce and fir from the north and tolerant hardwoods from the south, as well as current logging practices. Present stands are restricted mostly to dry, sandy, or gravelly soils where the species can be reproduced successfully with the aid of prescribed fire for seedbed preparation.

Cary, Austin. 1936. **White pine and fire.** Jour. Forestry 34: 62-65.

The author observed that a large part of the pine originally found in Maine started following fire, and that without fire it has seldom reproduced itself in the natural state because of competition from the more tolerant species. On sandy soils pine will usually reproduce itself without help, and on the medium soils the new stand may be thrown into pine with a little management; but on the loamy soils the hardwoods will inevitably follow pine unless the area is pastured, plowed, or burned.

Christensen, Clyde M., and A. C. Hodson. 1954. **Artificially induced senescense of forest trees.** Jour. Forestry 52: 126-129.

Fifteen white pine trees (25 to 35 years old) were tightly banded 4 to 5 feet above ground with 1-inch wide steel bands. Describes damage, death, and subsequent invasion by diseases and insects.

Conover, David F. 1953. **Effects of competition on red pine and white pine reproduction.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 392. 2 pp.

Competition from brush and heavy overstory seriously retard growth and abundance of red pine seedlings, while under the same conditions white pine seedlings often continue to grow and increase.

Eyre, F. H. 1933. **Aspen competition in Norway pine plantations.** Jour. Forestry 31: 318-321.

White pine will usually have a better survival rate than red pine in competition with aspen but the white pines will be smaller. Systematic care by periodic weedings and release cuttings is the only way to insure success of pine plantations where aspen is present.

Gast, P. R. 1930. **A thermo-electric radiometer for silvical research with preliminary results on the relation of insolation to the growth of white pine.** Harvard Forest Bul. 14, 76 pp., illus.

The apparatus, which gives a better record than any other method previously used, is described. Radiation that is 27% of radiation in the open is the minimum for white pine survival. Leader growth is proportional to radiation, as measured by the thermopile, up to the intensity of full solar radiation.

Grasovky, Amihud. 1929. **Some aspects of light in the forest.** Yale Univ. School Forestry Bul. 23, 53 pp., illus.

Discusses the physiological effects of solar radiation on plants, the measurement of light in silvical studies, and some concepts of the effect of light on forest vegetation. Experimental pot cultures of white pine and other species studied over a 10-month period under various light intensities and ranges of the visible spectrum demonstrated that at 300 foot-candles all plants survived and grew regardless of light quality but at 65 foot-candles all were dead or dying.

Henry, Alfred J. 1902. **The climate of the white pine belt.** Forestry and Irrig. 8: 419-423.

Climate of the Lake States pine belt is described from weather records. It seems probable that occurrence of pine should be ascribed to a fortunate combination of soil and climate. The dominating climatic characteristics are: (1) an atmosphere that contains a high percentage of moisture, with much cloudiness and little bright sunshine; (2) frequent precipitation uniformly distributed throughout the year; and (3) relatively low temperature, and no hot winds or prolonged periods of high temperature.

Hutchinson, A. H. 1918. **Limiting factors in relation to specific ranges of tolerance of forest trees.** Bot. Gaz. 66: 465-493.

Records of exploration and personal knowledge of the forests of Ontario are the basis for this discussion of limiting site factors and the role of competition in the forest succession. White pine is held to be a pioneer species with relatively limited range of tolerance to shade, moisture, and temperature. Light is the limiting factor in the competition of white pine with hemlock and maple.

Lyon, Charles J. 1940. **Tree growth beside a rain gauge and thermometer.** Ecology 21: 425-437.

Yearly deviaions of secondary growth for nine white pines and trees of other species were compared with rainfall and mean daily temperature for certain parts of the year over a period of 70 years. Significant correlation coefficients of growth with rainfall throughout the growing season and with March and April mean daily temperatures were obtained.

Lyon, Charles J. 1943. **Water supply and the growth rates of conifers around Boston.** Ecology 24: 329-344.

Comparison of growth rates with the rainfall records for nearby weather stations brought out the importance for rainfall during the growing season. There was also some evidence of lag and cumulative effects from previous seasons and a general demonstration that fluctuations in growth rates from year to year reflect variations in water supplied through the soil.

Maissurow, D. K. 1935. **Fire as a necessary factor in the perpetuation of white pine.** Jour. Forestry 33: 373-378.

White pine in both virgin and cut-over land in southwest Pontiac County, Quebec, originated following fire. Fire is not recommended as a tool, but cutting methods should be aimed to reproduce fire conditions. Erosion, inundation, and windthrow were other factors that permitted white pine to come in.

Mayall, K. M. 1941. **White pine succession as influenced by fire.** Natl. Res. Council Canada Interim Rpt. 989. 29 pp., illus.

A survey of seven widely scattered areas in the Ottawa Valley Region revealed that white pine regeneration on cut-over and burned-over lands is insufficient for future requirements, and that in the tolerant hardwood cover type white pine is no longer significant. Burning in stands of mature timber stimulates regeneration but the results of fire in young stands are doubtful.

Minckler, Leon S. 1939. **Transpiration of trees and forest.** Jour. Forestry 37: 336-339.

Direct measurements of transpiration were made on samples from several white pines and on some northern hardwoods *in situ*. Mean annual rainfall was 40 inches. The average seasonal transpiration per tree and for a hypothetical pure forest of each species were calculated. Species make-up, the amount of foliage, the foliage exposure, soil-moisture, and the atmospheric humidity level are the important factors in comparing water losses from different forests.

Mitchell, H. L. 1936. **The effect of varied solar radiation upon the growth, development, and nutrient content of white pine seedlings grown under nursery conditions.** Black Rock Forest Papers 1 (4): 15-22.

Experimental evidence indicates that the largest (total dry weight) white pine seedlings are grown under conditions of full light in temperate humid regions. Young seedlings grown in low light intensities are taller and have more and longer needles than those exposed to higher light intensities, but they are light, spindly, and succulent and have poorly developed roots.

Mitchell, H. L., and R. O. Rosendahl. 1939. **The relationship between cumulative solar radiation and the dry weight increase of nursery-grown white pine and red pine seedlings.** Black Rock Forest Papers 1 (13): 88-93.

Experiments indicate that for white pine and red pine there is an arithmetic/logarithmic correlation between seedling yields and cumulative solar radiation. This relationship, which takes the form of a linear proportion, is valid under certain conditions of mineral nutrition, and when the radiant-energy measurement used is that of total radiation. Seedlings exposed to full sunlight during the greater part of the growing season are not only heavier (total dry weight) but have better root systems and a more favorable root/shoot ratio than plants grown in lower light intensities.

Motley, J. A. 1949. **Correlation of elongation in white and red pine with rainfall.** Butler Univ. Bot. Studies 9: 1-8.

Measurements of annual elongation were taken of the main stems and secondary branches of 100 white pines and 50 red pines in Indiana. Curves of growth were plotted for both main and secondary stems, and composite curves were made for each of these. Rainfall data were collected, and curves were plotted for various combinations of months. Elongation in white pine showed closest correlation with rainfall of the storage season (May-November) of the preceding calendar year. This was true of both primary and secondary axes.

Perry, George S. 1932. **Some tree antagonisms.** Pa. Acad. Sci. Proc. 6: 136-141.

When white pine grows in association with black walnut and black locust, the pine becomes unthrifty and finally dies. Walnut is known to excrete root toxins that are inimical to many kinds of vegetation, and black locust may do the same. But association with red maple and other hardwoods seems to benefit white pine.

Shirley, Hardy L. 1936. **Lethal high temperatures for conifers and the cooling effect of transpiration.** Jour. Agr. Res. 53: 239-258.

The ability of white pine, red pine, jack pine, and white spruce to withstand high temperatures was tested in the laboratory. There was little difference among them. Resistance increased with increasing age and with size or mass of plant or tissue; tops were more resistant than roots. White pine and white spruce were able to rcover from heat injury by sending out epicormic shoots but the other species were inferior in this respect.

Shirley, H. L. 1943. **Is tolerance the capacity to endure shade?** Jour. Forestry 41: 339-345.

Reviews history of 90-year-old concept of tree tolerance and its many modifications. Includes an evaluation of the Lake States studies (1929-38) of seedling jack, red, and white pine, and white spruce that were exposed to various degrees of natural and artificial shade, drought, heat, root competition, and nutrient deficiencies. The author found that survival and rank in successional series depended primarily on shade tolerance, but that this was not necessarily related to the other environmental deficiencies.

Shirley, Hardy, L. 1945. **Reproduction of upland conifers in the Lake States as affected by root competition and light.** Amer. Midland Nat. 33: 537-612, illus.

Experiments on the reaction of jack pine, red pine, white pine, and white spruce to various light and moisture conditions in the nursery and under aspen and jack pine stands were followed by surveys of light conditions and natural reproduction in aspen, jack pine, and red pine stands. For all species tested, at least 20% but less than 43% light was necessary for satisfactory establishment and growth in the nursery. Either shade or root competition may be limiting factors in the growth of young conifers.

Tourney, J. W. 1919. **Relation of gray birch to white pine.** Jour. Forestry 17: 15-20.

Competition between birch and pine of about the same age was studied on a series of temporary plots on or adjacent to a sand plain near Keene, N. H. The birch was not dense enough to kill the pine, but pine height growth decreased with increasing density of the birch overstory. The principal competition was for soil moisture and nutrients rather than for light. White pine understories can be released by cutting birch for fuelwood as markets and rate of growth dictate.

Tourney, James W., and Earnest J. Neethling. 1924. **Insolation a factor in the natural regeneration of certain conifers.** Yale Univ. School Forestry Bul. 11. 63 pp.

Data from nine variously treated plots under full or partial sunlight indicate that nearly all first-year mortality of white pine, hemlock, and white spruce seedlings was caused by heat lesions formed at ground line by high soil temperature. This type of mortality took place even though the roots of the seedlings remained in the zone of available moisture.

Wood, O. M. 1932. **An example of white pine reproduction on burned lands in northeastern Pennsylvania.** Jour. Forestry 30: 838-845, illus.

From a group of 11 white pines that had survived logging and subsequent fires, study strips were run in the four cardinal directions. Amount of white pine reproduction was less at greater distances from the seed trees and was greatest on the east and north strips, least on the west strip (prevailing wind was from the southwest). Establishment of reproduction was greatest 7 to 9 years after the last fire and declined steadily since then.

Wyman, Donald. 1950. **Killing woody plants with chemicals.** Arnoldia 10: 70.

Several white pines 35 feet tall died within 3 weeks after poison ivy under them had been sprayed with ammate in early spring.

EDAPHIC RELATIONS

Adams, W. R. 1934. **Studies in tolerance of New England forest trees. XI. The influence of soil temperature on the germination and development of white pine seedlings.** Vt. Agr. Expt. Sta. Bul. 379, 18 pp., illus.

Report on a greenhouse study of white pine germination, survival, and first-year growth in sandy loam soils with ample moisture held at four constant soil temperatures (bracketing the natural range of soil temperature). Results are discussed in relation to white pine silviculture.

Aikman, J. M. 1945. **Response of pine seedlings to site selection on eroded soils.** Iowa Acad. Sci. Proc. 52: 77-82.

On Lindley loam soils eroded of all but 1 foot of the B horizon, white pine 5 years after planting showed better height growth but slower diameter growth and less crown volume than red pine.

Alway, F. J., Joseph Kittredge, and W. Methley. 1933. **Composition of the forest floor layers under different forest types on the same soil type.** Soil Sci. 36: 387-398.

Study on Star Island, Minn., showed in all forest types an increase in ash, lime, and nitrogen, and a decrease in acidity on passing from the litter, through the duff, to the leafmold. All values for material from the white pine stand were intermediate, but were closer to those of the other pines than to those of hardwoods. White and red pine leaves are similar in composition.

Alway, F. J., W. J. Methley, and O. R. Younge. 1933. **Distribution of volatile matter, lime, and nitrogen among litter, duff, and leaf mold under different forest types.** Soil Sci. 36: 399-407, illus.

By laboratory analysis of 25 representative 1-square-foot samples from each of four forest types (jack pine, red pine, white pine, and maple-basswood) on Starr Island, Minn., the distribution of dry matter and some of its fractions in pounds per acre between the L, F, and H organic layers, the upper 2.75 inches of mineral soil, and the undergrowth that occurred on the samples, was determined. The greatest weight of organic matter occurred under the white pine type as did the greatest weight of volatile matter.

Asahi, Masami. 1953. **An edaphological study on growth of white pine.** Tokyo Univ. Forests Bul. 45: 103-110, illus.

Studies in the Tokyo University Forest in Hokkaido led to the conclusion that the growth of white pine is affected by the properties of the deeper layers of soils as well as the upper layers because its roots penetrate deeply. Among soils of different physical properties, all except excessively clayey soil seem favorable for growth. Experiments with potted seedlings showed that 25% calcium saturation is the optimum and 80% the upper limit for growth.

Auten, John T. 1945. **Relative influence of sassafras, black locust, and pines upon old-field soils.** Jour. Forestry 43: 441-446.

Analysis of soil samples from natural stands of sassafras and black locust and from pine plantations indicates that these species are all useful in preparing old-field sites for native hardwoods. The pines have economic value themselves and can prepare the site for the eventual succession of native hardwoods on the temporarily deplated soils of the region.

Burns, George P. 1944. **Soil temperature as influenced by the density of white pine cover.** Vt. Agr. Expt. Sta. Bul. 513, 35 pp.

Records of average soil temperature over a 10-year period and detailed records for a sample year are presented for thinned and unthinned white pine stands and a station on bare ground. Temperatures are variable but show some unexpected relationships with forest cover; most of these can be explained in terms of season, depth of snowfall, and snow melt. It is emphasized that average temperatures are of little use when studying tree growth.

Chandler, Robert F., Jr. 1943. **Amount and mineral content of freshly fallen needle litter of some northeastern conifers.** Soil Sci. Soc. Amer. Proc. 8: 409-411.

Analysis of samples of eastern white pine litter from a plantation near Ithaca, N. Y., and a natural stand in the Adirondacks yielded nutrient contents of 0.60% Ca, about 0.19% Mg, 0.18% K, 0.06% P, and about 10.7% N. Annual white pine litter deposition was 2,700 pounds per acre and nutrient returned to the soil was (in pounds) about 16 Ca, 5 K, 2 P, and 29 N.

Craib, Ian J. 1929. **Some aspects of soil moisture in the forest.** Yale Univ. School Forestry Bul. 25, 62 pp., illus.

Compares moisture and related physical characteristics of soil supporting a white pine stand with those of an adjacent nonforested soil. Effect of trenching (cutting roots) on soil moisture under white pine stands is described.

Doak, K. D. 1934. **Cortical parasitism of conifer-seedling roots in pure culture by mycorrhizal and non-mycorrhizal fungi.** (Abs.) Phytopath. 24: 6-7.

A fungus resembling *Rhizoctonia silvestris* Melin formed the mantle and Hartig network characteristic of ectotrophic mycorrhizae on white pine and other conifers and also infected the cortex of mother roots. Two physiologic strains of *Armillaria mellea* grown with white pine infected the cortices of short roots and mother roots.

Doak, K. D. 1934. **Fungi that produce ectotrophic mycorrhizae of conifers.** (Abs.) Phytopath. 24: 7.

In pure-culture syntheses the following fungi gave typical ectotrophic mycorrhizae on white pine: *Boletus granulatus, Boletinus picitis, Canthorellus cibarius, Amanita muscaria, Russula lepida*, and *Scleroderma vulgare*. The mantle and Hartig' network characterizing this form was demonstrated histologically in each case.

Dosen, R. C., S. F. Peterson, and D. T. Pronin. 1950. **Effect of ground water on the growth of red pine and white pine in central Wisconsin.** Wis. Acad. Sci. Arts and Letters Trans. 40: 79-82, illus.

A site with an impoverished sandy soil on the edge of an artificial lake was planted with red and white pine. After 20 years the height of the trees growing where the water table was about 50 inches deep was more than double that where the water table was about 160 inches deep. The growth effect was due in part to the chemical composition of the ground water.

Ernst, Fritz. 1937. **Wirkungen der einzelnen Hilfspflanzen in den nordostbayerischen Krüppelbaständen.** Forstwiss. Centbl. 59: 50-66, 105-122, 177-192, 217-227, 291-299, illus.

Various trees and shrubs have been used to improve the soil and stand conditions in the scrubby pine forests of northeastern Bavaria. White pine seems to thrive best of all conifers on raw soils, but is shallow-rooted and does not improve the site for *P. silvestris*. Successful establishment of forest on these sites requires soil cultivation and introduction of soil-improving species.

Fisher, R. T. 1928. **Soil changes and silviculture on the Harvard Forest.** Ecology 9: 6-11, illus.

The profile of sandy loam soils under an 80-year-old white pine-hemlock stand and under an adjacent 18-year-old hardwood stand that had succeeded a similar softwood stand are described. Under the softwoods there was an accumulation of 3 inches of litter and mor humus over a ¾-inch leached horizon and ½-inch horizon of illuviation. Under the hardwoods there was ¼-inch of litter and mull humus over 3 inches of A horizon in which there was no leached horizon. This evidence of soil change, together with the strong natural succession to hardwoods, were the basis for recommending that mixed pine-hardwood stands be favored.

Fraser, Donald A. 1954. **Ecological studies of forest trees at Chalk River, Ontario, Canada. I. Tree species in relation to soil moisture sites.** Ecology 35: 406-414, illus.

Relationships between soil moisture and species distribution. White pine is primarily associated with the dry sites.

Garin, George Illichevsky. 1942. **Distribution of roots of certain tree species in two Connecticut soils.** Conn. Agr. Expt. Sta. Bul. 454, 167 pp., illus.

Results from a detailed study made in 7-year-old pure and mixed plantations on Merrimac loamy sand and Charlton fine sandy loam soils. White pine had the greatest number of roots of all sizes. There was a short, stubby tap root, with small roots forming a heavy mass around the root crown. Silvicultural implications are discussed.

Garstka, Walter Urban. 1932. **The calcium content of Connecticut forest litter.** Jour. Forestry 30: 396-405.

Study indicates a correlation between Connecticut forest associations in their trend toward the climax and the calcium content of their litter. Total calcium content increased with the advance of the forest types towards the climax (hemlock-hardwoods) up to the oak-hickory-hardwoods types, after which it showed a slight decrease.

Gast, P. R. 1937. **Contrasts between the soil profiles developed under pines and hardwoods.** Jour. Forestry 15: 11-16.

A brief review of literature and of studies at the Harvard Forest on the influence of land-use history and earthworm activity on the development of soil profiles.

Gast, P. R. 1937. **Studies on the development of conifers in raw humus. III. The growth of scots pine (*Pinus sylvestris* L.) seedlings in pot cultures of different soils under varied radiation intensities.** Statens Skogsförsöksanst. [Sweden] Meddel. 29: 587-682, illus.

Radiation, nitrogen nutrition, and potassium nutrition were varied simultaneously in pot cultures of white pine. Dry weights of the plants increased rapidly with increases in nitrogen concentration from 50 to 100 ppm. and much more slowly up to 250 ppm. The whole series of experiments reported show that the effect of nitrogen supply is always dominated by the level of radiation intensity.

Goldthwait, Lawrence, and Charles J. Lyon. 1937. **Secondary growth in white pine in relation to its water supply.** Ecology 18: 406-415.

In central New Hampshire and Vermont total precipitation absorbed by the soil during the season for secondary growth (normally May to July) is the dominant element in the complex of climatic factors affecting the width of annual rings.

Griffith, B. G., E. W. Hartwell, and T. E. Shaw. 1930. **The evolution of soils as affected by the old field white pine-mixed hardwood succession in central New England.** Harvard Forest Bul. 15, 82 pp., illus.

Data on profile development, organic matter and nitrogen content, buffer content, pH, texture, tilth, and fauna of the soil were collected in old-field white pine stands up to 80 years old, in succeeding hardwood stands up to 40 years old, and in a virgin forest area. It was concluded that in all major respects the quality of the soil for forest growth is deteriorated by old-field pine stands and is improved by second-growth hardwood stands.

Hatch, Alden B. 1936. **The role of mycorrhizae in afforestation.** Jour. Forestry 34: 22-29.

Growth of white pine seedlings in sandy prairie soil from Wyoming resulted in obvious starvation, but when these soils were inoculated with several mycorrhizal fungi there was a marked increase in absorption of nitrogen, potassium, and phosphorus.

Hatch, A. B. 1937. **The physical basis of mycotrophy in *Pinus*.** Black Rock Forest Bul. 6, 168 pp., illus.

Critical review of the literature and a series of experiments with white and other pines has led the author to conclude that the mycotrophic relationship in pine is a symbiotic one that increases the absorption of soil nutrients. The greater absorption capacity of mycorrhizal seedlings is caused by, and is proportional to, increases in the effective absorbing surface area of short roots. The magnitude of the surface area of short roots, and the relative importance of mycorrhizae in tree nutrition, is determined by the availability of soil nutrients.

Hatch, A. B., and C. Talbott Hatch. 1933. **Some hymenomycetes forming ectotrophic mycorrhizae with *Pinus strobus* L.** Arnold Arboretum Jour. 14: 324-334, illus.

In pure cultures with white pines, typical ectotrophic mycorrhizae were formed by 12 fungi. The mycorrhizal relationship of three of them was not previously known. Methods of study are described.

Hwang, Y. 1938. **Field experiments on nitrogenous decomposition and acidity changes in decaying forest litter.** Forstwiss. Centbl. 60: 661-676.

Experiments were made near Munich on the decomposition of litter of white and jack pines and of several hardwood species. In the pine litter there was an absolute increase in nitrogen after decomposition. Mobilization of nitrogen was much slower than in the hardwood litter. A correlation was found between the initial pH of the litter, the pH of the underlying soil, and that of the decomposed material. Pine litter had an acid buffer-effect except on a very acid soil, when a basic buffer-effect appeared. Mixture of hardwood with pine litter aided the decomposition of the latter.

Li, Tsi-Tung. 1926. **Soil temperature as influenced by forest cover.** Yale Univ. School Forestry Bul. 18, 92 pp., illus.

Influence of young and old white pine stands and grass stands on soil temperature at various depths was studied from July to October at Keene, N. H. Both forest and grass cover modified soil temperatures, particularly by reducing extreme daily fluctuations. Forest cover was more effective than grass but there was little difference in the effect of young and old forest. The effects were more evident in the upper layers of soil than in the lower layers.

Lunt, Herbert A. 1948. **Soil properties and tree growth. *In* The forest soils of Connecticut.** Conn. Agr. Expt. Sta. Bul. 523: 71-73.

A 1942 planting of white pine and Norway spruce at Windsor, Conn., had striking growth differences due to differences in soil texture. Merrimac loamy sand and Manchester sandy loam with more than average moisture were compared. By 1947 the pine had grown 17% more and the spruce 70% more in height on the loam than on the sand.

Lunt, Herbert A. 1951. **Effect of slash mulch and slash burn on pine and spruce plantings.** Conn. Agr. Expt. Sta. Bul. 548, 21 pp., illus.

Survival of white pine was unaffected by treatment but growth was increased about 13% in a 6-year period of application of white pine slash mulch. Burning the slash increased growth more. Soil analyses show that slash mulch increased the available potassium and total soluble salts and that burning of the slash increased it more. Presence of slash favored ammonification and slash burning increased phosphorus slightly.

Lunt, Herbert A. 1951. **Liming and twenty years of litter raking and burning under red (and white) pine.** Soil Sci. Soc. Amer. Proc. 15: 381-390, illus.

Parallel series of 1/40-acre plots in red pine and white pine plantations were used to compare the effect on soil properties and tree growth of annual litter raking, annual litter burning, and undisturbed litter -- with and without addition of lime. The white pine plots were destroyed after 9 years but showed some effects of treatment on soil pH and soil nitrogen.

Lutz, H. J. 1945. **Vegetation on a trenched plot twenty-one years after establishment.** Ecology 26: 200-202.

The white pine on the plot in 1930 (Toumey and Kienholz, 1931) was all gone in 1943, but the hemlock thrived and increased slightly in numbers. The conclusion: radiation was too low for the relatively shade-intolerant white pine but was favorable for the shade-tolerant hemlock. Thus, while the plot illustrates strikingly the importance of root competition, it illustrates with equal force the importance of solar radiation.

Lutz, Harold J., Joseph B. Ely, Jr., and Silas Little, Jr. 1937. **The influence of soil profile horizons on root distribution of white pine (*Pinus strobus* L.).** Yale Univ. School Forestry Bul. 44, 57 pp., illus.

Seventeen profiles of gray-brown podzolic soils under pure even-aged white pine stands 35-45 years old were examined. The concentration of roots in the upper horizons appears to result from a combination of factors: (1) greater content of fine soil material; (2) generally better physical conditions, particularly structure and consistency; (3) higher moisture equivalent values; (4) higher content of organic matter; (5) higher content of total nitrogen; and (6) higher total exchange capacity and higher content of exchangeable bases.

Lyford, W. H. 1941. **Mineral composition of freshly fallen white pine and red maple leaves.** N.H. Agr. Expt. Sta. Tech. Bul. 77, 12 pp.

Red maple and white pine leaves were collected from several sites on the same soil type (Gloucester sandy loam) and ash analyses were made. Percentage of ash averaged 6.21 and 2.62 respectively and it was shown that the ash of red maple, as compared with that of white pine, contains a larger proportion of silica and a smaller proportion of calcium.

Lyon, Charles J. 1949. **Secondary growth of white pine in bog and upland.** Ecology 30: 549-552.

White pines growing in a bog subject to rise and fall of water level in response to local rainfall and temperature showed the same sequence of narrow and wide rings during the years of unsuppressed growth as upland trees, probably because they had shallow root systems. For young and suppressed pine there is a negative correlation with upland trees, indicating a deep root system.

McComb, A. L., and John E. Griffith. 1946. **Growth stimulation and phosphorus absorption of mycorrhizal and non-mycorrhizal northern white pine and Douglas-fir seedlings in relation to fertilizer treatments.** Plant Physiol. 21: 11-17, illus.

Grown in Iowa on a sandy loam soil, 2-year-old seedlings of both species made satisfactory growth when the soil was inoculated with coniferous humus containing mycorrhizal fungi; on soil not inoculated but fertilized with phoshorus, only white pine made satisfactory growth. Good growth was associated with high phosphorus absorption.

Mitchell, Harold L. 1934. **Pot culture tests of forest soil-fertility with observations on the effect of varied solar radiation and nutrient supply on the growth and nitrogen content of Scots and white pine seedlings.** Black Rock Forest Bul. 5, 138 pp., illus.

White pine seedlings were tested in nutrient-sand cultures and in cultures of four forest soils — with nutrient supplements — to determine the influence of varied nitrogen supply on dry-weight increase, root-shoot ratio, and internal nitrogen concentration of seedlings grown in full sunlight with other nutrients at near optimum supply. In the nutrient-sand cultures, dry weight increase of seedlings — adjusted for size of seed — was greatest when the nitrogen supply was 300 ppm.

Mitchell, H. L. 1939. **The growth and nutrition of white pine (*Pinus strobus* L.) seedlings in cultures with varying nitrogen, phosphorus, potassium, and calcium, with observations on the relation of seed weight to seedling yield.** Black Rock Forest Bul. 9, 135 pp., illus.

A detailed report and discussion of a series of experiments in which cumulative solar radiation was controlled and the response of seedling (dry-weight increase adjusted for reserve dry-weight of the seed) to varying concentrations of N, P, K, and Ca in the nutrient solution was determined.

Mitchell, H. L., R. F. Finn, and R. O. Rosendahl. 1937. **The relation between mycorrhizae and the growth and nutrient absorption of coniferous seedlings in nursery beds.** Black Rock Forest Papers 1 (10): 58-73.

The beneficial influence of ectotropic mycorrhizae on the growth of red spruce and white pine seedlings is inversely proportional to the mineral nutrition of the soil. In the most fertile soils mycorrhizae have no influence, but in very infertile soils seedlings cannot exist without them.

Mogren, E. W. 1954. **Comparison of growth rate of three species of pine on two soil classes on the Lake Vadnais plantation, Minnesota.** Jour. Forestry 52: 359-360.

Growth of the three native pines on two different soil types was compared. The sites were thought to be similar except for difference in soil texture. Growth was better on the Milaca and Bradford fine sandy loam than on the relatively sterile dry Zimmerman loamy fine sand. The growth differences were all significant.

Moore, Barrington. 1926. **Influence of certain soil and light conditions on the establishment of reproduction in northeastern conifers.** Ecology 7: 191-220, illus.

Report on a study on Mt. Desert Island, Maine, of the influence of humus versus mineral soil, and of shade under a forest canopy versus light in small openings, on the germination and survival of red spruce, white pine, red pine, and white spruce. White pine germination was fair on mineral soil in the open but there was no survival after 2 years.

Plice, Max J. 1934. **Acidity, antacid buffering, and nutrient content of forest litter in relation to humus and soil.** Cornell Univ. Agr. Expt. Sta. Mem. 166, 32 pp., illus.

Part I of this report gives, for the fresh leaf litter of white pine and other common northeastern tree species, the content of lime and other principal bases, antacid buffering, acidity, and total nitrogen content. In Part II studies of the same type on humus and soil under different forest types (one of them white pine) are reported. White pine seems to be intermediate between hemlock and most hardwoods in its effect on humus and soil.

Scott, David R. M. 1952. **Growth of hybrid aspen in pot cultures of the litter of forest plants.** Jour. Forestry 50: 107-108.

Nine types of litter, of which one was white pine litter, were analyzed spectroscopically for elements of known nutritional value (except nitrogen). There appeared to be little correlation between the nutrient content of the litter and the growth of hybrid aspen.

Shear, G. M., and W. D. Stewart. 1934. **Moisture and pH studies of the soil under forest trees.** Ecology 15: 145-153, refs.

Five stations were established, one under each of five species in pure stands. Periodic samples for soil moisture were taken at 1-foot intervals to depths of 7 to 10 feet. Moisture equivalent, wilting coefficient, and pH were determined for each depth; and the depth of the water table was recorded. Comparison of these records showed no period of increased water consumption by white pine.

Thomas, W. D. 1941. **The mycorrhizal fungi and mycorrhizae of four coniferous plantations in the Rhine Valley.** Phytopath. 31: 567-569.

Mycorrhizae were studied on four 1-hectare plots in the Black Forest. Hymenomycetes and mycorrhizae were numerous on only one plot and only on this plot did the white pine and other planted conifers appear healthy or give promise of high yields. On the other three plots the trees showed signs of nitrogen starvation.

Toumey, J. W. 1929. **The vegetation of the forest floor: light versus soil moisture.** Internatl. Cong. Plant Sci. Proc. 1: 575-590, illus.

Effects of light and soil moisture on the germination, survival, and growth of white pine and hemlock seedlings and other vegetation were studied on a series of trenched plots. Litter was removed from parts of some plots. It was concluded that, even at very low light intensities, soil moisture was the limiting factor in the germination and growth of tree seedlings. Heavy litter impeded germination and leaf fall under dense stands smothered most of the young plants.

Toumey, James W., and Raymond Kienholz. 1931. **Trenched plots under forest canopies.** Yale Univ. School Forestry Bul. 30, 31 pp., illus.

In trenched and untrenched plots established under a white pine stand in 1922 a distinct succession of vegetation occurred as illustrated by the increasing abundance, density, and number of species and the gradual change from complete dominance by herbs to increasing dominance by woody species. White pine and hemlock seedlings were present on the trenched plot from the beginning, and they maintained the same abundance throughout the period. There were twice as many pines as hemlocks but the hemlocks grew faster.

Tryon, E. H. 1948. **Effect of charcoal on certain physical, chemical, and biological properties of forest soils.** Ecol. Monog. 18: 81-115, illus.

Crocks of soil and charcoal mixtures were set in a greenhouse and sown with white pine seed. Two soils and two kinds, two sizes, and three rates of charcoal application were involved. Germination of white pine was reduced by charcoal, the extent depending on its size and rate of application. Weight of seedlings was little affected, but height was reduced, the extent depending on the size of the charcoal. Effects on damping-off, mycorrhizae, and physical and chemical soil properties are discussed.

Wherry, E. T. 1922. **Soil acidity preferences of some eastern conifers.** Jour. Forestry 20: 488-496.

The local distribution of 23 species with respect to soil acidity was studied at widely scattered points. White pine was studied from North Carolina to New York. It does not appear to colonize soils of high acidity or rich, black alkaline soils of calcarious regions. It is most abundant in typically intermediate habitats, though it is also found on limestone ledges.

PLANT SOCIOLOGY : COVER TYPES

Alway, F. J., and P. R. McMiller. 1933. **Interrelationship of soil and forest cover on Star Island, Minn.** Soil Sci. 36: 281-294.

Jack pine, Norway pine, white pine, and maple-basswood forest types are found on these sandy soils in practically virgin condition. The soil was examined to a depth of 7 to 12 feet at 40 places where the surface is 15 to 46 feet above the lake surface and only coarse-textured soil was found. Describes characteristics of soil profile, organic and acid content of soil, and the forest floor.

Ashe, W. W. 1922. **Forest types of the Appalachian and White Mountains.** Jour. Elisha J. Mitchell Sci. Soc. 37: 183-198.

A white pine type with three site qualities is recognized in the Appalachians. The type occurs on drained alluvial soils and in valleys within the Alleghenian area of the Transition Life Zone. Listed among the xerophytic associations, the type is briefly described as pure but grading at places into hemlock and chestnut-white oak. It is localized in area, being best developed between altitudes of 500-2,000 feet in Pennsylvania, and 3,000-4,000 feet in Tennessee and North Carolina.

Ayres, H. B., and W. W. Ashe. 1905. **The southern Appalachian forests.** U.S. Geol. Survey Prof. Paper 37, 291 pp.

White pine, an important timber tree throughout the southern Appalachians, is most abundant on northwest slopes between elevations of 1,700 and 4,000 feet. Size, distribution, associates, sites, growing conditions, and uses are discussed. Includes a tabulation of some height and diameter measurements at various ages. Volume of standing timber (by species) is tabulated in board-feet for each of the major drainages.

Baldwin, H. I. 1951. **A remnant of old white pine-hemlock forest in New Hampshire.** Ecology 32: 750-752.

A ¼-acre plot was measured and described in a stand of 150-to-200-year-old trees near Bradford, N. H. The main stand contained an average of 360 trees per acre, 64 of which were white pines with an average diameter of 30 inches. The white pines contained 60% of the total stand volume (115,000 board feet).

Ball, J. Curtis. 1949. **Association of white pine with other forest tree species and *ribes* in the southern Appalachians.** Jour. Forestry 47: 285-291.

White pine is gradually establishing itself on a wide variety of sites both at low and high elevations. The optimum range is between 1,200 and 3,500 feet. White pine reproduces readily and competes favorably with the associated species. Fourteen years of fire protection and blister rust control have materially aided the establishment of white pine.

Bergman, H. F. 1924. **The composition of climax plant formations in Minnesota.** Mich. Acad. Sci. Arts and Letters Papers 3: 51-60.

Analyzes the composition of the three climax associations: pine forest, deciduous forest, and prairie. The numbers of trees by species and diameter classes and the character of the secondary vegetation on nine quadrats in uncut and seven quadrats in lightly-cut pine forest are the basis for the conclusions. White pine and red pine are the climax dominants, more numerous and larger than the associated fir, birch, spruce, and poplar.

Braun, E. Lucy. 1950. **Deciduous forests of eastern North America.** 596 pp., illus. Philadelphia.

Describes the present forest cover and the climax conditions for each of nine forest regions. In the hemlock-white pine-northern hardwoods region, the forest formation in each of the seven physiographic sections recognized is discussed separately.

Bromley, Stanley W. 1935. **The original forest types of southern New England.** Ecol. Monog. 5: 63-89, illus.

Describes the pre-colonial forest in each of the three forest regions of southern New England, primarily from interpretation of early records. In its region, white pine dominated the forest by its size and age rather than by its numbers. The species maintained this position over a long period because of its adaptation to dry sites and its ability to compete well on better sites in openings created by fire or windthrow.

Brown, R. T., and J. T. Curtis. 1952. **The upland conifer-hardwood forests of northern Wisconsin.** Ecol. Monog. 22: 217-234.

Analysis of 116 stands showed great variation in composition as expressed by the two to four leading dominants. However, it was found that all the stands were part of a continuum of one great community complex and could be arranged along an environmental gradient from xeric pioneer conditions to mesic climax conditions. The stands in less than pioneer condition were dominated by red pine and white pine, those in intermediate condition by white pine, red oak, and red maple.

Cain, Stanley A. 1940. **The identification of species in fossil pollen of *Pinus* by size-frequency determinations.** Amer. Jour. Bot. 27: 301-308.

The size-frequency curve method for pollen analysis is described. Pollen dimensions for white pine and 11 other pine species are given.

Cain, Stanley A., Louise G. Cain, and George Thomson. 1951. **Fossil pine pollen size-frequencies in Heart Lake sediments, Oakland County, Michigan.** Amer. Jour. Bot. 38: 724-731, illus.

Size-frequency analyses were made of fossil pine pollens at depths of 13 to 21 feet in the sediments, and of modern pollens of pines native to the area. There was sufficient agreement to show that the fossil pollens were from the same species. Studies strongly indicate that during the spruce-fir and pine periods jack and red pine were important elements of the vegetation, and white pine may have been present. During the period of hardwood dominance atfer the pine period was over, white pine became an important element.

Cline, A. C., and S. H. Spurr. 1942. **The virgin upland forest of central New England.** Harvard Forest Bul. 21, 58 pp., illus.

In an examination of 68 remnants of the virgin forest, 7 distinct forest types were found as well as numerous minor variations. Nearly all the important differences can be explained in terms of elevation and aspect of the stands and dates and severity of fire, wind, and other destructive forces. The climatic climax occurs on lower slopes and consists of hemlock, beech, sugar maple, and black birch. The ridge top physiographic climax is a hemlock-white pine association with beech, black birch and red maple as minor elements.

Coker, W. C., and H. R. Totten. 1932. **Notes on extended ranges of plants in North Carolina.** Jour. Elisha J. Mitchell Sci. Soc. 48: 138-140.

Brief note on white pine occurrence in Davie County and the southern edge of Chatham County. One tree in 1921 measured 61 inches in circumference 3 feet above the ground, and small trees and seedlings were plentiful.

Colvin, Walter S., and Walter S. Eisenmenger. 1943. **Relationships of natural vegetation to the water-holding capacity of the soils of New England.** Soil Sci. 55: 433-446, illus.

A study of the relationship between natural vegetation and the water-holding capacity of the soil indicated that certain trees, shrubs and herbs grow in greatest abundance on soils of particular water-holding ranges while many other species, including gray birch, hemlock, red maple, red cedar, and white pine, grow on soils varying widely in their moisture-retaining properties.

Cook, H. O. 1931. **Original forests of Cape Cod.** Jour. Forestry 29: 422-423.

After 300 years of occupancy by the white man, the forests of Cape Cod are composed primarily of the fire-resistant species: pitch pine, bear oak, white oak, and scarlet and black oak. Early records tell little of the original forest except that white pine was once abundant. Two small islands near the mainland that have been protected from fire give evidence of the original forest type. These islands now support stands of white pine, hemlock, beech, soft maple, birch, red oak, and some subsidiary species.

Cooper, William S. 1913. **The climax forest of Isle Royale, Lake Superior, and its development.** Bot. Gaz. 55: 1-44, 115-140, 189-235, illus.

Describes the dominant forest, which is equated with the climax for the island. Traces the plant succession from bare rock to climax and emphasizes the importance of windfall in the dynamics of the forest. White spruce and white pine occur very sparsely on the island, and then as individuals towering over the present forest. Reproduction is sparse or lacking. Neither species is important in the climax forest.

Corson, C. W., J. H. Allison, and E. G. Cheyney. 1929. **Factors controlling forest types on the Cloquet Forest, Minnesota.** Ecology 10: 112-125.

Experiments at the Cloquet station failed to develop a satisfactory method of determining forest types on the basis of topography, air temperatures, soil temperatures, humidity, or evaporation. Classification on the basis of the moisture equivalent of the soil seemed to check fairly well with virgin and second-growth stands, but the method is cumbersome and requires technical skill and expensive apparatus.

Dansereau, Pierre. 1953. **The post-glacial pine period.** Roy. Soc. Canada Trans. Ser. 3 Sec. 5, 47: 23-38, illus.

The consistent post-glacial period of dominance by pine in the vegetation of eastern North America is considered in the light of climatic periods and alternation of periods under two hypotheses: requirements of the species for growth and survival (1) unchanged, (2) changed during the period. Questions are raised concerning ecological interpretations of this period.

Donahue, William H. 1954. **Some plant communities in the Anthracite Region of northeastern Pennsylvania.** Amer. Midland Nat. 51: 203-231, illus.

A quantitative ecological analysis was made of nine forest and two shrub communities in Luzerne County. Such characteristics as species composition, density, frequency, basal area, shrub and herbaceous strata, and soil profiles were studied in each stand. Two communities were representative of the oak-chestnut forest region — scrub oak and white oak-red maple. In the latter, white pine was present. In all communities where white pine was in a subdominant position it showed promise of becoming a dominant element in the stand.

Egler, F. E. 1940. **Berkshire plateau vegetation, Massachusetts.** Ecol. Monog. 10: 145-192.

White pine is found at intermediate elevations (Bray's vegetation zone C). It is mixed with sugar maple, beech, yellow birch, and hemlock. Within this zone the old fields are dominated by gray birch and white pine with about 50 secondary species.

Friesner, Ray C., and J. E. Potzger. 1934. **Climax conditions and ecological status of *Pinus strobus*, *Taxus canadensis*, and *Tsuga canadensis* in the Pine Hills Region of Indiana.** Butler Univ. Bot. Studies 3: 65-83, illus.

Eastern white pine characteristically occurs as an upper fringe species in the belt transitional between the *Tsuga* and deciduous hardwoods of the upland plateaus. It and eastern hemlock are considered relict species of a former climatic climax, both having at one time been climatic dominants, but as the climate changed in post-glacial time they gave way to maple and beech, the present climatic dominants.

Friesner, Ray C., and John E. Potzger. 1936. **Soil moisture and the nature of the *Tsuga* and *Tsuga-Pinus* forest associations in Indiana.** Butler Univ. Bot. Studies 3: 207-209.

Figures of total soil moisture less wilting coefficients at several depths are shown for soils under the associations in question (seedling and mature) and under mature *Fagus-Acer* associations. The fact that available soil moisture is least in the *Tsuga* and *Tsuga-Pinus* associations is interpreted to mean that these associations are preclimax relicts in Indiana rather than normal constituents of the present climax associations.

Goodlet, John C. 1954. **Vegetation adjacent to the border of the Wisconsin drift in Potter County, Pa.** Harvard Forest Bul. 25: 93 pp., illus.

The study, though primarily of the relation of the drift border to present vegetation, considers the peculiar status of white pine in the county. Before the heavy logging of 1860 to 1900, white pine was abundant. Now it is virtually nonexistent. Present lack of pine results from the removal of the seed source by logging, the unfavorable seedbeds, and the widespread fires that followed logging.

Graham, Samuel A. 1941. **Climax forests of the Upper Peninsula of Michigan.** Ecology 22: 355-362, illus.

Although composed largely of climax species, the mixed hardwood-hemlock forests are not yet in the climatic climax state. It is questionable if that hypothetical state can be reached except occasionally, and for a short time, because of fire, biotic, and climate catastrophies.

Grant, Martin L. 1934. **The climax forest community in Itasca County, Minnesota, and its bearing upon the successional status of the pine community.** Ecology 15: 243-257.

The climax plant community of the county is the balsam fir-basswood association, largely restricted to the heavy clay soils of the gray drift. On the sandy red drift there is an edaphic climax of Norway and white or jack pines, and on peat soils an apparently stable subclimax swamp forest of black spruce and tamarack or white-cedar.

Grayson, John F. 1954. **Evidence of four pine species from fossil pollen in Michigan.** Ecology 35: 327-331, illus.

A size-frequency study of fossil pollen at three depths in the sediments of a pond in Livingston County strongly indicates the presence of jack, red, and white pine there during the pine period. The presence of a fourth pine species at the end of the pine period is also indicated. This may have been shortleaf pine.

Halliday, W. E. D. 1937. **A forest classification for Canada.** Canada Forest Serv. Bul. 89. 50 pp., illus.

Describes the division of Canadian forests into eight regions. For the Great Lakes-St. Lawrence Region, the indicator species are white pine, hemlock, red pine, and yellow birch, sugar maple, red maple, and beech. This is the most complex of the regions because of transitional elements, the history of early settlement, and the relatively wide range of climatic conditions covered. White pine probably reached its maximum development in the Algonquin-Laurentides Section.

Halliday, W. E. D. 1950. **Climate, soils, and forest of Canada.** Forestry Chron. 26: 287-301.

Reviews the climate, geology, and soils of Canada and their relations to forest vegetation, which is the basis for classification into eight distinctive forest regions. The Great Lakes-St. Lawrence Region (see Halliday, 1937) is characterized by extensive stands of white and red pine, although sugar maple is also abundant. Pines and hemlock are the climax species of the region, but they can only share this dominant position with certain hardwoods common to the deciduous forest to the south — the maples, yellow birch, and possibly beech.

Harvey, LeRoy H. 1919. **Some phytogeographical observations in Lake County, Michigan.** Mich. Acad. Sci. Rpt.: 213-217.

The white pine type is considered as an edaphic climax. The traditional climatic climax theory is not sufficient to explain the vegetation complex, as the case of white pine shows.

Harvey, LeRoy H. 1922. **Yellow-white pine formation at Little Manistee, Michigan.** Bot. Gaz. 73: 26-43, illus.

Suggests that the area had been possessed for centuries by a stable pine formation. The few veterans in the stands studied were part of that formation and survived a catastrophe some 200 years earlier. Since that time the original formation has been under gradual replacement with another of the same kind. (Early surveyors and some North Woods lumbermen recorded *Pinus resinosa* as "hard pine" or "yellow pine" about 1800).

Hawley, Ralph C. 1933. **Does northern white pine form a climax type?** Jour. Forestry 31: 866-868.

Detwiler's (1933) interpretation of the ecological position of white pine is disputed. The northern white pine type is not the climax type over any considerable area. It is shown that several authors were quoted out of context to support contrary views. However, the ideas and conclusions of Detwiler regarding the intensive management and protection from blister rust are supported.

Heimburger, Carl C. 1934. **Forest-type studies in the Adirondack region.** Cornell Agr. Expt. Sta. Mem. 165, 122 pp., illus.

The forest lands of the Adirondack Region are classified into biologically equivalent sites on the basis of ground vegetation. The importance of physiographic features is recognized and the 22 types described are grouped into three series that correspond to climatic areas with different floristic provinces. White pine occurs in at least 14 of the vegetation types and is an important element in 9 of them — those that occur on the drier and poorer soils.

Hough, A. F. 1943. **Soil factors and stand history in a virgin forest valley on the northern Allegheny Plateau.** Soil Sci. 56: 19-28, illus.

Studies of stand history and soil characteristics were made in a hemlock-beech, beech-maple, and white pine-hemlock virgin forest in northwestern Pennsylvania. The author concludes that climatic and biotic factors are as important in creating these forest associations as are soil characterisics. However, soil characteristics, especially of the humus horizon, were related to the successional stage of the major forest associations.

Hough, A. F., and R. D. Forbes. 1943. **The ecology and silvics of forests in the high plateaus of Pennsylvania.** Ecol. Monog. 13: 299-320.

In this region there are three major and generally distinct forest associations in the virgin forest: white pine-hemlock, hemlock-beech, and beech-maple. The first is a sub-climax type originating from fire, windthrow, or other catastrophies. Major associates were chestnut, red maple, and oaks. The white pine types, being sub-climax, are especially impermanent and difficult to manage in perpetuity. They occur most frequently on south and west slopes.

Kittredge, Joseph Jr. 1934. **Evidence of the rate of forest succession on Star Island, Minnesota.** Ecology 15: 24-35.

These forests afford excellent examples of the four stages in the succession from jack pine to Norway pine to white pine to sugar maple-basswood. The evidence of the transition between each two stages is exceptionally complete and leaves no doubt that the entire succession would be consummated in a sufficient period of time. The minimum periods of occupation are: jack pine, 100 years; Norway pine, 300 years; white pine, 250 years; a total of at least 650 years before the climax would become dominant.

Lindsey, Alva J. 1932. **Preliminary fossil pollen analysis of the Merrillville, Indiana, white pine bog.** Butler Univ. Bot. Studies 2: 179-182, illus.

The bog consists of three general strata: peat, water, and mud. Pine pollen was found in the top of the mud stratum but mostly in the peat. The order of post-glacial succession in this bog area has been Abies-Picea, Picea-Pinus, and Pinus-other genera.

Lindsey, Alva J. 1932. **The Merrillville white pine bog, Lake County, Indiana.** Butler Univ. Bot. Studies 2: 167-178.

The bog is about 40 acres in size and is filled with about 25 feet of peat. A pure white pine stand — the only one in Indiana — occupies about 9 acres in the center of the bog. The bog has not yet reached its climax stage, as attested by the lack of pine seedlings and the presence of oak seedlings. The white pine has neither the density nor the coverage that would be expected of the dominant tree.

Livingston, Burton Edward. 1905. **The relation of soils to natural vegetation in Roscommon and Crawford Counties, Michigan.** Bot. Gaz. 39: 22-41, illus.

Describes the white pine type, one of seven vegetation types in the area. This type occurs on the uplands, specifically on clay hills, moraines, gravelly ridges, and often at swamp margins. It is concluded that soil texture is the main factor determining the distribution of forest types in this area. Of second importance, only because of its limited occurrence, is the nearness of ground water to the soil surface.

Lutz, H. J. 1930. **Original forest composition in northwestern Pennsylvania as indicated by early land survey notes.** Jour. Forestry 28: 1098-1103.

Land-survey notes made in 1814-15 contained nearly 6,000 references to some 32 tree species. Abundance and frequency values calculated indicate that, as a whole, the original forest was composed chiefly of beech, hemlock, maple, birch, white pine, and chestnut. These species made up over 88% of the stand, of which nearly 6% was white pine. The composition was not greatly different from that at Heart's Content.

Lutz, H. J. 1930. **The vegetation of Heart's Content, a virgin forest in northwestern Pennsylvania.** Ecology 11: 1-29.

In this remnant of the original forest of the Allegheny Mountains in northwestern Pennsylvania, two forest communities were recognized: hemlock-beech association covering about 75% of the area and a hemlock consociation covering the remaining 25%. The principal tree species in the first, in their order of abundance, were hemlock, beech, white pine, red maple, chestnut, and black birch. In the second they were hemlock, white pine, yellow birch, and beech. White pine appears to be dying out in both of these communities; reproduction of the species is practically absent.

Lutz, H. J. 1934. **Additions to the flora of Heart's Content, a virgin forest in Northwestern Pennsylvania.** Ecology 15: 295-297.
About 60 plant species are added to those given by Lutz above.

Lutz, H. J., and A. L. McComb. 1935. **Origin of white pine in virgin forest stands in northwestern Pennsylvania as indicated by stem and basal branch features.** Ecology 16: 252-256.
The pine at Heart's Content is not even-aged as previously thought; but neither is it all-aged because no pines are younger than 175 years. The stand originated under a partial canopy of hardwoods and hemlock and there were only about seven trees per acre. At Ludlow the stand originated under open conditions and came in pure and even-aged as can be read from the features.

McIntosh, R. P. 1951. **Pine stands in southwestern Wisconsin.** Wis. Acad. Sci. Arts and Letters Trans. 40: 243-257, illus.
A study of the flora and site factors of many areas of southwestern Wisconsin and adjacent northwestern Illinois where white pine trees are a conspicuous element of vegetation suggests that these are relict stands of the general southward extension of the northern coniferous forest in glacial times. The trend toward eventual extinction continues.

Maissurow, D. K. 1941. **The role of fire in the perpetuation of virgin forests of northern Wisconsin.** Jour. Forestry 39: 201-207.
Comparative studies were made of the species composition of reproduction, crown classes, and age structure in virgin forest and rehabilitating burns in and around the Nicolet National Forest. Life history of the virgin forest was interpreted. Forest fires in the last five centuries have not been great catastrophies, but periodic and normal ecological events.

Morey, H. F. 1936. **A comparison of two virgin forests in northwestern Pennsylvania.** Ecology 17: 43-55, illus.
Compares the composition and development of Cook Forest and Heart's Content, two virgin forests in northwestern Pennsylvania. Ninety-three species were common to both forests — 91 in Heart's Content alone, and 57 in Cook Forest alone. Heart's Content had a much lower percentage of white pine, a smaller number of trees per acre, and a smaller basal area per acre. There is evidence in both forests that the key species of white pine, oak, and chestnut are being replaced by hemlock and members of the maple-beech association.

Nichols, G. E. 1935. **The hemlock-white pine-northern hardwood region of eastern North America.** Ecology 16: 403-422.
The region centers around the Great Lakes and the St. Lawrence Basin between the northern conifer region and the southern deciduous forest region. The common species are placed in four groups according to their ranges. Through most of its range, white pine is a normal but minor part of the climatic climax, occurring in mixed stands with hemlock and hardwoods.

Potzger, J. E. 1942. **The lake forest of northern Wisconsin and upper Michigan: a phytosociological study.** (Abs.) Ind. Acad. Sci. Proc 51: 75.
A study was made of 11 forest stands, 9 of hardwoods and 2 of pine. Red pine is more prominent on dry sandy uplands and white pine on moist sites. Red maple constitutes the second-layer tree stratum in the red pine type and balsam fir in the white pine type.

Potzger, J. E. 1946. **Phytosociology of the primeval forest in central northern Wisconsin and a brief postglacial history of the lake forest formation.** Ecol. Monog. 16: 211-250.

A lengthy discussion of existing forest formations and their probable origins. Based on phytosociological survey of 2 pine and 8 hardwood stands and on 25 pollen profiles. Concludes that pine is an edaphic climax in the lake forest but once covered a wide belt east to New Jersey and south to Texas. An extensive literature review.

Potzger, J. E. 1953. **History of forests in the Quetico-Superior country from fossil pollen studies.** Jour. Forestry 51: 560-565.

Analysis in 15 bogs shows an initial forest cover of spruce-fir or spruce-fir-pine. A long period of pine domination followed, during which no doubt a succession from jack pine to white-red pine occurred. Five major or minor successions and perhaps the same number of changes in climate stand out prominently. Indications are that pine is no longer a climatic climax but represents an edaphic or microclimatic climax determined by sandy soil.

Potzger, John E., and Ray C. Friesner. 1948. **Forests of the past along the coast of southern Maine.** Butler Univ. Bot. Studies 8: 178-190, illus.

Pollen analyses of six bogs between Mt. Desert Island and West Rockport indicate the following forest succession: spruce-jack pine to white pine (red pine), to white pine-birch-oak to white pine-hemlock-birch (with hemlock and birch alternating in representation), to a mixed coniferous-broadleaved forest complex of spruce, pine, hemlock, birch, oak, and beech. The results are discussed in relation to climatic changes.

Raup, Hugh M., and Reynold E. Carlson. 1941. **The history of land use in the Harvard Forest.** Harvard Forest Bul. 20, 64 pp., illus.

Early descriptions of timber and early records of land tenure and use show that the pre-colonial forests in Petersham were similar in composition and general topographic arrangement to the old forest types still remaining on certain tracts in the Harvard Forest. The complex mosaic of present forest types can be much simplified if they are related, through a time dimension, to the original arrangement of forest types as expressed by these relict woodlands.

Recknagel, A. B. 1942. **The cathedral pines.** Jour. Forestry 40: 344-345.

This virgin remnant in northwestern Connecticut consists of white pine and hemlock. Measured on a ¼-acre plot were 23 white pines 17 to 34 inches d.b.h., 4 to 5 logs high; and 26 hemlocks 6 to 24 inches d.b.h., 3 logs high. There was very little ground cover or reproduction of any sort.

Society of American Foresters. 1954. **Forest cover types of North America (exclusive of Mexico).** 68 pp. Soc. Amer. Foresters.

In the Northern Forest Region, three forest-cover types are recognized in which white pine is a major component: white pine-northern red oak-white ash, white pine, and white pine-hemlock. All are typically found on fresh to moist sites. White pine is listed as associate species in many other cover types. In the Central Forest Region, a white pine-chestnut oak type on dry sites is listed. For each cover type the definition and composition, nature and occurrence, and transition forms and variants are given.

Society of American Foresters, New England Section. 1922. **Forest region and type classification for New England.** Jour. Forestry 20: 122-129, 795-798.

Three forest regions are recognized in New England. The central New England or white pine region, a transition belt between the hardwoods of northern and southern New England, is characterized by white pine and a wide variety of hardwoods. The forest types occurring in these regions are described by composition, origin, location, and importance.

Stallard, Harvey. 1929. **Secondary succession in the climax forest formations of northern Minnesota.** Ecology 10: 476-547.

In a detailed study of the forests of northern Minnesota, a pine-hemlock climax represented chiefly by red and white pine, and a beech-maple climax were recognized. A number of secondary successions leading to these climaxes are described and their site associations are discussed. White pine consociations succeed aspen-birch, aspen-tamarack, oak, and probably tamarack-spruce. The role of fire is discussed and reasons for the dominance of pine are suggested.

Stearns, Forest. 1950. **The composition of a remnant of white pine forest in the Lake States.** Ecology 31: 290-291.

The dominant stand consisted of a few old white pines up to 40 inches in diameter and thought to be 390 years old. The second story was white pine, hemlock, and paper birch, 160-175 years old. The understory, 1 to 8 inches in diameter, was mostly hemlock, the rest sugar maple. Small reproduction was sparse — mostly sugar maple with occasional white pine and hemlock.

Transeau, Edgar N. 1905. **Forest centers of eastern America.** Amer. Nat. 39: 875-889, illus.

Four great forest formations are recognized by the author. Each formation is made up of many societies bearing a definite successional relationship to one another. It was found that if the ratios of rainfall to evaporation were plotted on a map, they would show climatic centers that correspond well with centers of plant distribution. The northeastern conifer region, centering in the St. Lawrence Basin, has white pine as one of its major components.

Veatch, J. O. 1928. **Reconstruction of forest cover based on soil maps.** Mich. Agr. Expt. Sta. Quart. Bul. 10: 116-126, illus.

From notes on forest distribution collected during several years of soils mapping in Michigan, the author offers examples of maps showing the original forest distribution and the observed relations between soils and vegetation. White pine is shown to be a major component of the original forest types on two soil-type groups, of which the Grayling and Roselawn soil series are prominent members.

White Pine Forest Association. 1912. **The white pine forest of Ogle County, Ill.** 18 pp., illus. White Pine Forest Assoc., Oregon, Ill.

Description of the 500-acre tract that contains the only natural white pine forest in Illinois. Although there is strong competition from a wide variety of hardwoods, the pine is reproducing itself here.

Silviculture and Management

FINANCIAL ASPECTS : CASE HISTORIES

Bryant, R. C. 1917. **Silviculture at Axton and in the Adirondacks generally.** Jour. Forestry 15: 891-895.

Between 1898 and 1903 Fernow cleared and burned old-growth hardwoods and planted Scotch, red and white pine, and Norway spruce. Although they have been unmanaged since planting, the plantations have grown well and are successful. Recommends that white pine and Norway spruce be planted on the better soils and that Scotch pine and red pine be planted on the poorer ones.

Cline, A. C. 1931. **The William H. Walker Forest and wood-using industry.** Jour. Forestry 29: 611-612.

A brief account of how the forest and the wood-working plant (all since inundated by the Swift River reservoir) were built up together as a profitable sustained-yield unit.

Cline, A. C., and C. R. Lockard. 1925. **Mixed white pine and hardwood.** Harvard Forest Bul. 8, 67 pp.

Traces the history of the white pine woodlot and presents a study of competition in natural pine-hardwood stands. It is evident that white pine will not maintain itself in pure stands on most sites in central New England and that past cutting has resulted in a continual degradation of the stands with poorer and poorer hardwoods. It is suggested that the best composition in this region is 50 percent white pine in groups and 50 percent better hardwoods, including red oak, white ash, basswood, and birch. The advantages of the mixed pine-hardwood stand over pure pine are set forth and compared economically.

Cromie, George A. 1938. **Shaker Pines Forest.** Jour. Forestry 36: 77-78.

The property consists of 290 acres of which 60 acres are covered with a red and white pine stand that originated from a broadcast sowing of mixed pine and buckwheat seed beginning in 1871. A corporation formed by leading conservationists had purchased the property to hold and manage. It was planned to establish a demonstration of good practical forestry and to prove, if possible, that such a tract can be managed on a sustained-yield basis.

Dana, Samuel T. 1930. **White pine region.** ***In*** **Timber growing and Logging practices in the Northeast.** U.S. Dept. Agr. Bul. 166: 55-79, illus.

Previously published material is organized into a helpful guide to the management of the principal forest types—white pine, transition hardwoods, and gray birch. Regeneration, methods of cutting, clearings and thinnings, slash disposal, protection, and yields are discussed. Material on fire protection, planting, logging, forest areas, and utilization for the Northeast as a whole is given elsewhere in the bulletin.

Eyre, F. H., and P. J. Zehngraff. 1948. **Red pine management in Minnesota.** U.S. Dept. Agr. Dept. Cir. 778, 70 pp., illus.

Throughout this bulletin there is information on white pine old growth, reproduction, ecology, and management in the white and red pine forests of Minnesota.

Federal Reserve Bank of Boston. 1953. **Here's convincing evidence that good forest management pays.** New England Farm Finance News 8 (1): 1.

A brief history of a 50-acre white pine lot in Barnet, Vt., that has been under continuous management since 1914. Originally it contained about 600,000 board feet; now it contains 800,000 board feet. During the period, 575,000 board feet have been harvested, 175,000 in an initial thinning and most of the rest since 1940.

Ferree, Miles J. 1952. **Report presented at the 1952 summer meeting of the New York Section, Society of American Foresters.** N.Y. State Univ. Coll. Forestry, 6 pp.

Summary table of the growth, development, and financial aspects of plantations of Norway spruce, white pine, red pine, Scots pine, and larch in Dutchess and Lewis Counties, N. Y. Definitions of plantation site qualities for the area of study are included. Reports wide spacing of plantations is most profitable.

Fisher, R. T. 1916. **Utilization and round-edge lumber.** Soc. Amer. Foresters Proc. 11: 386-393.

Describes the many uses of round-edge lumber and the close utilization of it in specialty markets.

Fisher, Richard Thornton. 1921. **The management of the Harvard Forest, 1909-1919.** Harvard Forest Bul. 1, 27 pp., illus.

A brief description of the area and its potentials for management together with a statement of objectives, silvicultural policy, and accomplishments. The allowable cut was about ¼ million board feet annually. Details cutting methods used.

Fisher, Richard T. 1924. **Close utilization in New England.** ***In*** **Report of the National Conference on Utilization of Forest Products.** U.S. Dept. Agr. Misc. Circ. 39: 24-27. illus.

On the Harvard Forest and in the surrounding area, close utilization has provided additional income to finance the shelterwood cuttings and later weedings necessary to ensure a new crop.

Foster, J. H. 1915. **Present forest tax situation in New Hampshire.** Forestry Quart. 13: 474-480.

Some 126 woodlots in New Hampshire were studied with respect to assessed valuation for tax purposes. Most of the woodlots were second-growth white pine of average value, and the majority of them would not have come onto the market normally for 10 to 20 years. Discusses effect of increases in tax assessments on premature cutting of white pine stands.

Foster, Clifford H., and Burt P. Kirkland. 1949. **The Charles Lathrop Pack Demonstration Forest, Warrensburg, N.Y. Results of twenty years of intensive forest management.** Charles Lathrop Pack Forestry Foundation, 36 pp. Washington.

A brief review of the early history, development, objectives and management of the Forest. Outlines silviculture for white pine, hemlock, and hardwoods, as applied on the Forest. The importance of careful utilization and market development to better forest management is stressed. Includes a financial analysis of results of management on the Forest.

Foster, Clifford H. 1953. **The importance of timber quality as a goal in silviculture.** Jour. Forestry 51: 487-490.

The success of silviculture is judged by the quality and quantity of usable wood produced. Intensive silvicultural practices should be applied to a few choice species on the best and most accessible sites. Too often foresters have avoided work of important future significance on the grounds that it would not give immediate net return. Cites methods to produce high-quality white pine.

Frothingham, E. H. 1914. **White pine under forest management.** U.S. Dept. Agr. Bul. 13, 70 pp., illus.

This bulletin, a complete treatment of the subject, is still "the bible" of white pine in New England. It covers white pine's general suitability for management, geographical range, and place in the history of lumbering. General characteristics of old-growth and second-growth stands are discussed and the section on silvical characteristics includes description of site requirements, form, natural reproduction, growth of individual trees and stands. Other sections are devoted to planting, protection, tables of yield, and management finances.

Gedney, D. R., and T. W. McConkey. 1951. **1-man chain saw may save manpower in logging white pine.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Res. Note 2. 3 pp.

A study of logging-cost records for over ½ million board-feet of white pine timber indicates that felling, limbing, and bucking operations with 1-man power saws uses about 1½ man-hours per thousand board feet less labor than when the work is done with 2-man power saws. The logs produced varied in size from 11 to 26 logs per thousand board feet.

Gevorkiantz, S. R., and Raphael Zon. 1930. **Second-growth white pine in Wisconsin: its growth, yield, and commercial possibilities.** Wis. Agr. Expt. Sta. Res. Bul. 98, 40 pp.

White pine on average sites will produce 10,500 board feet at 40 years, 36,500 board feet at 60 years, and 59,000 board feet at 80 years. On poor sites the yield at 40 years will be only 2,400 board-feet but on the best sites the yield will be 19,000 board-feet at the same age. Detailed tables of volume and yield. Yields of white pine in Wisconsin are shown to be about the same as those in New England.

Graves, Henry Solon, and Richard Thornton Fisher. 1903. **The woodlot: a handbook for owners of woodlands in southern New England.** U.S. Dept. Agr. Bur. Forestry Bul. 42, 89 pp., illus.

Management of hardwoods and white pine in Massachusetts and Connecticut is discussed briefly. Various cultural measures are illustrated and discussed in some detail.

Haasis, Ferdinand W. 1930. **Forest plantations at Biltmore, North Carolina.** U.S. Dept. Agr. Misc. Pub. 61. 30 pp., illus.

A guide to plantings, sowings, and experimental thinnings of about 40 species; the majority of the successful stands were white or shortleaf pine. Most of the plantations were very dense (2,000+ trees per acre) but were never thinned. The experimental thinnings on small plots greatly increased net growth. Recommends certain choices of species and planting methods. Concludes that it is unwise to select species to plant simply because of their prevalence in the virgin forest. Changes in soil and environment from past use must also be considered.

Hawes, A. F. 1911. **The management of Vermont forests with special reference to white pine.** Vt. Agr. Expt. Sta. Bul. 156: 99-139, illus.

Designed for owners of small woodlands in Vermont, this manual gives yield and growth tables for white pine, and discusses management of pure and mixed pine stands with special attention to thinnings and improvement cuttings, final cuttings, regeneration, growth and yield, protection, marketing, and costs and returns. Some case histories.

Hawkins, Guy C. 1924. **How one wood-using industry has made use of a forester.** Jour. Forestry 22: 140-148.

An account of the forest operations of the New England Box Company in central New England, which uses 40 million board feet of white pine annually. To meet these needs, the company has set up working groups around each of its mills. Forestry practices include planting, weeding, and thinning.

Hawley, Ralph C., and Robert T. Clapp. 1942. **Growing of white pine on the Yale Forest near Keene, New Hampshire.** Yale Univ. School Forestry Bul. 48. 44 pp., illus.

A discussion of the management of the forest where pure white pine stands for lumber production is the objective. Describes physical facts of the forest and discusses suitable practices for harvesting merchantable wood and timber, establishing the new crop, improving the new crop by pruning and thinning, and protecting the crop.

Hawley, Ralph C., and Harold J. Lutz. 1943. **Establishment, development, and management of conifer plantations in the Eli Whitney Forest, New Haven, Connecticut.** Yale Univ. School Forestry Bul. 53. 81 pp., illus.

White pine and Norway spruce planting should continue on the old fields of southern Connecticut. Recommends a 60-to-80-year growing period, followed either by a forest of hardwoods, naturally seeded, or by pine or spruce in varying mixture with hardwoods. Original plantings may be in pure stands or in small grouped mixtures of pine and spruce, and possibly red oak.

Heiberg, Svend O. 1942. **Cutting based upon economic increment.** Jour. Forestry 40: 645-651.

Charts the economic increment of white pine and hemlock for trees of three quality classes and diameters from 8 to 20 inches (white pine), the current realization value, the number of rings per inch needed to earn different rates of interest. Charts are based on a detailed logging and mill study at the Pack Forest, Warrensburg, N. Y. The application of cutting for economic increment and its effect upon the form of the forest are discussed.

Heiberg, Svend O. 1945. **Does economic cutting pay?** Jour. Forestry 43: 109-112.

An example from the Pack Forest, Warrensburg, N. Y., of cutting based on economic increment. Cutting has increased earnings and put the stand in condition for continued high earnings under proper treatment. Discusses the details of application, particularly the relation of the biological requirements of the forest to economic increment.

Hersey, Edmund. 1896. **Facts gathered by observation and experience relating to the white pine (*Pinus strobus* L.).** Bussey Inst. Bul.: 373-385.

Discusses the natural reproduction of white pine and means of supplementing it by seeding or by transplanting wildlings. The importance of soils to reproduction and to choice of a rotation is stressed. In Plymouth County, Mass., mill scale yields of 50,000 feet of 5/8-inch box boards per acre, in 30 to 35 years, are not uncommon. On the better soils even greater volume growth is possible, and individual trees grow to about 20 inches stump diameter in the same period. Discusses the merits of short rotations for rough lumber versus long rotations for clear material.

Kittredge, Joseph, Jr. 1929. **Forest planting in the Lake States.** U.S. Dept. Agr. Bul. 1497, 88 pp., illus.

A comprehensive treatment of the subject. White pine can be planted on some of the sandy loam soils, but best sites for white pine are found on the loams or any soil that has been cleared and cultivated. On the sandier soils, white pine should be planted only if there is more than 40 percent cover to protect the trees. On the finer soils, cover is not so important. Planting may be done in either spring or fall with 2-1 or 3-0 stock.

Lyford, C. A., and L. Margolin. 1906. **Forest conditions in southern New Hampshire.** *In* N.H. Forestry Comn. Rpt. 1905-06: 161-276, illus.

A treatise on the condition and management of the forests of southern New Hampshire. The authors deal primarily with white pine, for which they discuss the distribution and silvics, make silvicultural recommendatons for intermediate treatments and regeneration, and provide yield tables and other mensurational tools as aids for management. These yield tables are the first developed in the Northeast.

Moore, J. C. 1945. **Christmas tree production.** Ala. Agr. Expt. Sta. Circ. 92, 15 pp.

White pine is one of several species that gave promise of making good Christmas trees when grown in Alabama and the Southeast. They also provided erosion-control cover on sloping lands where cultivated crops are inadvisable.

New Hampshire Forestry Commission. 1922. **Management of farm woodlots.** N.H. Forest Comn. Bien. Rpt. 1921-22: 128-151.

Briefly describes the economic position and the condition of the woodlot in southern New Hampshire. A discussion of woodlot care and improvement emphasizes the growth of white pine. Margolin's yield table for white pine is reprinted and the financial rotation is discussed. Natural stands yield the greatest net profits with a rotation of 35 to 40 years while plantations reach financial maturity at about the same age.

New Hampshire Forestry and Recreation Commission. 1937. **Woodlot management.** N.H. Forest Comn. Bien. Rpt. 1935-36: 163-167.

A brief review of general considerations. To grow white pine, blister rust and grazing must be eliminated and special measures taken against the white-pine weevil and in some cases the gypsy moth.

Pettis, C. R. 1909. **How to grow and plant conifers in the Northeastern States.** U.S. Dept. Agr. Forest Serv. Bul. 76, 36 pp., illus.

Briefly explains the more important phases of seed procurement, nursery establishment, nursery practice, and field planting. Much of the experience related has been gained with white pine. Cost calculations on the various operations are included.

Rendall, R. E. 1923. **Bates Forest.** Jour. Forestry 21: 162-172.

The acquisition and first steps in management of the Bates Forest in Maine (now included in the Massabesic Experimental Forest) are described. The forest is largely in white pine types, but these are considered temporary; hemlock, pitch pine, and white-cedar swamp are recognized as the permanent types.

Rudolf, Paul O. 1950. **Forest plantations in the Lake States.** U.S. Dept. Agr. Tech. Bul. 1010, 171 pp., illus.

A comprehensive bulletin on forest planting and plantation maintenance for the Lake States region. Sections deal with the history and background of planting; direct seeding; where, what, why, how, and when to plant; cost of planting; protection, growth, and culture of plantations; judging the success of plantations; record keeping; and the necessary groundwork in reforestation planning.

Simmons, J. R. 1915. **The older forest plantations in Massachusetts.** 38 pp., illus. Boston.

From 1820 to 1880, 10.000 acres of white pine were planted. Some of the plantations showed a current annual growth of 1,000 board feet per acre and the mean annual growth was frequently about 500 board feet per acre.

Spring, S. N. 1905. **The natural replacement of white pine on old fields in New England.** U.S. Dept. Agr. Bur. Forestry Bul. 63, 32 pp., illus.

Concludes that the extension of white pine on old fields and pastures has been vigorous in the past and that it remains so where seed trees are present. Reestablishment of white pine can be assured by leaving seed trees. Suggestions are also given for tending young stands.

Spurr, Stephen H., and A. C. Cline. 1942. **Ecological forestry in central New England.** Jour. Forestry 40: 418-420.
In central New England it is evident that plantations and the old-field white pine, aspen, gray birch-red maple, and paper birch types are expensive and biologically unsound for forest management except where they form a physiographic climax. Silvicultural practice should aim at low-cost production of late successional forest types—the hardwood-hemlock associations.

Toumey, J. W. 1914. **Forest planting in New England as an investment.** Forestry Quart. 12: 538-543.
The profitability of planting in New England is discussed, using several profitable white pine plantations as examples. Planting will return a good income if white or red pine is planted on first—or sometimes second-quality sites near good markets for thinnings and other expected products, if the land is equitably taxed, and has good fire protection. Only a limited area meets these requirements.

Toumey, James W. 1932. **The Yale demonstration and research forest near Keene, New Hampshire.** Yale Univ. School Forestry Bul. 33. 106 pp., illus.
This report on the operation of the forest since 1913 reviews the research and accomplishments as well as the organization of the property as a business enterprise. The organization, records, management aims for each major type, inventory, growth, and yield of the forest are all described. Most of the area is devoted to growing white pine pure or in mixture.

Toumey, J. W., and R. C. Hawley. 1916. **The Keene Forest.** A preliminary report. Yale Univ. School Forestry Bul. 4. 25 pp.
A statement of the early organization and plan of management of the forest. Out of 900 acres in the property, 400 acres are in white pine.

Wackerman, A. E. 1924. **Growth of the "grayling pine".** Jour. Forestry 22:796-797.
Report on growth of a 76-acre tract of virgin white pine (1884-1924) in lower Michigan.

Zon, Raphael. 1928. **Timber growing and logging practice in the Lake States. Measures necessary to keep forest land productive and to produce full timber crops.** U.S. Dept. Agr. Bul. 1496. 64 pp., illus.
Describes the four principal forest-type groups of the Lake States. Common logging practices, fire, and other factors affecting the productive capacity of the forest are discussed. In the Norway and white pine types, partial cutting is recommended. This means leaving at least 10% and perferably 20% of the merchantable volume and all the smaller trees until the area has become fully stocked with reproduction.

TREE SEED

Baldwin, H. I. 1934. **Effect of after-ripening treatment on germination of white pine seeds of different ages.** Bot. Gaz. 96: 372-376. illus.
Germination tests were made of several lots of seed of different ages. In most cases after-ripening for several weeks at 8 to 10° C. increased the rate of germination markedly. This increase was most prominent in the case of seed 2 to 3 years old. Germination descreased with age, that of stratified seed more rapidly than that of untreated control seed.

Baldwin, Henry I. 1935. **Catalase activity as a measure of viability of tree seeds.** Amer. Jour. Bot. 22: 635-644, illus.

Fourteen lots of white pine seed were among those tested. It was found that the catalase quotient (average oxygen evolution of stimulated seed over that of dry seed) was high in seed lots of high viability and low in seed lots of low viability. The seed lots varied from 0 to 84.5% in germinative energy.

Baldwin, H. I., and Florence Flemion. 1941. **Rapid method for testing white pine germination.** N.H. Forestry and Recreation Comn. Fox Forest Notes 30, 1 p.

The excised embryo germination test of white pine seed was compared with germination after planting directly in the soil and with stratification before planting. There was a close correlation between the exised embryo test and the actual percentage germination of the stratified seeds so that a good approximation of germinative energy can be obtained in 10 days instead of the usual 12 weeks.

Barton, Lela V. 1930. **Hastening the germination of some coniferous seeds.** Amer. Jour. Bot. 17: 88-115.

Results of stratification for varying periods at a number of different temperatures (constant) are compared with several other treatments. White pine was difficult to germinate but stratification (especially at 10° C. for 2 months) gave much better germination than other treatments.

Bibby, K. M. 1953. **Experiments in pregermination treatment of tree seed.** New Zeal. State Forest Serv. Forest Res. Notes 1 (7): 9-16.

Pre-chilling in moist conditions before germination greatly improved rate and amount of germination in white pine.

Blumer, Jacob C. 1908. **Amerikanische Versuche mit Kiefernsamen.** Ztschr. f. Forst- u. Jagdw. 40: 236-240.

Describes germination tests with seeds of American pine in the U. S. Department of Agriculture Seed Laboratory. At a temperature of 52° F. there was no germination of white pine at 100 days, but with temperatures varying beween 68 and 95° F. germination was 85% in 10 days. White pine seed, the most resistant to injury by high temperatures, withstood a temperature of 122° F.

Brooks, R. O. 1951. **Chemical weeding as applied to forest nursery practice.** Pa. Dept. Forests and Waters 3 (2): 42-43, 47-48.

Good results were obtained with applications of Sovasol and Stanisol to nursery beds of white pine. Light applications at a very early stage are recommended.

Eliason, E. J. 1939. **Storage of eastern white pine seed for seven years.** N.Y. State Conserv. Dept. Forest Invest. Note 29, 2 pp.

Tests confirm the value of air-tight storage of conifer seed at low constant temperature for maintaining viability. White pine seed stored in sealed carboys, in a seed vault having a temperature of 36-38° F. and 85-90% relative humidity, showed 87% germination at the end of 7 years.

Eliason, E. J. 1942. **Data from cone collections of various species in New York.** N.Y. State Conserv. Dept. Forest Invest. Note 39, 1 p.

Summarizes data from special collections made since 1927 for various experiments. Five lots of white pine were collected. Per bushel of green cones they averaged 27 pounds, 521 cones, and 15.3 ounces of seed.

Gravatt, A. R., D. H. Latham, L. W. R. Jackson, and others. 1940. **Multiple seedlings of pines and Douglas fir.** Jour. Forestry 38: 818, illus.

Two cases in which two well-developed white pine seedlings developed from a single seed are among those reported. One case was in a lot of 6,450 seedlings.

Heit, C. E. 1938. **Stratification technique for white pine.** N.Y. State Conserv. Dept. Forest Invest. Note 12, 1 p.

Stratification period for white pine should be 20 days, based on results from test periods of 10 to 50 days. Place the seed on a pod and wick in a small germinator and cover with a glass funnel. Temperature should be maintained at 36 to 40° F. This procedure will give 10 to 15% better germination than stratification in sand.

Johnson, L. P. V. 1946. **Effect of chemical treatments on the germination of forest tree seeds.** Forestry Chron. 22: 17-24.

Chemical treatments were tested, in comparison with stratification and pre-soaking, for their effects on germination of the seed of many tree species. With white pine, significant increases in percentage germination were obtained from stratification for 50 days.

Johnstone, G. R. 1940. **Further studies on polyembryony and germination of polyembryonic pine seeds.** Amer. Jour. Bot. 27: 808-811, illus.

Eleven species of pine bear multiple seedlings. The seeds of five species were dissected to reveal true polyembryony. Reports unpublished observation by Meier that approximately 2% of white pine seed is polyembryonic.

Kirkham, Dayton P. 1930. **Germination of seed from different parts of cone and crown.** Minn. Univ., The Gopher Peavy: 30-36.

Concludes from limited germination tests that viability of white pine seed is related more closely to the position of the cone on the tree than to the position of the seed in the cone. Seeds from the lower crown and from the basal portion of the cone germinated best.

Knecht, Hans. 1931. **Über die Beziehungen zwischen Katalaseaktivität und Vitalität im ruhenden Samen.** Bot. Centbl. Beih. Abt. 1, 48: 229-313, illus.

With individual seeds the author found no relation between catalase activity and vitality. In two pine species studied, medium and high catalase activity was associated with high germination and low activity with low germination; but with white pine high catalase activity was associated with low germination and medium and low activity with high germination.

Koblet, Rudolf. 1932. **Über die Keimung von Pinus strobus unter besonderer Berücksichtigung der Herkunft des Samens.** Schweiz. Bot. Gesell. Ber. 41: 199-283.

The effects of storage and seedbed temperatures on germination of white pine seed of different geographic origins was studied. There was no apparent relation between origin and germination temperature. Germination was rapid and complete at a constant temperature of 6 to 12° C.; at higher constant temperature or with daily alternation between low and high temperatures, germination was lower. Chemical analyses showed that poor germination was not due to lack of sugar. In the seedbed, seed showed an increase in pH, especially at higher temperatures.

Lake States Forest Experiment Station. 1930. **Pre-treatment of white pine seed for spring sowing.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 29, 1 p.

White pine seed for spring planting should be stratified in fine sand or sawdust moistened with 1 to 2 times its weight of water for about a month. The temperature should be maintained at 33 to 50° F. After sifting from the sand or sawdust, the seed should be sowed immediately.

Lake States Forest Experiment Station. 1932. **Dryness—key to storage of pine seed.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 56, 1 p.

Red pine seed dried to less than 5% moisture content and white pine seed dried to about 6% keep well for 3 to 4 years, particularly if stored at temperatures below 40° F. Seed should be stored in sealed containers so it will not absorb moisture.

Lake States Forest Experiment Station. 1940. **When to pick pine cones.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 170, 1 p.

Criteria of ripeness are given for red, white, and jack pine cones, and the method of testing is described. White pine cones are ripe when they are yellowish green in color with brown on scale tips and when the specific gravity is 0.92.

Lake States Forest Experiment Station. 1941. **Testing cone ripeness.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 176, 1 p.

Describes a field kit for flotation tests. White pine cones are ripe when they float in linseed oil—usually from August 27 to September 6 in lower Michigan.

Rietz, R. C. 1939. **Kiln design and development of schedules for extracting seed from cones.** U.S. Dept. Agr. Tech. Bul. 773, 70 pp., illus.

Results of studies of cone opening, seed yield, cone moisture reduction, seed moisture reduction, viability of seed from kiln-dried cones, and seed heating are reported for white, red, and jack pine. For extraction of white pine seed it is recommended that the cones be pre-cured.

Roe, Eugene I. 1948. **Viability of white pine seed after 10 years of storage.** Jour. Forestry 46: 900-902.

On the basis of a study with five temperature and five moisture levels, the author recommends that white pine seed be dried to not more than 7% moisture content and should then be stored in moisture-proof containers at a temperature of 36° F. Under these conditions viability should be fully retained for at least 10 years.

Rohmeder, E. 1939. **Curing arrested germination in seeds of Weymouth pine, Douglas fir, and larch by pre-treatment under cold and wet conditions.** Forstwiss. Centbl. 61: 393-406.

Experiments at the Forstliche Samenprufstelle in Munich confirmed the value of pre-treatment of Weymouth pine seed on the lines developed by Schwappach, Grisch, Lakon, and Koblet. Except for very poorly germinating samples, the rate and percentage of germination was greatly increased by moist storage at 2 to 4° C. for 28 days.

Rudolf, Paul O. 1940. **When are pine cones ripe?** Minn. Acad. Sci. Proc. 8: 31-38.

Ripeness of white pine cones was closely associated with color and specific gravity of the cones. Cones with a specific gravity of 0.973, cone scales tipped with brown, cones yellowing and a few brown, germinated better than 80% of the seed and may be considered ripe. These conditions coincided with the time squirrels began to cut cones.

Schmidt, W. 1925. **Über Vorquellung und Reizbehandlung von Koniferensaatgut.** Zellstimulationsforschungen 1: 355-368.

White pine seed stored dry will not germinate without soaking in water. Storage in a cool, moist room for 30 days after a swelling period of 16 hours has given 78% germination from dry-stored seed. Soaking in a 1% solution of hydrogen peroxide instead of water has given 81% germination in 60 days.

Schubert, G. H. 1954. **Viability of various coniferous seeds after cold storage.** Jour. Forestry 52: 446-447.

Germination capacity was tested for seed lots of many species stored under generally favorable condition at 41° F. in 5-gallon cans with tight lids for 2 to 24 years. A single lot of eastern white pine seed stored more than 10 years gave no germination.

Sibenik, M. 1952. **Mocenje semena zelenega bora pred setvijo-odlicen uspeh. (Excellent results obtained by soaking seeds of Pinus strobus before sowing.)** Gozd. Vestn. 10 (7): 217.

Seeds were soaked for 14 days in water that was changed every other day; when sown after some drying, they germinated 100%. Controls had very poor germination.

Spurr, Stephen H. 1944. **Effect of seed weight and seed origin on the early development of eastern white pine.** Jour. Arnold Arbor. 25: 467-480, illus.

In a controlled experiment it was determined that seed weight is directly related to germination, survival, and the early size of the plant. The correlation between seed weight and shoot weight diminishes as the plant ages, but is still noticeable after 3 years. Seed origin is related to germination, appearance, moisture content, and seedling growth. The influence of seed origin on plant size is as strong at the end of the third year as at the end of the first growing season.

Tillotson, C. R. 1921. **Storage of coniferous tree seed.** Jour. Agr. Res. 22: 479-510.

Seed of white pine and 5 other conifers was stored at 13 geographic locations under 3 temperature conditions and in 5 types of containers. Air-tight bottles maintained seed quality far better than any other containers. Seed so stored was not affected by temperature or location. After 5 years in sealed bottles, white pine seed germinated 44 to 51%. After 10 years in sealed bottles that were opened once at the end of the 5th year, white pine seed failed to germinate.

Toumey, J. W., and W. D. Durland. 1923. **The effect of soaking certain tree seeds in water at greenhouse temperatures on viability and the time required for germination.** Jour. Forestry 21: 369-375.

Seed of different species differ widely in response to pre-soaking. White pine is in a group of species whose seed normally germinates in late spring. In tests, white pine seed was soaked from 0 to 30 days; the most rapid and most complete germination occurred with seed that had been soaked 10 days.

Toumey, J. W., and C. L. Stevens. 1928. **The testing of coniferous tree seeds at the School of Forestry, Yale University, 1906-1926.** Yale Univ. School Forestry Bul. 21, 46 pp.

Results of extensive tests on the seed of 36 species. In 26 lots of white pine seed tested, the number of seeds per pound varied from 24,000 to 43,000, an average of 28,000. Highest germination capacity was 94%, lowest 15%, average 67%. There was great variation in the time required for germination.

United States Forest Service. 1948. **Woody-plant seed manual.** U.S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.

A comprehensive manual with chapters on seed and its development, seed production and dispersal, seed source, collection, processing and storage of seed, pretreatment, and seed testing. Part 2 gives, for white pine and many other species, all the available information on the above subjects.

Wright, Jonathan W. 1945. **Influence of size and portion of cone on seed weight in eastern white pine.** Jour. Forestry 43: 817-819.

In a cone collection from six trees, the fresh weight of the seed was found to increase significantly from small to large cones and from the apical to the basal portion of the cone. There were also significant differences in seed weight among trees. No obvious correlation was found between seed or cone size and the age, diameter, or growth rate of the parent.

NURSERY PRACTICE : VEGETATIVE PROPAGATION

Burns, George P. 1914. **Development of white pine seedlings in nursery beds.** Vt. Agr. Expt. Sta. Bul. 178: 127-144, illus.

Nursery and greenhouse tests produced results from which the following conclusions were drawn. Damping-off of seedlings can be controlled with formaldehyde or sulfuric acid. In sandy soils, seed should be planted not less than ½ inch deep. If seed is sown early in wet weather, no top shade is needed to get an even stand. If seed is sown late in dry weather, the surface soil must be kept moist by watering or by full shade top.

Burns, George P. 1927. **Leaf efficiency in thrifty and stunted white pine seedlings.** Vt. Agr. Expt. Sta. Bul. 267, 27 pp., illus.

From a study of supplemental watering of white pine seedlings in nursery beds, it was concluded that stunting is due primarily to intense root competition, which may be caused by lack of rainfall or the use of too much seed. From the limited data it seemed that leaves of stunted trees are as efficient for wood production per unit of dry weight as those of the more thrifty trees. The stunted trees recovered quickly when transplanted to favorable conditions. Density of the crown is an indication of the amount of available water.

Chittenden, A. K., and P. W. Robbins. 1928. **Best white pine seedlings follow fall planting.** Mich. Agr. Expt. Sta. Quart. Bul. 10: 95-97, illus.

Seed sown the last of October in the Upper Peninsula of Michigan and from November 10 to 25 in the Lower Peninsula will give better 1-year-old seedlings than spring sowing. The roots are larger, stronger, and more branching, the loss from damping-off is reduced by early germination, and germination is faster and more regular, with little or no seed holding over to the second spring before germinating.

Deuber, C. G. 1940. **Vegetative propagation of conifers.** Conn. Acad. Arts and Sci. Trans. 34: 1-83.

Dormant cuttings of white pine rooted better than summer cuttings but there was no marked seasonal trend in winter. Cuttings from younger trees, especially from seedlings 2 to 4 years old, rooted better and more consistently than those from older trees. Removing the lower needles and waxing the cuttings both proved to be detrimental. Small cuttings 2 to 4 inches long, taken from lateral shoots, survived better and rooted more abundantly than larger ones, especially those from terminal shoots.

Deuber, Carl G. 1942. **The vegetative propagation of eastern white pine and other five-needled pines.** Arnold Arboretum Jour. 23: 199-215.

In rooting trials with white pine it was found that trees 2 to 6 years old possessed considerable natural ability to root, but usually rooting from trees 8 to 90 years old was very poor or a complete failure. Treating young stock with auxins in various ways was favorable to rooting, except when mixed with lanolin as a paste. Treatment with sugar and a variety of chemicals did not appreciably influence root formation.

Doran, W. L. 1946. **Vegetative propagation of white pine.** Mass. Agr. Expt. Sta. Bul. 435, 16 pp.

In tests of cutting season, type of cutting, and rooting medium, the best results were obtained by taking cuttings in late winter from the lower limbs of young trees. The cuttings should be small twigs from the last season's growth, with no needles removed. The treatment is completed by immersing the cuttings for a short time in a concentrated solution of indole-butyric acid and then setting them in sand-peat or sand-sedge for rooting, in a rooting room with a high relative humidity. White pine trees vary in their ability to root, but those that root successfully will do so in 3 to 5 months after treament.

Doran, William L. 1953. **The vegetative propagation of some forest trees.** Northeast. Forest Tree Improve. Conf. Proc. 1: 41-47.

The author has successfully rooted cuttings of a number of species, including eastern white pine. White pine does not root easily. In recent trials, cuttings from only 1 out of 16 quality white pine were successfully rooted. Rooting ability may well be as important a basis for selection as timber quality. Cuttings taken from the tips of lateral branches of young trees between December and March appear to root most successfully.

Eliason, E. J. 1938. **Toxicity of zinc sulphate to coniferous seedlings.** N.Y. State Conserv. Dept. Forest Invest. Notes 10. 1 p.

Zinc sulfate applied to nursery beds after sowing and sanding materially reduced number of weeds but did not affect germination or injure seedlings of white pine. Under certain dry conditions other conifers were injured.

Eliason, E. J. 1938. **Pre-germination in fall-sown seed beds.** N.Y. State Conserv. Dept. Forest Invest. Note 11. 1 p.

White pine germination and growth has been best in fall-sown beds, the very best in October. There was no fall germination in any of the beds sown at various dates in the fall. Results differed with other species.

Farrar, J. L., and N. H. Grace. 1942. **Vegetative propagation of conifers. XII. Effects of media, time of collection, and indolylacetic acid treatment on the rooting of white pine and white spruce cuttings.** Canad. Jour. Res. Sect. C 20: 204-211.

Semi-monthly cuttings from July to October were planted in different media: two types of sand and two peats (sedge and sphagnum) in different proportions. A series of concentrations of the acid in talc were dusted on the cuttings but showed no appreciable effort on rooting. Cuttings collected in late August and propagated in sedge peat rooted 62%. No other season of cutting or combination of media gave as good results.

Gruenhagen, R. H. 1940. **Growth substances of doubtful benefit for treatment of pine seeds.** Jour. Forestry 38: 739-740.

In the tests reported, applications of naphthalene-propionic acid and several concentrations of indol-3-acetic acid failed to control damping-off or to increase germination in white and red pine seeds.

Iowa Agricultural Experiment Station. 1946. **(Effect of 2,4-D on different tree species.)** Iowa Agr. Expt. Sta. Rpt. 253.

The effect of 2, 4-D on different tree species was tested at the State Forest Nursery with the object of using it on weeds if it proved harmless to trees. The new leaves of hardwoods were killed by this chemical. The succulent new growth of white pine and Douglas-fir was also affected.

Lake States Forest Experiment Station. 1939. **Thinning of conifer seedlings in the nursery produces bigger but fewer plantable trees.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 143, 1 p.

Red and white pine seedlings were root-pruned and thinned to several densities in the spring of the third year. The treatments increased the average weight and stem diameter of the seedlings but reduced the plantable number per square foot regardless of the acceptable planting size. The desired density should be obtained by reducing the amount of seed rather than by thinning.

Lake States Forest Experiment Station. 1942. **Root pruning—a labor saver.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 190. 1 p.

Root pruning of seedlings at the beginning of the third year produces planting stock nearly as good as 3-year transplants, especially if used for spring planting. The cost is considerably less. White pine 3-0 root-pruned stock had a survival in field planting of 73 to 98%.

Larsen, J. A., and W. G. Stump. 1939. **Some experiments with fertilizers for evergreen seedlings.** Iowa State Col. Jour. Sci. 13: 293-311, illus.

Describes nursery and greenhouse experiments on the effect of various organic and inorganic fertilizers on the growth of seedlings of white pine and several other conifers. In general, nitrogen fertilizers increased top growth and phosphorus fertilizers increased root growth. In the nursery a combination of fertilizers was most effective.

McIntyre, Arthur C., and J. W. White. 1930. **The growth of certain conifers as influenced by different fertilizer treatments.** Jour. Amer. Soc. Agron. 22: 558-567.
Fertilizer experiments were carried out with white pine in pots of sand and Hagerstown silt loam, and in Hagerstown silt loam nursery beds. In sand, all treatments were beneficial; but lime, alone or in combinations, produced the heaviest 2-year seedlings. In silt loam, dried blood at the rate of 200 pounds per acre gave the heaviest seedlings. Sodium nitrate and superphosphate, alone and in combinations, produced the next heaviest seedlings.

Mirov, N. T. 1938. **Vegetative propagation of white pine as a possible method of blister rust control.** Jour. Forestry 36: 807-808.
The author and J. H. Murray of Marsh Botanical Garden have been successful in rooting cuttings of white pine. The author took cuttings 3 to 4 inches long from young trees in December, put their tips in warm water for about 2 hours, and planted them in coarse sand. Temperature of the sand was maintained at 74 to 78° F. Roots appeared by the end of May.

Patton, R. F., and A. J. Riker. 1954. **Top growth and root development of rooted white pine cuttings.** Jour. Forestry 52: 675-677, illus.
Two- and 3-year-old rooted cuttings were compared with 2-2 seedlings in a checkerboard field planting. Survival after 7 to 9 years: cuttings 83%, seedlings 89%. Form and size of shoots were the same. Root systems of cuttings were adequate for growth and approached those of seedlings as plants grew older. Root pruning helped form good root systems on cuttings.

Petheram, H. D. 1927. **Season for sowing red and white pine seeds.** Jour. Forestry 25: 57-61.
Four seasons for sowing red and white pine seeds were tested: late fall, early spring, mid-spring, and summer. Results in the Cass Lake Nursery, in Minnesota, showed that a late-fall sowing had the best germination and the best 2-year survival, followed by an early-spring sowing. The summer sowing had good germination but poor survival and low-quality stock. A sample of each stock was field-planted and checked for survival over a 3-year period. In these tests the late-fall and early-spring sowings were generally the best and had the lowest cost per thousand in terms of survivors.

Reineke, L. H. 1942. **Effect of stocking and seed on nursery development of eastern white pine seedlings.** Jour. Forestry 40: 577-578.
A significant difference is found in seedling development when density is reduced: stems are longer, diameters increase, tap roots are longer, lateral roots increase, and more terminal buds develop. In short, reduced density of seedlings shortens the preparation time for planting stock.

Shirley, Hardy L., and Lloyd J. Meuli. 1939. **Influence of moisture supply on drought resistance of conifers.** Jour. Agr. Res. 59: 1-21.
Drought resistance of white, red, and jack pine seedlings was increased by subjecting them to moderate soil drought during the period of vegetative activity, but improved resistance did not depend solely upon the smaller shoots and greater root-shoot ratios developed. Exposure to severe dryness of soil temporarily weakened the plants and, unless followed by an ample period of recovery, rendered them more susceptible to drought. Improvement of drought resistance of Lake States pine seedlings by controlling the moisture supply in the nursery was demonstrated to be practical.

Snow, Albert G., Jr. 1940. **Rooting white pine cuttings.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Occas. Paper 11, 6 pp., illus.

Rooting was most successful with cuttings from younger trees and those farthest removed from the terminal leader. Maximum rooting was obtained by treating with indolebutyric acid followed by auxin dust. Cuttings from individual white pine trees showed considerable clonal variation in rooting ability.

Snow, Albert G., Jr. 1941. **Effect of needle removal on survival of white pine cuttings.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 38, 2 pp.

Any reduction of leaf area is detrimental to survival of white pine cuttings. Clipping the upper needles just above the bud usually resulted in mortality within 2 months. Mortality was attributed to loss of reserve materials such as starches, amino acids, and growth substances; possibly also to detrucive effect of fungi.

Snow, Albert G., Jr. 1941. **White pine propagation.** Jour. Forestry 39: 332-333.

The most successful rooting of white pine was obtained in media containing fungi. The fungi may help by providing an extra auxin supply or by aiding in the mineral nutrition.

Stoeckeler, J. H. 1949. **Control of weeds in conifer nurseries by mineral spirits.** U.S. Forest Serv. Lake States Forest Expt. Sta., Sta. Paper 17, 23 pp.

In white pine beds dosages of 50 to 75 gallons per acre controlled weeds less than 1 inch high and did not damage the pines, especially if the beds were shaded and true needles had formed.

Stoeckeler, Joseph H. 1950. **Can nurserymen produce white pine seedling stock comparable to transplants?** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 339, 1 p.

By growing 3-0 white pine seedlings at a nursery density of about 25 per square foot, stock comparable to 2-1 transplants can be produced at a lower cost. Densities from 13 to 81 seedlings per square foot were tested.

Thimann, Kenneth V., and Jane Behnke. 1947. **The use of auxins in the rooting of woody cutting.** Maria Moors Cabot Found. Pub. 1, 272 pp.

A tabulation of data and notes on the trials made. Many trials, some of them successful, were made with white pine.

Thimann, K. V., and Albert L. Delisle. 1939. **The vegetative propagation of difficult plants.** Arnold Arboretum Jour. 20: 116-136, illus.

This progress report on controlled trials with serveral species shows that cuttings from 3- or 4-year-old white pines rooted very well when treated with a strong (200 to 400 ppm) solution of indole-acetic acid. Application of a sugar solution following the auxin treatment increased rooting and decreased mortality.

Thimann, K. V., and Albert L. Delisle. 1942. **Notes on the rooting of some conifers from cuttings.** Arnold Arboretum Jour. 23: 103-109.

In white pine the individual needle bundles or brachyblasts form roots at least as readily as do ordinary cuttings, particularly if they are treated with auxins.

Thomas, J. E., and A. J. Riker. 1950. **Progress on rooting cuttings of white pine.** Jour. Forestry 48: 474-480.

From 50 to 90% of cuttings were successfully rooted when taken from 3- or 4-year-old white pines between mid-July and mid-September, treated with growth substances, and placed in shaded glass-covered cutting beds. Older trees and untreated trees did not root so well. Root pruning appears necessary to stimulate a well-branched root system.

Wilde, S. A. 1941. **A balanced diet for nursery stock.** Better Crops with Plant Food 25 (6): 14-16, 40-42, illus.

A brief discussion of the role of soil nutrients in seedling growth and nursery soil management. From thousands of virgin forest soil analyses, standards or optimum levels and balance (balance emphasized) for nursery soil nutrients are presented with a general statement of how these standards can be met in nursery practice.

SEEDING AND PLANTING

Allen, John C. 1953. **A half century of reforestation in the Tennessee Valley.** Jour. Forestry 51: 106-113.

Of some 170 million trees planted up to 1946, more than 5 million were white pine. Under average conditions, the early height growth of white pine compares favorably with that of the five other major species used. All of these species except yellow-poplar (which does best in shales) grew best on granitic soils with some ground cover. White pine is the preferred species to plant within its natural range on granitic soils and on shales where there is little or no erosion.

Baldwin, H. I. 1938. **Comparison of planting in ploughed furrows and unbroken sod.** N.H. Forestry and Recreation Comn., Fox Forest Notes 5, 1 p.

Planting in furrows was easier, and showed better survival and better height growth over 9 years, than planting done in unbroken sod on abandoned fields. White pine, white spruce, red spruce, and red pine were planted.

Baldwin, H. I. 1938. **Comparison of spring and fall planting.** N.H. Forestry and Recreation Comn. Fox Forest Notes No. 8, 1 p.

Tests made in 1 year indicate that spruces and white pine can be planted in late September at Hillsboro with good survival and even better initial growth than from spring planting.

Baldwin, Henry I. 1938. **Planting experiments in the Northeast.** Jour. Forestry 36: 758-760.

Experiments in the Northeast have shown that white pine survival and growth were best when the stock was fall-planted. White pine planted with the slit method made considerably better growth and had somewhat better survival than those hole-planted. Better growth was made by 3-0 stock than by 2-2 stock.

Baldwin, H. I., and G. M. Hopkins. 1941. **Course of seasonal height growth in summer planted white pine.** N.H. Forestry and Recreation Comn., Fox Forest Notes 25, 1 p.

The trees were taken from cold storage and planted on July 17, when white pine has normally completed more than 90% of its height growth. These trees completed 95% of their height growth in 3 weeks and, though the entire growing period was much shortened, the growth curves still conformed well to the typical normal growth curve of this species.

Baldwin, Henry I., and Alfred Pleasonton. 1952. **Cold storage of nursery stock.** N.H. Forestry and Recreation Comn. Fox Forest Notes 48, 2 pp.

Three-year old seedlings, lifted in the fall and spring, were stored in deep-freeze lockers, meat-storage vaults, and in a cool cellar. After planting in April, June, and July, these results were recorded: fall-lifted trees had a lower survival than those spring-lifted; best survival was obtained with trees from the meat-storage vault; white pine withstood storage better than the other species.

Bramble, William C. 1952. **Reforestation of strip-mined bituminous coal land in Pennsylvania.** Jour. Forestry 50: 308-314, illus.

During 5 years of 100-tree test plantings with many species it was found that early survival of white pine was 40% or better on acid yellow-brown and blue shale and on acid sandstone mixed with shale. It was 35% in 3 plantings on very acid, thin-bedded, carbonaceous shale. The minimum survival that could be described as adequate was 40%.

Brooks, Henry. 1900. **Planting white pine seedlings.** Amer. Forestry Assoc., The Forester 6: 169.

White pine seedlings may be potted in paper pots and can be set out in the field at the rate of 100 per hour. If well-watered and kept in the partial shade of an orchard, for instance, the seedlings can be kept in good condition throughout the year. This method is suggested for those who are planting small areas and find it more convenient to plant throughout the year rather than concentrating the work in the spring.

Burns, G. P., and E. S. Irwin. 1942. **Studies in tolerance of New England forest trees. XIV. Effect of spacing on the efficiency of white and red pine needles as measured by the amount of wood production on the main stem.** Vt. Agr. Expt. Sta. Bul. 499, 28 pp., illus.

A detailed study using 28-year-old white and red pine trees initially spaced 2 x 2 and 4 x 4 feet on a level uniform site. Samples of 10 to 16 trees were cut May 1941, needles removed, and stems sectioned. Results show that tree d.b.h. was 48 and 16% greater on the 4 x 4 spacing than the 2 x 2 for red and white pine respectively. A highly significant correlation was found between the volume increment of 1940 on the main stem and needle development in terms of dry weight, numbers, surface area, or cubic volume.

Chapman, A. G., and R. D. Lane. 1951. **Effects of some cover types on interplanted forest tree species.** U.S. Forest Serv. Central States Forest Expt. Sta. Tech. Paper 125, 15 pp.

In connection with some hardwood planting tests on old fields in Ohio, white, pitch, and shortleaf pines were planted pure and in mixture with black locust. After 12 years the survival of white pine was good, but total height was only 10.5 feet in the mixed planting compared to 24 feet in the pure. Pitch and shortleaf pines did not survive in the mixed planting.

Coolidge, Philip T. 1911. **Silvicultural treatment of abandoned pastures in southern New England.** Forestry Quart. 9: 253-261, illus.
From published yield figures and general observations on pasture conditions, it appears profitable to open holes in juniper and redcedar stands to plant white pine.

DenUyl, Daniel. 1951. **From field to forest—a 50-year record.** Jour. Forestry 49: 698-704.
In nearly 50 years of experience with forest planting on the Clark State Forest in Indiana, seeding and planting of hardwoods has been generally unsuccessful, and the earliest plantings of softwoods have also been unsuccessful. However, white pine planted under hardwood plantations have survived and developed well. These stands required release from hardwoods and have been thinned and pruned.

Fernow, B. E. 1917. **Axton plantations.** Jour. Forestry 15: 988-990.
In the absence of an official record of the establishment of the plantations, these notes were prepared as a brief record of conditions at the time of planting. Most of the planting stock was white pine, Scotch pine, and Norway spruce. The plantings were made under 14 different conditions during the period 1898-1903.

Fraser, J. W. 1952. **Seed-spotting of conifers under a mixed hardwood stand.** Canada Forestry Branch Silvic. Leaflet 67, 3 pp.
This experiment indicates that seed-spotting of white spruce, white pine, or red pine under thinned 50-year-old white birch-aspen-red maple stands is not likely to succeed unless competition from less desirable species is controlled by cleanings, chemical spraying, or other means. After 26 years, white pine survival was only 11% and average height was only 1.4 feet with a maximum height of 5.8 feet.

Haasis, F. W. 1914. **Results of an experiment on the effect of drying of the roots of seedlings of red and white pine.** Forestry Quart. 12: 311-318.
Bare-rooted planting stock was exposed to full sun on a board for various lengths of time and then planted. The test was a small one but it is perhaps safe to say that such exposure for a period of 2 hours in the morning is not necessarily fatal. Red pine seems to have been more affected than white pine.

Hart, A. C. 1954. **Hardwoods now predominate on burn at Centerville, Maine.** Jour. Forestry 52: 360-361.
An area in southern Maine that was burned by a hot fire in the fall of 1947 was seeded from the air with white pine in March 1948. The succeeding summer season was very dry and by 1950 the seeding was judged a failure. In 1952 the area was well stocked with aspen, birch, and red maple, under which there was a moderate amount of spruce but little fir or pine.

Hetzel, J. E. 1941. **Forest plantations in northwestern Pennsylvania.** U.S. Forest Serv., Allegheny Forest Expt. Sta. Occas. Paper 3, 5 pp., illus.
Some 73 plantations of the most commonly planted species (including 13 plantations of white pine) were scored, at about 20 years of age, on height growth, diameter growth, and form of individual trees. White pine had the lowest score on each criterion. Despite the former value of white pine in this region, the author does not recommend the species. Slow early growth; competition from faster-growing species; severe damage by the white-pine weevil, browsing by deer, rabbits, and domestic stock; and infection by blister rust all combine to give poor survival and inferior form to white pine plantations.

Hicock, Henry W. 1942. **The rainbow forest plantations.** Conn. Agr. Expt. Sta. Bul. 464: 619-702, illus.

About 120 acres of experimental plantings have been made at Windsor and East Granby, Conn.—most of them with white pine. The soil is a deep Merrimac coarse sand. On the basis of these plantings, it is recommended that white pine be planted in pure groups in openings surrounded by cover 25 feet or more high; or establish two-aged stands by first planting any fast-growing species, to be followed by white pine in 5 to 10 years. The mixture should be by groups of 30 to 50 trees. The overstory should be gradually removed beginning about 10 years after white pine is planted.

Kemptom, Harold B. 1903. **The planting of white pine in New England.** U.S. Bur. Forestry Bul. 45. 40 pp., illus.

This early discussion emphasizing planting results is based primarily on examination of some older plantations for which summaries of history, condition, and growth are given. Concludes that planting is profitable for the small landowner on rotations of 40 years or longer.

Lake States Forest Experiment Station. 1930. **Germination and survival of conifers under aspen.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 28. 1 p.

Some 32 days after sowing Norway pine, white pine, and white spruce in prepared seed spots, there were white pine seedlings in 26 out of 50 spots where the aspen overstory was clear-cut, in 4 out of 50 where 35% of the aspen stand was removed, and in only 2 out of 50 where the aspen overstory was uncut. The differences are probably due to the higher soil temperatures in the cut plots.

Lake States Forest Experiment Station. 1935. **Prolonged exposure of roots causes death of planting stock.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 96. 1 p.

In the severe climatic conditions of a drought machine, the roots of 1-1 white pine, Norway pine, jack pine, and 2-0 white spruce were damaged after only 10 minutes' exposure; exposures of more than 15 minutes may eventually prove fatal. Exposures of 5 to 6 hours completely killed the planting stock.

Logan, K. T. 1951. **Seed-spotting in a cut-over jack pine stand.** Canada Forestry Branch. Silvic. Leaflet 57, 2 pp., illus.

Regeneration by seed-spotting was tested on a dry medium site from which was clear cut a mature stand of jack pine with an understory of red and white pine. Less than 40% of the white pine spots were initially successful and 7 years later all of the white pine had died.

Logan, K. T., and J. L. Farrar. 1953. **An attempt to grow white pine under an aspen stand.** Canada Forestry Branch Silvic. Leaflet 77, 3 pp.

Underplanting white pine in a young aspen stand on fresh to very moist sites was unsuccessful because of mortality caused by grazing, blister rust, and suppression by hazel *(Corylus cornuta)*, wild raisin *(Viburnum cassinoides)*, mountain holly *(Nemopanthus mucronata)*, and aspen. Best survival was less than 10% and best growth was only 9 feet in 13 years.

Maissurow, D. K. 1939. **Mixed group planting on the Nicolet National Forest.** Jour. Forestry 37: 853-855.

Jack, red, and white pines and other conifers have different cover requirements in early stages of growth after planting. On areas that had uniform site but lacked uniform cover, two or three species of different cover requirements were mixed in groups, the size and location of which were determined by the density of protective vegetation. Survival and growth of planted seedlings appeared to be favored by this method compared with planting one species only, and the cost per acre of plantation establishment was relatively lower for mixed-group planting.

Maki, T. E., H. Marshall, and C. E. Ostrom. 1945. **Effects of naphthaleneacetic acid-sprays on the development and drought resistance of pine seedlings.** Bot. Gaz. 107: 297-312.

Seedlings of white pine were sprayed in September, October, and March with various concentrations of naphthaleneacetic acid in 1% Dowax emulsion. Other seedlings were top-pruned. All treatments were an attempt to inhibit growth and increase resistance to drought. White pine was not affected by the growth-regulator treatments.

Marshall, Hubert, and T. E. Maki. 1946. **Transpiration of pine seedlings as influenced by foliage coatings.** Plant Physiol. 21: 95-101, illus.

In a test of foliage coatings on three pine species to reduce transpiration and lessen drought killing, 30 seedlings were lifted from the nursery, potted in fine moist sand, and exposed to artificial drought conditions for a 5-day period. The top-dipped specimens transpired 40% less than the untreated controls during the first 4 days of drought. Higher temperature and lower relative humidity during the fifth day severely injured white pine controls and increased water loss of treated plants. Water loss was shown to vary directly as the fresh weight of the seedling in both controls and coated samples.

Merz, R. 1951. **Comparative survivals and costs of plantations by different methods of ground preparation and planting.** U.S. Forest Serv. Central States Forest Expt. Sta., Sta. Note 64. 2 pp.

Experiments on old fields in southeastern Ohio showed little difference in first- or second-year survival of white and red pine when different methods of ground preparation and planting were used. Machine-planting with no ground preparation was the cheapest method, and planting by the mattock method in scalps the most expensive.

Minckler, Leon S. 1941. **Planting white pine in laurel and rhododendron "slicks."** Jour. Forestry 39: 1036.

Several methods of site preparation were tried. It was most efficient to cut back the thickets in strips or holes with widths either equal to or three-quarter of the height of the thicket. The spacing and arrangement of the prepared sites and of the pines within the sites depended upon the height of the thicket. Under these conditions, 80% survival and 2 feet of total height may be expected of white pine 5 years after planting.

Morey, H. F. 1935. **A success index for young forest plantations.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 16, 3 pp., illus.

Presents alinement charts for judging success of young white, red, and Scotch pine and Norway spruce plantations on the basis of survival, total height, and age. Plantations may be compared to each other with a relative success index, or their height may be compared with the averages on which the charts are based.

Paton, R. R. 1927. **Mixed vs. pure forest plantations.** Ohio Agr. Expt. Sta. Bimo. Bul. 12: 18-20.

Mixed plantations are practical and their advantages of protection outweigh the disadvantages. White pine can be successfully planted in mixed plantations with sugar maple, yellow-poplar, or red pine, the choice depending upon the site.

Polivka, J. B., and O. A. Alderman. 1937. **The problem of selecting the desirable pine species for forest planting in Ohio.** Jour. Forestry 35: 832-835.

Selections should be based on growth rate and susceptibility to insects of local occurrence. Mixed planting may cause reduction of insect damage. The most desirable species to plant (in order) are: white, jack, Norway, and shortleaf pines. The principal enemies of white pine in this area are the pine bark adelges, the Pales weevil, and the leaf feeder *Pachystethus oblivia* Horn.

Schantz-Hansen, T. 1932. **A comparison of the results obtained with forest-pulled and nursery-grown planting stock in northern Minnesota.** Jour. Forestry 30: 406-408.

Forest-pulled stock of white and red pine can be used on some areas with a reasonable degree of success. Nursery stock is superior but not so much as might be expected. Apparently some overhead shade is as beneficial to the forest-pulled stock as it is to other kinds.

Schantz-Hansen, T. 1945. **The effect of planting methods on root development.** Jour. Forestry 43: 447-449.

When 2-2 stock of white, red, and jack pine and white spruce was planted in sandy soil, the method of planting did not seriously affect either survival or root development.

Shirley, Hardy L., and Lloyd J. Meuli. 1938. **Influence of foliage sprays on drought resistance of conifers.** Plant Physiol. 13: 399-406.

Drought resistance of red and white pine and white spruce was not increased by beeswax, beeswax-parawax, rubber solution, or hydrowax foliage sprays. Tests were conducted in a drought machine.

Stafford, Earle. 1931. **Skeleton planting.** Jour. Forestry 29: 41-47.

Describes the various plant successions on good and poor sites on abandoned meadows, pastures, and cutover land in southwestern Massachusetts, and the resultant increase of soil fertility. The author proposes "skeleton planting" of conifers (300 trees per acre instead of 1,200) as being cheaper to start with and productive of more and better timber in the end. Disadvantages are also discussed.

Stoeckeler, Joseph H. 1947. **Planting poorly-drained wet sites.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 276, 1 p.

Planting in three plowed furrow positions on poorly drained silt loams and stiff silty clays was tested with five species. Survival and growth of white pine was uniformly poor.

Stoeckeler, J. H. 1950. **How long can conifers be held in spring by cold storage?** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 343, 1 p.

Jack, red, and white pine and white spruce trees were lifted on May 3 and stored at 50° F. for 1, 2, 3, 4, and 5 weeks respectively before transplanting in Wisconsin. Trees were also lifted at weekly intervals from May 3 to June 7 and transplanted immediately to determine the effect of late transplanting. Prolongd cold storage before transplanting reduced seedling vigor and size of trees at end of first year by shortening the favorable season for growth. Late transplanting, with or without cold storage, had an adverse effect on growth, which was accentuated by long storage.

Stoeckeler, J. H., and G. A. Limstrom. 1950. **Reforestation research findings in northern Wisconsin and upper Michigan.** U.S. Forest Serv. Lake States Forest Expt. Sta., Sta. Paper 23, 34 pp., illus.

This report supplements Rudolf (1950) with information derived from various experimental plantings, totalling 490 acres. Discusses in detail the best available methods for reforestation, emphasizing planting sites. A planting-site classification shows, for different combinations of soil texture, soil drainage, overhead cover, and ground cover, the recommended species and size of planting stock. Release from hardwood competition is also discussed.

Stoeckler, J. H., and A. W. Sump. 1940. **Successful direct seeding of northern conifers on shallow water-table areas.** Jour. Forestry 38: 572-577.

Fair results were obtained with white pine where the water table was 1.5 to 5 feet below the surface. Partial stands may be obtained where the water table is deeper. The seed should be sowed between the middle of April and the second week of May.

Trenk, F. B. 1948. **Influence of planted tree belt in Plainfield sand on erosion control and moisture conservation.** Iowa State Col. Jour. Sci. 22 (4): 449-461.

An experimental 8-row shelterbelt composed of conifers and hardwoods was established between 1928 and 1932 on a field of Plainfield sand. Abnormal heat and drought during the first five growing seasons caused high mortality in the initial plantings. Conifers (including white pine) averaged 17 feet high when 10 years old; they were effective in trapping snow and protecting soil and crops from the prevailing wind. Cultivation for the first 5 years after planting stimulated tree growth moderately.

Tryon, Henry H. 1932. **A study of several coniferous underplantings in the upper Hudson highlands.** Black Rock Forest Bul. 3, 27 pp., illus.

White pine, planted under a cordwood-size stand of oak, chestnut, and maple, was less than 2 feet high at 10 years compared to 12 feet on the same site when open-grown. Similar comparisons are made for Scotch and Norway pine, larch, and Norway spruce. Both in the open and under the overstory, white pine was the slowest growing species. Coniferous underplantings cannot be successfully brought to maturity without subsequent cultural treatment.

Wahlenberg, W. G., and W. T. Doolittle. 1950. **Reclaiming Appalachian brush lands for economic forest production.** Jour. Forestry 48: 170-174, illus.

A number of tests demonstrated that white pine can successfully replace laurel and rhododendron thickets. If planted in holes as wide as the height of thicket (if less than 3 feet high) or in lanes equal in width to three-quarters the height of the thicket, white pine will be free of competition in about 6 years. These openings can be prepared by cutting back or bulldozing the thicket. Openings made by fire or logging can also be used.

Wappes, L. 1941. **Erfahrungen über Freisaaten.** Deut. Forstwirt 23 (77/78): 581-583.

Broadcast sowing of white pine has been successful under fairly heavy shade, using seed at the rate of 1 kilogram per hectare, preferably with an admixture of silver fir seed. The author concludes that, in general nothing can be expected of seedlings if there is a heavy growth of grass.

Westveld, Marinus. 1949. **Airplane seeding: a new venture in reforestation.** Soc. Amer. Foresters Proc. 1948: 302-311, illus.

Describes methods and equipment used to reseed a burned-over white pine area on the Massabesic Experimental Forest near Alfred, in southern Maine. Ground checks showed satisfactory seed distribution.

Ziegler, E. A. 1915. **Further notes on the effect of exposure on white pine seedlings.** Forestry Quart. 13: 163-170.

Data are presented on the amount of drying out in white pine seedling planting stock on calm sunny days, calm cloudy days, and sunny days with a high wind. The length and season of exposure (lying on the ground) were varied, and unexposed check trees were also recorded. No attempt was made to interpret the data.

STAND IMPROVEMENT : HARVEST CUTTINGS NATURAL REGENERATION

Anonymous. 1950. **Forest practice standards for New Hampshire woodlands.** Univ. N.H. Ext. Bul. 98, 16 pp.

An interpretation of the forest-practice standards that serve as a basis for yield-tax abatement under the New Hampshire forest tax law. In pine stands, good practice consists of group or individual tree selection cutting, the openings usually not to exceed ¼ acre. In larger stands, strip cuttings or a combination of strips and the above are good practices. Clean cuttings are occasionally good practice in older pine stands where young growth has become well established. Provision is made for special cases.

Anonymous. 1953. **New Hampshire guides for improvement cuttings in immature stands.** Univ. N.H. Ext. Folder 26, 4 pp.

Guides used to judge the acceptability of improvement work under the Agricultural Conservation Program. An acre of unmerchantable stand containing 150 to 800 red or white pine crop trees 2 inches d.b.h., or the equivalent, may be improved by removal of competing hardwoods. How to do the work is discussed briefly. The costs should be between $8 and $25 per acre.

Baldwin, H. I. 1950. **Damage to advance reproduction in selective logging.** N.H. Forestry and Recreation Comn. Fox Forest Notes 46, 2 pp.

Selective cutting in a pine-hemlock stand, if done carefully, can conserve two-thirds to three-fourths of the advance conifer reproduction. Greatest injury occurred among trees 4 to 5 feet high. Small seedlings can be protected best if logging is done on snow. Hemlock was least susceptible to damage, white pine the most susceptible, and spruce intermediate.

Bertram, John. 1898. **The reproduction of white pine in North America.** Mich. Polit. Sci. Assoc. Pub. 3 (4): 121-125.

General observations on the reproduction of white pine and the way in which stands of overmature pine, mixed pine and hardwoods, and dense pine stands should be cut. In the latter two cases, clearcutting and burning is recommended.

Brown, R. M., and H. D. Petheram. 1926. **The conversion of jack pine to red and white pine.** Jour. Forestry 24: 265-271.

Jack pine invades sites originally occupied by better species and unless controlled becomes the dominant type on the lighter soils. This is one of the main management problems on the Minnesota National Forest. Studies of white pine and red pine reproduction were made in jack pine stands clearcut and uncut, but of various densities. Clearcutting perpetuates jack pine. Where seed trees are present, partial cutting will bring in red and white pine. A light cut will reduce the proportion of jack pine.

Burnham, C. F., M. J. Ferree, and F. E. Cunningham. 1947. **The white pine-oak forests of the Anthracite Region.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 8, 35 pp., illus.

The white pine-oak forests occupy a fifth of the forested area in Pennsylvania's Anthracite Region, but because of heavy cutting and fires they are in poor condition. Suggests measures needed to improve the productivity of these forests, and especially to increase the dwindling proportion of white pine.

Burnham, C. F., M. J. Ferree, and F. E. Cunningham. 1947. **The white pine-hemlock forests of the Anthracite Region.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 11, 25 pp., illus.

White pine-hemlock forests, found chiefly on well-drained slopes and along ravines, occupy less than 8% of the forest area in the Anthracite Region of Pennsylvania, but they contain 29% of the volume in saw-timber stands. Even so, they produce only half of what they could. Silvicultural treatments to improve the stands and to increase the proportion of white pine are suggested.

Burns, George P. 1933. **The effect of thinning on white pine reproduction.** Vt. Agr. Expt. Sta. Bul. 354, 24 pp.

From studies in two white pine stands on sandy soil near Burlington, Vt., it is concluded that white pine cannot be reproduced by natural methods or by any of the grades of thinning in practice. Under all conditions of thinning, a birch-red maple forest is the immediate result. But, when a thinned area is heavily pastured, the cattle keep down the hardwoods and white pine will dominate the reproduction. Where similar areas were planted, white pine in almost pure stands resulted.

Cary, Austin. 1924. **Notes from the white pine country.** Jour. Forestry 22: 49-52.

Observations in southwestern Maine on three white pine lots clearcut in the winters before, during, and after a seed year. The resulting reproduction is hardwood on the first, dense pine on the second, and well-stocked pine with some hardwood on the third. This points up the importance of making clearcuttings in seed years.

Chapman, Gordon L. 1954. **Cutting weed hardwoods increases woodlot yields.** Maine Univ. Forestry Dept. Tech. Note 30, 2 pp.

When weed hardwoods overtopping 700 to 1,000 spruce, fir, pine, and hemlock per acre on softwood sites can be cut profitably at 30 to 40 years of age, the additional released softwood growth can be looked upon as clear profit. If hardwood markets are not available the 500 hardwood weed trees per acre, averaging 4 inches in diameter, could be poisoned at a cost of $10 to $15 per acre. Allowing $3.50 per cord as a stumpage value of softwood pulpwood, this investment in stand improvement should be repaid by additional growth in 7 to 10 years.

Chapman, G. L., and N. W. McGowan. 1954. **A comparison of five commercially clear-cut white pine stands in southern Maine eight to thirteen years after cutting.** Maine Univ. Forestry Dept. Tech. Note 34, 5 pp.

Commercial clearcutting resulted in a relatively permanent forest type change in one instance and only minor and temporary changes in the other four. In three cases, however, it resulted in stands that will produce much lower yields in quantity and quality during the next rotation than could rightly be expected unless the situation is corrected by application of weedings and/or improvement cuttings in the near future.

Chapman, H. H. 1948. **(A review of) Red pine management in Minnesota.** Jour. Forestry 46: 775-778.

Primarily a discussion of regeneration of red pine with particular emphasis on the use of fire in regenerating both red and white pine. It is noted that a fire, just before seedfall, is the natural and most effective method of regenerating these species. (See also Eyre and Zehngraff, 1948).

Chapman, H. H. 1951. **More about pines and fire.** Jour. Forestry 49: 285-286.

It is noted that many years ago Fernow (1905), Zon (1912), and Frothingham (1914) published statements to the effect that properly timed and controlled fires can play a major part in obtaining reproduction of both red and white pine. The author's observations confirm these views.

Cline, A. C. 1924. **The group selection method with white pine.** Jour. Forestry 22: 128-134.

Cites the financial and silvicultural advantages gained by group-selection cutting beginning before the entire stand is merchantable, as compared to clearcutting. The woodlot is left in better condition for growth. Over a period of 23 years the group-selection method would have produced a profit four times as large as the investment, whereas the clearcutting would barely yield double the investment based on an operation on the Harvard Forest.

Cline, A. C. 1929. **Forest weeding, with special reference to young natural stands in central New England.** Mass. Forestry Assoc. and Harvard Forest, 19 pp.

States that weeding is the most profitable woods treatment. Detailed instructions are given for weeding various types of young stands. In general, the first weeding should be made 4 to 8 years after clearcutting. White pine and the better hardwoods should be released at the rate of 150 to 200 trees per acre. Only the stems overtopping the crop trees should be cut, leaving the rest as stand fillers. Weeding should be heavier in stands that follow clearcutting of hardwoods. White pine especially should be released in groups rather than as single stems.

Cline, A. C., and H. J. MacAloney. 1931. **A method of reclaiming severely weevilled white pine plantations.** Mass. Forestry Assoc. Bul. 152, 11 pp., illus.

Even severely weevilled plantations usually contain many codominant and intermediate white pines that are not badly deformed. About 200 of these per acre can be selected as crop trees. They should be released by girdling (single ax frill) the competing weevilled trees. If the crop trees are 3 to 7 inches d.b.h., they should be pruned to not more than one half their total height. The treatment should be carried out in about three operations at intervals of about 3 years.

Cline, A. C., and H. J. MacAloney. 1933. **Additional notes on the improvement of weevilled white pine plantations.** Conn. Forest and Park Assoc. Pub. 24, 11 pp., illus.

Field studies showed that tree deformation by weevilling is much more severe when the weevil kills two internodes rather than one. It is suggested that the removal of weevilled leaders with the double objective of reducing weevil population and weevil damage may be a profitable undertaking.

Condit, G. R., M. A. Huberman, and John R. McGuire. 1942. **Collect the bounty on your wolf-trees.** Jour. Forestry 40: 680-682, illus.

Wolf-trees are white pines with heavy, wide-spread crowns and other deformities that give them a low product value. Sample strips in pine woodlots in southwestern Maine showed that there were more than six such trees per acre and that they occupied 13% of the area. These wolf trees hold back the growth of straight young trees of good species and potential fast growth. Release of these trees and seedlings can be done profitably by sale of products from the wolf trees.

Cook, David B., and Lawrence S. Hamilton. 1953. **Chemi-peeling pulpwood in New York.** Jour. Forestry 51: 566-569, illus.

Discusses advantages and disadvantages of chemi-peeling and describes the technique of using an ax for the girdle and a bucket and brush to apply the sodium arsenite solution to the girdle. White pine treated in June to early August will show bright foxy-red foliage in 7 to 14 days. The bark will peel well in October and will come off easily the following spring. White pine should be peeled as early as possible to avoid insect damage and blue stain.

Coulter, L. L., and R. A. Ralston. 1954. **Aerial spray tests with 2,4,5-T for scrub oak control in lower Michigan.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Notes 424, 1 p.

Results 2 years after one test and 1 year after another indicate that jack, red, and white pines can be effectively released from scrub oak overstory by an aerial spray in August of 1 pound 2,4,5-T acid equivalent in 2.25 gallons of oil and water per acre. The pines were not damaged by August spraying. Most of the scrub, red, and northern pin oaks, and the scattered red maples, pin cherries, and juneberries were killed.

Downs, Albert A. 1943. **Response of eastern white pine reproduction in the southern Appalachians to liberation.** Jour. Forestry 41: 279-281.

Liberation of eastern white pine reproduction from a decadent hardwood overstory resulted in 17 to 62% greater height growth than on check plots; smaller stems showed greater response. After treatment, damage to pine reproduction by falling limbs or snags was slight. For trees under 11 inches in diameter, poisoning was somewhat more effective than girdling for reducing sprouting of oaks and hickories but not of sourwood, which grew back to menace white pine reproduction.

Egler, F. E. 1949. **Herbicide effects in Connecticut vegetation, 1948.** Ecology 30: 248-256.

The third report on a project at Aton Forest, Conn. Reports early results from the application by various methods of different mixtures and concentrations of 2,4-D, and 2,4,5-T to 116 species. Bark painting, which is cheaper than trunk-wound painting, affected white pine, through complete kill has not yet been verified.

Engle, LaMont C. 1951. **Releasing white pine from oak and aspen.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 346, 2 pp., illus.

As appraised after 8 years, success in releasing white pine from oak and aspen overstorys depends primarily on the height of the pines when released. When 1 foot high and 4 years old, released pines were soon overtopped and needed to be released again. Those 5½ feet high and 19 years old, while sometimes overtopped, are still growing well and should not need another release. Pine 8½ feet high and 22 years old remained above the surrounding sprouts to compete successfuly.

Fisher, R. T. 1918. **The yield of volunteer second growth as affected by improvement cutting and early weeding.** Jour. Forestry 16: 493-506.

After logging, at least 20% of the central-hardwoods region is well stocked with white pine and valuable hardwood reproduction. But these better species seldom are able to compete without help. Many of the older cut-over stands are still dominated by gray birch and aspen after 40 years or more. It is imperative that an improvement cutting be made by the 20th year, and earlier on good sites, if the stand is to yield a substantial percentage of white pine and valuable hardwoods.

Fisher, R. T., and E. I. Terry. 1920. **The management of second-growth white pine in central New England.** Jour. Forestry 18: 358-366.

A brief review of management results on the Harvard Forest and the results of cutting practices on some 54 cut-over pine lots in central New England. Clearcutting in the fall or winter of a seed year is the best and cheapest means of reproducing white pine. Strip and patch cutting have had variable results. Selection cuts are not applicable. The surest method of reproduction is the two-cu,t shelterwood, which has consistently given the best reproduction and is standard practice on the Harvard Forest except in seed years.

Foster, Clifford H. 1954. **The use of silvicides to establish white pine by natural reproduction.** Northeast. Weed Control Conf. Proc. 8: 415-419.

Timely application of the new chemicals shows promise as an economical and satisfactory solution to the competition problem in pine regeneration. An example on the Pack Forest is described in which a poor mixed-hardwood stand is being reproduced to pine from the available seed source. The site was prepared by 2,4,5-T and 2,4-D in oil basal spray of the small advance hardwoods, deadening of pulpwood trees with sodium arsenite, and a heavy cutting of most of the overstory hardwood in a pine seed year.

Fraser, J. W., and J. L. Farrar. 1955. **Strip-cutting in a mixed pine stand.** Canada Forestry Branch Tech. Note 1, 17 pp., illus.

In 1934 a mixed stand of 80-year-old jack pine with a 47-year-old understory of red and white pine was strip-cut in 1- and 2-chain wide strips. One-chain wide strips were left uncut until 1942 when they were partially cut for poles and saw-logs. The sites were considered average for mixed pine. In 1949 and 1950 all areas had at least 60% stocking of white pine reproduction.

Geerinck, Paul A., Willis A. Getchell, and Gordon L. Chapman. 1954. **Response to release of under-planted white and red pine.** Maine Univ. Forestry Dept. Tech. Notes 29, 2 pp.

White pine and red pine planted in alternate rows on a well-drained site under a young birch-maple-aspen stand responded well to a full release made 7 years later. The response of white pine was better than that of red pine. Plots released only lighly or not at all did not show satisfactory growth of pines. Thus, pine should not be planted under such stands until a merchantable cut can be made to release them within a few years.

Hutchinson, Wallace I. 1902. **Treatment of second-growth white pine.** Forestry and Irrig. 8: 319-323, 370-373.

Brief directions for the thinning, pruning, and reproduction of second-growth white pine. Natural stands are generally preferred over planted ones; thinning from below will encourage fastest growth and most rapid turnover of the forest. Pruning should be done carefully with an ax, but not beyond 8 feet. Heavier thinnings beginning about the 30th year will encourage reproduction to replace the stand when it is clearcut in about the 40th year—preferably a seed year.

Littlefield, E. W. 1952. **The pitch pine is dead—long live the white pine!** N.Y. Conserv. 7 (2): 24-25.

A brief discussion of the rehabilitation of pitch pine barrens by the release of natural or planted white pine in the understory. In two examples from eastern New York it is shown that, 4 years after the pitch pine was girdled, the white pine was growing well and was free from weevilling.

Logan, K. T. 1950. **Influence of thinning on reproduction beneath a red and white pine stand.** Canada Forestry Branch Silvic. Leaflet 50, 3 pp.

In this 45-year-old stand on a medium site, thinnings have increased the survival rate of seedlings and resulted in a slight improvement in growth of white pine seedlings. The amount of white pine reproduction has increased only after heavy thinnings, which have not affected reproduction of red pine.

Logan, K. T. 1951. **Effect of seedbed treatment on white pine regeneration.** Canada Forestry Branch Silvic. Leaflet 54, 2 pp.

A 10-year test indicated that seedbed treatment on a medium site under a 55-year-old stand of crown density 70% was beneficial to pine regeneration. With both artificial and natural seeding, a heavy burn, which exposed mineral soil, was very effective, while litter removal by raking and hacking, which exposed mineral soil, was good only when there was sufficient seed (artificial seeding). Light burning was not very successful.

Lutz, R. J., and A. C. Cline. 1947. **Results of the first thirty years of experimentation in silviculture in the Harvard Forest, 1908-1938. Part I. The conversion of stands of old field origin by various methods of cutting and subsequent treatments.** Harvard Forest Bul. 23, 182 pp.

Discussion of a series of case histories, mainly of old-field white pine, grouped according to soil characteristics. These experiments showed that pine would be very difficult to maintain, so later weeding and thinnings favored the better hardwoods rather than the pine. Better stands might have resulted had this practice been started earlier.

McKinnon, F. S., G. R. Hyde, and A. C. Cline. 1935. **Cut-over old field pine lands of central New England.** Harvard Forest Bul. 18, 80 pp., illus.

Some 226 stands in central Massachusetts and southern New Hampshire were examined to determine the relations between present stand conditions and the character of the preceding old-field pine stand, site quality, and other items of stand history. The silvicultural aspect of the results are discussed and recommendations are given for various situations.

Miller, William D. 1934-35. **The effect of weeding on the survival and growth of white and red pine.** Jour. Forestry 32: 1021-1022; 33: 87.

Plantations set out in 1916-17 were weeded 2 to 8 years later; the results in 1931 are given. White pine survival was not affected, but growth was increased 75 to 200% in diameter and 35 to 50% in height, despite heavy weevilling after the weeding.

Morton, Nathaniel. 1898. **Fixing up a woodlot in Massachusetts; trimming white pine.** Forester 4: 125-127, 145-146.

Discusses early experiences with pruning, weeding, and growth of white pine in Plymouth, Mass. Pruning was best done with an ax or drawshave, cutting into the bark all round the knot. Oak stumps may be killed by pounding the frozen sprouts in winter about 4 years after cutting. Hardwood covers should be left for pine seedlings until they are 4 years old but then should be removed. A tract handled in this way became well stocked with thrifty young white pine.

Northeastern Forest Experiment Station. 1945. **Guide for cutting eastern white pine.** U.S. Dept. Agr. AIS-7, 8 pp., illus.

Guide for merchantable stands (2,000 board-feet per acre cut) in which at least half the trees 6 inches d.b.h. or larger are white pine. Not more than 60% of the merchantable volume should be cut. The remaining stand should contain (about 40 feet apart) some trees 10 inches d.b.h. or larger. Another cut can be made in 15 years. Several log rules are supplied and simple cruising methods are described.

Robertson, W. M. 1945. **Succession cutting in pine.** Canada Forestry Branch Silvic. Res. Note 74, 8 pp.

At Petawawa Experiment Station a 70-year-old overstory of jack pine was removed to release the succession stand of young (37 years old) white and red pine. Diameter growth was greatly stimulated; height growth was slightly retarded. Volume growth increased from 1.1 to 4.5%; this large increase occurred almost entirely in immature red and white pine, the jack pine being unaffected. Much more important is the improvement in quality increment, from the transfer of growth from mature jack pine to immature white and red pine.

Robertson, W. M. 1946. **Selection cutting in pine.** Canada Forestry Branch Silvic. Res. Note 80, 6 pp.

This study was undertaken to evaluate the effects of selective cutting to crown densities of 80, 40, and 20% and clearcutting in strips in a two-aged stand of jack, white and red pine where the overstory, mainly jack pine, was overmature. Records were taken on a series of seven permanant sample plots over a period of 6 years. It would seem that succession cutting is the most desirable method of treating such two-aged stands.

Sarles, R. L. 1953. **Chemical bark peeling of white pine by applying sodium arsenite in September.** Ohio Agr. Expt. Sta. Forest Mimeo. 4, 2 pp., illus.

In a small-scale test white pine was successfully treated with sodium arsenite as late as September 24. Complete separation of the bark from the wood was obtained within 4 months of treating.

Schantz-Hansen, T. 1937. **The response to full release of white pine planted under jack pine.** Jour. Forestry 35: 263-265.

An open jack pine stand on very light soil was underplanted with white pine spaced 6 x 6 feet. Survival was good and 11 years later the white pine averaged about 4 feet in height. At that time the jack pine was cut from part of the area. The white pine showed response to release the third year after cutting. Ten years after release, the white pine averaged 13.6 feet high, and 50% of the trees were weevilled. On the uncut plot, the white pine was 10.7 feet high but only 8% of the trees were weevilled.

Smith, David M. 1951. **The influence of seedbed conditions on the regeneration of eastern white pine.** Conn. Agr. Expt. Sta. Bul. 545, 61 pp., illus.

This comprehensive report shows that few seedlings die from deficient soil moisture. The author concluded that regeneration was best where there is a minimum of direct light and a maximum of diffused light reaching the forest floor. Once established, seedlings grow well only in full sunlight.

Smith, Lloyd F. 1940. **Factors controlling the early development and survival of eastern white pine in central New England.** Ecol. Monog. 10: 373-420, illus.

Germination, survival, and early growth of white pine seedlings were studied experimentally on similar sites under white pine stands representing full shade, and full light conditions. Solar radiation, surface temperature, soil temperature, and soil moisture were important to seedling development and were most affected by stand conditions. Concludes that shelterwood or small group cuttings with slash and litter dispersal are the best ways to regenerate white pine in New Hampshire.

Society of American Foresters, New England Section. 1944. **Recommended forest practice standards for New England.** Jour. Forestry 42: 716-725.

The forests of the white pine-transition hardwoods region vary widely as to stocking and composition. They are generally in a depleted and deteriorated condition caused by cuttings, fires, and insect and disease depredations during the last 50 years. Recommends that some form of partial cutting be the standard practice for this region.

Society of American Foresters, New England Section. 1930. **(Comments on) Report of the committee on the improvement of composition of stands with special reference to release cuttings.** Jour. Forestry 28: 1164.

The committee argues that release cutting offers the most profitable field in silvicultural operations. Girdling hardwoods increased growth on the spruce or pine under them; girdling worthless hardwoods to increase growth on merchantable softwoods promised the best financial returns. Where there is an adequate number of crop trees, release cutting (either weeding or girdling) will produce a more acceptable stand at less cost than planting.

Spaeth, J. Nelson. 1922. **Notes on the release of white pine in Harvard Forest, Petersham, Mass.** Jour. Forestry 20: 117-121.

On abandoned farmlands in central New England, white pine must compete with hardwoods that not only shade out the pine but also hinder growth by whipping the pines' terminal and lateral buds. Red maple is the worst competitor. Recommends release cuttings between 10th and 25th years to favor pines.

Stickel, Paul W. 1930. **Artificial vs. natural replacement on blight-killed chestnut land.** Jour. Forestry 28: 572-573.

Studies of sample plots on typical land where chestnut was blight-killed indicate that artificial replacement of the chestnut with white pine has been successful within 10 years. On plots where replacement has been natural, less than half the stand has commercial value. Weeding aids materially in the growth of planted stock.

Stoeckeler, Joseph H. 1947. **When is plantation release most effective?** Jour. Forestry 45: 265-271, illus.

Tests of the release of white, red, and jack pine in the Lake States showed a marked advantage in cutting aspen suckers and sprouts in late June, or just after the leaves attain full growth. The effective period continued to early August. Cuttings made in winter or early spring resulted in higher densities and more vigorous sprouts. Cutting in summer (one cut) saved at least one release operation in pine plantations.

Swain, Lewis O. 1954. **Economical tree killing.** N.H. Univ. Agr. Expt. Sta. Bul. 408, 15 pp., illus.

Small blotting-paper tabs containing about ½ gram of sodium arsenite are effective and economical tree killers when inserted in a pocket between the bark and the wood of the tree. A small peeling spud used to make the pocket is described. White pine is easy to kill and may be treated in any season.

United States Forest Service. 1945. **Proposed guides to minimum forest practices.** U.S. Forest Serv. Region 9, 17 pp.

Includes guides for red and white pine types of the Lake States: desirable residual stocking levels and cutting intensities for stands less than 125 years old and for stands more than 125 years old. Adequate levels of stocking for reproduction on cut-over lands are given.

Young, Leigh J., and Francis H. Eyre. 1937. **Release cutting in plantations of white and Norway pine.** Mich. Acad. Sci. Arts and Letters, Paper 22: 301-320.

Studies in Michigan and Minnesota indicate that white pine benefits during early years from overhead shade, especially on dry sandy soils, but to insure good growth, should be released as soon as it is well established. Response is prompt and roughly proportional to the degree of release. But a clearcutting of the overstory will over-expose suppressed pines and afford no protection against the white-pine weevil. Prolific sprouting in cut stands will destroy the underplanted white pine.

THINNING : PRUNING

Anonymous. 1930. **Much-thinned pine stand superior in volume.** U.S. Forest Serv. Forest Worker 6 (5): 17.

A 47-year-old stand of northern white pine at Durham, N. H., that had been thinned annually for the last 18 years had a greater volume than a comparable unthinned stand containing more than twice as many trees. Average annual diameter growth was twice as great in the thinned stand as in the unthinned stand and the trees were taller, of better quality, and more thrifty.

Adams, W. R., and M. R. Schneller. 1939. **Some physiological responses to close pruning of northern white pine.** Vt. Agr. Expt. Sta. Bul. 444, 26 pp., illus.

Only 13.6% of the dead branches pruned through the branch base showned callus formation on the face of the pruned stub, but this was six times the number when the branch base was not cut. When living branches were cut through the branch base the initial callus response was nearly perfect but less than 20% of the stubs showed callus when the branch base was uninjured. The cell composition of the callus and changes during formation are described. Recommends pruning with pruning saw and ladder (if necessary) between October and June for best healing.

Adams, W. R., and G. L. Chapman. 1942. **Competition in some coniferous plantations.** Vt. Agr. Expt. Sta. Bul. 489, 26 pp.

The 28-year-old plantations examined included some white pine planted at three densities (2 x 2 feet to 8 x 8 feet) on poor loamy sands in the Champlain Valley. White pine grew satisfactorily on this site and expressed dominance even in the densest stands, but adequate thinning to reduce competition is essential for the production of crop trees with good form and maximum wood volume.

Barrett, Leonard I., and Albert A. Downs. 1943. **Growth response of white pine in the southern Appalachians to green pruning.** Jour. Forestry 41: 507-510.

In a test of three degrees of pruning with 376 trees it was found that about 30% of the number of living whorls may be pruned without seriously reducing height or diameter growth; and that smooth flush cuts without splinters or breaks are important for rapid healing and quick production of clear lumber. The trees used in this test ranged from 2 to 7 inches d.b.h.

Behre, C. E. 1932. **Change in form of red spruce after logging and of northern white pine after thinning.** Jour. Forestry 30: 805-810, illus.

Young even-aged stands of white pine that have been heavily thinned from below generally show an average increase in form quotient. The change of form after cutting is closely correlated with the form quotient at time of cutting.

Bickerstaff, A. 1942. **The size of tree in pruning.** Canada. Dept. Mines and Resources, Dom. Forest Serv. Cilvic. Leaflet 9, 2 pp.

If trees are pruned when small (3 to 4 inches in diameter), pruning will be easier, scars will occlude more rapidly, and a greater proportion of clear lumber will be produced in the butt log in a given time or at a given size than if pruning is deferred. The practice at Petawawa is to prune to 7 feet, then 12 feet, and finally to 17 feet in three operations, keeping the knotty core to about 4 inches in diameter.

Bissell, Lewis P., and Gordon L. Chapman. 1952. **Increased yield from thinnings in a natural white pine stand.** Univ. Maine Forestry Dept. Tech. Note 14. 2 pp.

Records over 16 years in a 40-year-old stand where two ¼-acre plots were laid out (one thinned and the other unthinned) show that thinning stimulated growth but that after 10 years or so its effect was gone and another thinning should have been made.

Butler, O. M. 1925. **The pine pruner of Holderness.** Amer. Forests and Forest Life 31: 92-94, illus.

An account of the operations of O. M. Pratt of Holderness, N. H., who managed about 1,000 acres of pine for about 20 years. He pruned white pine to 16 feet when 3 to 4 inchest in diameter, usually after the stand had been thinned. A crosscut saw on a short pole was used to cut both live and dead limbs flush with the trunk.

Clapp, R. T. 1936. **First thinning in white pine plantations.** Jour. Forestry 34: 928-935.

Nearly 30 acres of plantation 26 to 38 years old in the Eli Whitney Forest, near New Haven, Conn. were commercially thinned for the first time. About 100 trees per acre were removed in the dense stands; these cuttings yielded as much as 1,800 board feet of 8- to 12-foot logs per acre. Lighter cuttings were made in the lighter stands, where the average yield was 836 board feet per acre. The author recommended a second thinning in the same stands in 5 to 10 years. Only a small profit resulted from the first thinning.

Cline, A. C., and E. D. Fletcher. 1928. **Pruning for profit as applied to eastern white pine.** Mass. Forestry Assoc. 23 pp.

Pruning small straight trees with small limbs is profitable, but badly weevilled trees or those with large limbs should not be pruned. Dominant trees that are to be retained for the final harvest should be selected for pruning when 3 to 4 inches d.b.h.

Cook, David B. 1951. **Justifications for forest pruning in the northeast.** Jour. Forestry 49: 487-489.

Pruning stimulates quality production (of any forest product) and this is a primary aim of forest management. Pruning increases stumpage values, helps protect the market for forest products, reduces logging and processing costs. It improves fire protection and soil conditions, improves the wildlife habitat, helps prevent infection by white pine blister rust and certain cankers, and provides off-season labor for forest labor forces.

Curtis, James D. 1936. **A method of pruning dead branches.** Forestry Chron. 12: 291-299.

Although no final conclusions can be drawn from the results obtained in this study, it would seem that in so far as the formation of callus is concerned, pruning dead branches close to the trunk so as to cut through and expose green tissue gives promising results after 1 year's growth.

Downs, Albert A. 1944. **Growth of pruned eastern white pine.** Jour. Forestry 42: 598.

The conclusions of Barrett and Downs (1943) were confirmed by data taken on the same study 3 years later. Eight years after treatment there were no statistical differences in height or diameter growth among three degrees of pruning. Pruning of 26 to 35% of the live branch whorls can be safely used with white pine. Total loss of diameter growth as a result of such pruning was about 1/10 inch.

Foster, Clifford H. 1929. **Thinnings in natural stands.** Jour. Forestry 27: 804-806.

Urges that thinning in young natural softwood stands supplant the common practice of clearcutting. By proper thinning, the financial rotation can be extended, which will mean less risk from destructive agencies in young stands, and will increase crop value and attractiveness of the investment. Logging costs will be decreased.

Frothingham, E. H. 1942. **Twenty years' results of plantation thinning at Biltmore, N.C.** Jour. Forestry 40: 444-452.

Concludes that light thinnings from below are porfitable because they salvage material that would die and also increase growth in both volume and quality. Heavy thinnings are to be avoided because they reduce net growth rather than increase it. The white pine plantations studied are now 40-45 years old and have been thinned four times. Based on several very small but uniform plots.

Glattfelter, Calvin F. 1952. **Report on bud-pruning of forest trees.** Pa. Dept. Forests and Waters 4: 52-53, 71, illus.

White and red pine and Japanese larch were bud-pruned for 3 years with little mortality or damage. White pine could be bud-pruned at the rate of 54 to 90 trees per man-hour, but there are indications that pruning of 1-year-old twigs is more efficient. White-pine weevil damage increased in both pruned and unpruned parts of the plantation.

Hawley, Ralph C. 1922. **A progress report of the results secured in treating pure white pine stands on experimental plots at Keene, New Hampshire.** Yale Univ. School Forestry Bul. 7, 32 pp.

Plots for study of repeated thinnings and a check plot were established in 1905 in a 35-year-old white pine stand on sandy site III soil. Three thinnings have been made in the 15-year period reported. The results show a reduction of 70% in tree numbers, concentration of growth on fewer and larger stems, salvage of mortality and increase in volume growth. A study of successful regeneration following two thinnings and harvest cutting by the shelterwood method in a 48- to 61-year-old stand is described.

Hawley, Ralph C. 1936. **Observations on thinning and management of eastern white pine (*Pinus strobus* Linnaeus) in southern New Hampshire.** Yale Univ. School Forestry Bul. 42, 16 pp., illus.

Third report on thinned and check plots established in 1905 near Keene, N. H., and remeasured over a 30-year period. Describes expermental area, treatments, and results. Increased diameter growth of 80 largest trees on thinned plot was compared with 80 largest on check plot. The height growth was not changed by thinning. However, volume growth in board feet did increase. Better financial returns resulted from early thinnings. Suggests plans for silvicultural operations to grow even-aged white pine crops on sandy soils.

Hawley, Ralph C., and Robert T. Clapp. 1935. **Artificial pruning in coniferous plantations.** Yale Univ. School Forestry Bul. 39. 36 pp.

Describes in detail the technique of pruning and presents data on costs and physical results. Recommends pruning 150 to 200 trees per acre in white pine plantations.

Knapp, F. B. 1913. **Silviculture of white pine (*Pinus strobus*).** Mass. Forestry Assoc. Bul. 106, 4 pp.

Mostly a discussion of pruning. Based on experiments of Nathaniel Morton in Plymouth, Mass., by the Eric Forest School and by O. M. Pratt of Holderness, N. H. The "Eric" method is described: prune early and often to develop one clear log with 4-inch knotty core. Gives estimates of tree size at start and end of pruning, growth, and returns.

Lorenz, R. W. 1948. **Thinning returns from an eastern white pine plantation in Ogle County.** Ill. Acad. Sci. Trans. 41: 39-42.

Results of studies made in four ¼-acre sample plots to determine yields and net stumpage from thinnings made at 34 and 39 years of age. The first thinning yielded (per acre) 390 fence posts and 1,600 board feet of lumber with a total stumpage of $77. The second thinning yielded 450 posts and 860 board feet, a total stumpage of $122 per acre.

Meyer, W. H. 1940. **Pruning natural pine stands.** Jour. Forestry 38: 413-414.

In a mixed pine-hardwood stand about 225 white and red pine (half the total number of stems) per acre were pruned to an average length of 14.7 feet. The trees pruned were 3 to 6 inches d.b.h. The most efficient tools were a 7-point, 14-inch saw on a 7-foot pole for the first 12 feet and a 5-point, 18-inch saw on a 14-foot pole for higher pruning.

Mollenhauer, Wm. J. 1938. **Tools and methods in an experimental pruning of white pine.** Jour. Forestry 36: 588-599, 812, illus.

Of 21 tools, the pole ax used as a mace proved most efficient for pruning dead branches from white pine boles up to 7 feet high. The use of edged tools generally resulted in low efficiency and high hazard to worker and to trees. For bole heights above 7 feet, hand saws were easiest and safest to use; standard pull-stroke models were superior to double-edged saws. Pole saws and pole shears were unsatisfactory. Climbing to desired pruning height and working downward was superior to methods requiring ladders.

New York Conservation Department. 1937. **Thinning recommendations based on study of diameter growth in plantations.** N.Y. Conserv. Dept. Notes on Forest Invest. 1, 1p.

Diameter growth in two successive 5-year periods on 5 unthinned and 2 thinned plots representative of 95 plots studied is presented to show that thinning in 10- to 20-year-old plantations will help prevent falling-off of diameter growth.

New York State Conservation Commission. 1939. **29th annual report.** 65 pp. N.Y. Conserv. Dept.

A relatively cheap method of thinning a 4- by 4-foot white pine plantation is the removal of every third row, and this appears to be the best practical way of admitting light, air, and hardwoods into a closed softwood stand with the object of preventing an accumulation of undecomposed needle litter, a condition known to be detrimental to plantation development.

Paul, Benson H. 1933. **Pruning forest trees.** Jour. Forestry 31: 563-566.

A brief review of pruning investigations and of the most important things remaining to be learned. Pruning of eastern white pine may be especially profitable because of the very poor natural pruning in this species. Pruning programs should be flexible and methods should be carefully chosen in the light of labor requirements.

Rich, J. Harry. 1954. **Dividends from pruning forest trees.** Mass. Univ. Ext. Serv. Leaflet 272, 8 pp.

Scattered information on white pine growth rates, healing rate of pruning scars, costs of pruning, and white pine lumber prices is drawn together. These data are used in examples to calculate the increased lumber values resulting from pruning and the relation that the increased lumber value bears to the cost of pruning. Shows how to determine costs and returns.

Sechrist, William C. 1939. **Profitable utilization of white pine thinnings.** Jour. Forestry 37: 232-235.

Trees 4 to 9 inches d.b.h. were cut into billets and run through a shingle mill to produce shingles and boxboards. The equivalent of about 4 standard cords per acre were produced. Detailed cost records are given and the operation was termed profitable. Markets for small material must be developed if thinnings from such plantations are to be utilized profitably.

Smithers, L. A. 1954. **Thinning in red and white pine stands at Petawawa Forest Experiment Station.** Canada Forestry Branch Silvic. Res. Note 105, 52 pp., illus.

Explores relationships between intensity and frequency of thinning, site class, and most stand characteristics in natural and planted white and red pine stands. Thinnings can be economical if they are begun early (about 30 years of age) and are light but frequent. The thinnings should be well distributed and should favor the growth of specified numbers of crop trees (preferably red pine). Site class yield tables are given for fully stocked stands and for stands in which the suggested thinning regimes are carried out.

Stevenson, Donald D. 1946. **Thinnings in the white pine plantations, Biltmore, North Carolina.** Jour. Forestry 44: 763-765, illus.

Describes a commercial pulpwood thinning in a 46-year-old white pine plantation that had been established with 4,000 trees per acre, of which 600 were left. Thinning reduced the number to 200 trees, all vigorous, well-formed, and in the dominant or codominant crown class.

Wahlenberg, W. G. 1953. **A 37-year test of thinning Appalachian white pine.** South. Lumberman 187 (2345): 180-183, illus.

White pine of uncertain seed source was planted in 1899 on an old orchard site that had eroded badly. Six thinnings (begun at 20 years old) were made at about 7-year intervals. Compared to the unthinned portion of the stand, the thinned portion had in 1953 an additional yield (including the thinnings) of 14 cords of wood and 6.4 thousand board-feet of sawlogs. The difference in stumpage value was nearly $200. Crown ratio is the best single criterion of tree development in the ensuing 10 years and is a practical marking guide.

Wave, Herbert E., David F. Wentworth, and G. L. Chapman. 1952. **A pruning time study for spruce and white pine in uneven-aged natural stands.** Maine Univ. Forestry Dept. Tech. Note 15, 2 pp.

In mixed stands of spruce and white pine where intensive management is possible, pruning to a height of 18 feet with hand and pole saws compares favorably in cost with pruning in plantations. It took 2¾ minutes per tree to prune white pines and 3½ minutes walking time between them. Only two to five trees per acre were pruned and they averaged 7 inches in diameter. Pruning spruce took two to three times as long as pruning pine.

Young, Leigh J. 1931. **Results of thinning in white pine.** Mich. Acad. Sci. Arts, and Letters, Paper 15: 337-348.

A 3 x 3 white pine stand was thinned 11, 21, and 26 years after planting by the Danish system to remove all neutral and injurious secondary trees. In a 4½ x 4½ stand, grade C thinnings were made 21 and 26 years after planting. The thinnings have made only very moderate increases in diameter and current volume growth. Computation of "distance factors" for these plots and some at Keene, N. H., show the relative weight of thinning.

Adams, W. R., Jr., and G. L. Chapman. 1942. **Crop tree measurements in thinning experiments.** Jour. Forestry 40: 493-498.

Analysis of growth measurements on 2,200 trees in thinned plots of a 27-year-old white pine plantation showed that the percentage basal-area growth of the total stand was increased by thinning from above and from below. However, among selected dominant crop trees, thinning made little difference.

Barrett, L. I. 1936. **Recent volume tables for some southern Appalachian species.** U.S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 19, 49 pp.

Includes volume tables for white pine on site class I, based on data from the Pisgah National Forest. Volumes are expressed in board feet, Scribner Decimal C log rule, for trees 10 to 36 inches d.b.h., one table giving volumes by ½-log height classes from one to four logs, the other giving both gross and net volume for trees of average height by diameter classes.

Bedell, G. H. D. 1948. **Form-class of white pine and jack pine as affected by diameter, height, and age.** Canada Forest Serv. Silvic. Res. Note 89, 11 pp.

Analysis of form-class data is described and discussed and tables of form class are presented. Those for white pine cover a range in age from 25 to 200 years, in height from 20 to 120 feet, and in d.b.h. from 1 to 30 inches. The form class itself ranges from 48 for the youngest and shortest trees to 79 for small old trees.

Bickford, C. Allen. 1951. **Form-class volume tables for estimating board-foot content of northern conifers.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 38, 38 pp.

The Mesavage-Girard form-class volume tables are not applicable to northern conifers. These new tables for pine, spruce, fir, hemlock, and cedar fill the need for comparable tables for these species. Volumes given in board feet International ¼-inch rule for trees 10 to 30 inches d.b.h., 1 to 5 logs in merchantable height, and with form class from 65 to 86.

Canada Forestry Branch. 1944. **Interpolated volume tables (total volume) for use in compilation of sample plot data.** Canada Forestry Branch Misc. Ser. 3. (n.p.)

For every inch of diameter and for each foot of height, total cubic-foot volumes are given for several species. The white pine tables are for trees up to 20 inches d.b.h., up to 100 feet high, and with form class 65 and 70.

Canada Forestry Branch. 1953. **Provisional form-class volume tables for Ontario log rule.** Canada Forestry Branch. (n.p.)

These tables use the same data and are an extension of the tables described above. Includes board-foot volumes for white pine trees with form classes 65, 70, and 75, diameters from 6 to 20 inches, and total height from 30 to 90 feet.

Cook, H. O. 1908. **Handbook on forest mensuration of the white pine in Massachusetts.** 50 pp. Boston.

Tables of the volume and growth of trees and stands in Massachusetts are given. Yield tables of volume, stumpage, and lumber value for three site qualities. Financial rotations are tabulated, as are yields from thinnings. The measurement of trees, stands, and round- and square-edged lumber are described.

Demeritt, D. B. 1952. **Second-growth white pine volume tables—southwestern Maine.** Maine Univ. Forestry Dept. Tech. Note 18. 5 pp.

The tables give volumes in board feet by the Maine rule, International ¼-inch rule, and Scribner rule, in cubic feet and in peeled cords. Volumes are given from 1-foot stump to a 6-inch top diameter. Volumes for trees 8 to 31 inches d.b.h. and 40 to 110 feet in total height are given.

Gevorkiantz, S. R., and L. P. Olsen. 1951. **Bark percent in Lake States trees.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 362, 1 p.

Gives regional averages for the major species. White pine poletimber has a bark percentage of 14; in second-growth sawtimber it is 16%, and in old-growth sawtimber 18%.

Hampf, Frederick E. 1954. **Relationship of stump diameter to d.b.h. for white pine in the northeast.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Forest Res. Note 38, 4 pp.

Data from wood-utilization studies in 10 states were used to construct a graph for estimating d.b.h. in inches from stump height and diameter.

Hepting, George H., Elmer R. Roth, and Bailey Sleeth. 1949. **Discoloration and decay from increment borings.** Jour. Forestry 47: 366-370.

Increment borings in white pine resulted in pitch-soaked streaks about 3 inches long.

Hicock, H. W., A. D. Rhodes, and A. R. Olson. 1939. **Volume tables for plantation-grown white pine (*Pinus strobus* L.) in Connecticut.** Conn. Agr. Expt. Sta. Bul. 427. 14 pp.

Total volume in cubic feet and merchantable volume in cubic feet, board feet (International ¼-inch rule) are given in tables and alinement charts for trees 2 to 16 inches d.b.h. and 15 to 65 feet in total height, except that board-feet are shown only for trees 6 to 13 inches d.b.h. and 25 to 60 feet in total height.

Hough, A. F. 1932. **Some diameter distributions in forest stands of northwestern Pennsylvania.** Jour. Forestry 30: 933-943.

White pine in northwestern Pennsylvania was found to be even-aged in second-growth stands and essentially even-aged in virgin stands; but stand graphs based on the entire mixture of species are misleading when used to estimate age conditions in such stands. Age conditions on areas cut in the past may be inferred from stand-distribution graphs by species.

Johnson, F. A., and J. R. Crawmer. 1941. **Volume tables for eastern white pine (*Pinus strobus*) in Holmes County, Ohio.** U.S. Forest Serv. Central States Forest Expt. Sta. Tech. Note 35, 1p.

Volume of the merchantable stem to a variable top diameter is given in board feet (International ¼-inch rule) for trees 7 to 28 inches in diameter and for one to seven 12-foot log lengths. Based on measurements of 96 trees.

Kittredge, J. 1944. **Estimation of the amount of foliage of trees and stands.** Jour. Forestry 42: 905-912, illus.

In a discussion of foliage estimation, white pine data published by Adams (1928), Burger (1929), and Burns and Irwin (1942) are among those used to show the relationship between weight of foliage and volume growth of wood. The same data are used to show a simpler method of estimating foliage weight from tree diameter, where log W = b log D-a. The regressions are all significant.

Lake States Forest Experiment Station. 1936. **Bark thickness of saw-timber trees in Michigan.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 108, 1 p.

The double-bark thickness of white pine in percentage of total diameter is shown to be 10.5% at d.b.h. and 7.5% at 18.3 feet above the ground.

Lyon, Charles J. 1953. **Vertical uniformity in three New England conifers.** Tree-Ring Bul. 20(2): 10-16, illus.

Cross-sections were cut at various heights in a red spruce, a hemlock, and two white pines, all grown in northern New England. One pine was sectioned at 5-foot intervals and the other at 8-foot. The graphs of the ring widths indicate a high degree of uniformity in the sequence of growth rings at different levels in the trees, except those levles well into the crown. Standard correlation coefficients were computed for each species for the period since 1850, using 25-year periods to offset growth trends with changing age. The coefficients for white pine are all positive and highly significant. White pine is consistently the most uniform for relative ring width at different trunk levels and in different 25-year periods.

MacDonald, James. 1932-33. **The form of the stem in coniferous trees.** Forestry 6: 53-62, 143-153; 7: 32-42, illus.

Percentile tapers and comparisons of the percentile measurements with those of the Hojer-Jonson, Hojer, and Behre theoretical stem-form curves are given by form classes for many species, including white pine (19 trees measured). The measurements from these few trees did not conform very well to the theoretical curves, but they are close to those given by Gevorkiantz and Hosley (1929). When root swell is eliminated, all the species are essentially alike inside bark.

Meyer, H. A. 1946. **Bark volume determination in trees.** Jour. Forestry 44: 1067-1070.

The bark volume of a tree may be obtained by multiplying the volume of the tree including bark by the factor $(1 - k^2)$, where k is a constant representing the regression coefficient of d (diameter inside bark) on D (diameter outside bark). Values of k and cubic-foot bark volume in percentage of total volume $(1 - k^2)$ are given for white pine and other species.

Meyer, Walter H. 1930. **Diameter distribution series in even-aged forest stands.** Yale Univ. School Forestry Bul. 28. 105 pp.

The fit of Charlier's Type A and Type B distribution curves to the diameter distributions of various conifer stands was found to be generally good. Data from a few white pine sample plots show that the diameter distributions of managed natural stands tend to be negatively asymetrical; that is, they have relatively more small trees than large ones. The curves for plantations are positively asymmetrical. Distribution series cannot be applied indiscriminately to natural stands and planted stands. The computations to fit these distribution series are explained.

Morey, H. F. 1936. **Age-size relationships of Heart's Content, a virgin forest in northwestern Pennsylvania.** Ecology 17: 251-257.

The relationship of d.b.h. with age and with total height was studied in 800 trees of the principal species at Heart's Content. White pine was the species with the largest d.b.h. and total height, but the oldest tree was a hemlock.

Mulloy, G. A. 1944. **Stand density vs. stand bole area and stand intensity indices in even-aged stands.** Forestry Chron. 20: 167-170.

Data from a large number of red and white pine plots at the Petawawa Forest Experiment Station were used to compare these indices. It appears that the stand bole-area index has the advantage of easy computation, being simply the product of average diameter, average height, and number of trees per acre. However, it has not yet been tested to the extent that stand-density index has.

Olson, A. R., Gordon L. Chapman, and H. W. Hicock. 1948. **Connecticut volume tables for plantation grown white pine.** Conn. Agr. Expt. Sta. Bul. 514. 23 pp.

Tables and alinement charts give volumes in cubic feet of solid stem wood, excluding stump; in cubic feet of stem wood and bark between stump and 2.0-inch d.o.b. and also between stump and 5-inch d.o.b.; and in board feet (International ¼-inch rule) for the stem between stump and 5-inch d.o.b. Tables cover trees ranging from 2 to 18 inches d.b.h. and 15 to 90 feet in total height. Details of volume-table construction are also given.

Paton, R. R., and L. J. Leffelman. 1928. **Preliminary report on partial measurements of forest plantations.** Jour. Agr. Res. 36: 91-96, illus.

Plantations of white pine and other species were used to study the errors of estimate resulting from measurement of a sample of the trees to determine volume. It appears that fewer measurements of height than of diameter may be needed for the same level of accuracy.

Roberts, Cecil M., and Harold E. Young. 1953. **Aids for computing tree volume in Maine.** Maine Univ. Forestry Dept. Tech. Note 19, 5 pp.

For white pine and several other species, average form class, double-bark thickness, and merchantable length to a 4-inch top are given by diameter class. The d.b.h. corresponding to stump diameters inside and outside bark are also given.

Schantz-Hansen, T. 1922. **Frustum form factor volume tables for white, Norway, and jack pines in Minnesota.** Jour. Forestry 20: 714-728.

The tables for white pine cover trees 8 to 40 inches d.b.h. and 2 to 7 logs high.

Spaulding, Perley. 1937. **Estimating the length of time that trees have been dead in northern New England.** Jour. Forestry 35: 393-395, illus.

In white pine some of the needles persists through the 2nd year after death and a few small shelf fungi may fruit. In the 3rd year the bark loosens and *Fomes pinicola* begins to fruit; sapwood is rotten but not punky. In the 4th and 5th years the sapwood becomes punky and smaller fungi are plentiful. During the 6th to 10th years the small annual fungi decrease in number, sapwood is well rotted, and branches begin to fall.

Turberville, H. W., and A. F. Hough. 1939. **Errors in age counts of suppressed trees.** Jour. Forestry 37: 417-418.

A study in the Allegheny National Forest showed that some annual rings were missing in suppressed or very slow-grown trees, particulary hemlocks and hardwoods. One suppressed 122-year-old white pine formed no visible rings at ground level in 28 recent years.

Wilson, F. G. 1946. **Numerical expression of stocking in terms of height.** Jour. Forestry 44: 758-761, illus.

On the basis of some thinning experiments with associated species it is suggested that pure white pine stands might be kept at a spacing equal to 1/5th to 1/6th of total height for best growth.

STAND GROWTH & DEVELOPMENT SITE APPRAISAL

Allison, J. H. 1943. **Forty years' growth of planted pines in north central Minnesota.** Jour. Forestry 41: 449-450.

Records on these previously reported plantations (Allison, 1923) show that weevilling seriously reduced height growth of the white pine up to 25 years of age, but there has been little weevilling since. Red and jack pine are considerably taller than the white pine where they were seeded into the pure white pine plantation and where the three species were planted in alternate rows. In the latter case the white pine is badly suppressed.

Ardenne, M. 1950. **Growth of second growth red and white pine in southeastern Ontario.** Ontario Dept. Lands and Forest Res. Rpt. 18, 13 pp., illus.

Growth in young white and red pine stands was studied by increment borings and plot measurements in fairly well stocked stands in and near Algonquin Park. Site classes were set up on the basis of height growth of dominant and co-dominant trees. The results, shown in graphs and tables, are used as a basis for estimating future yields.

Baldwin, Henry I. 1949. **Some older white pine plantations in New Hampshire.** Jour. Forestry 47: 347-399.

Reports measurements on three small plantations 40 to 60 years of age in 1948 The youngest was spaced 8 x 8 feet while the other two were spaced about 15 x 15 feet. All are now nearly fully stocked and have current annual increment of more than 1,000 board feet. The average d.b.h. of the wider-spaced plantations is 16 inches while the closer-spaced one has an average d.b.h. of only 9 inches.

Barrett, L. I. 1933. **Growth rate of northern white pine in the southern Appalachians.** Jour. Forestry 31: 570-572.

In northern Georgia, white pine reproduction was beginning to occupy an important place in the overstory over extensive areas. Growth studies of overstory trees showed that white pine grows significantly faster in diameter than do its associates, yellow-poplar, yellow pines, and the oaks. There was close correlation between age and diameter for white pine and some other species. The trees studied ranged in age from 20 to 110 years.

Belyea, Harold Cahill. 1924. **A study of comparative height growth of six planted species.** Jour. Forestry 22: 389-391.

In Otsego County, N. Y., the plantations were spaced 6 x 6 feet on sandy loam with a water table close to the surface. Red pine showed best vigor and growth after 15 years. White pine grew higher than red pine until the 13th year; the greatest difference came in the 8th year. Thereafter, heavy weevilling of the white pine constantly reduced its height in relation to red pine.

Brinkman, K. A. 1951. **Growth of a white pine plantation in Iowa.** Jour. Forestry 49: 445.

About 700 trees per acre were set out on a wind-blown sandy ridge 51 years ago and have been unmanaged since then. The plantation has made an average annual net growth of 137 cubic feet or 656 board feet per acre and now contains 425 trees per acre with an average diameter of 10.9 inches. Growth in basal area rose to a maximum (8.0 square feet per acre annually) in the third decade and then steadily decreased.

Brown, R. M., and S. R. Gevorkiantz. 1934. **Volume, yield, and stand tables for tree species in the Lake States.** Univ. Minn. Tech. Bul. 39, 208 pp.

For eastern white pine there are nine different volume tables, three Girard form-class-taper tables, a site-index graph, and yield tables for five site classes which show, for various ages, the average height of dominant trees, and for all trees 1 inch and more in d.b.h., the average height, average diameter, number of trees, basal area, and cubic-foot yield. Gives yield in board feet International ¼-inch rule for trees 7 inches d.b.h. and over and by the Scribner Decimal C rule for trees 8 inches d.b.h. and over.

Cutten, E. Y. 1950. **The development of a stand of *Pinus strobus* L. in Waiotapu State Forest.** New Zeal. State Forest Serv. Forest Res. Notes 1: 19-27, illus.

The white pine was planted in 1907 at 8 x 8 foot spacing, and interplanted with Austrian pine spaced 4 x 4 feet. Sample plots were established in 1925 and measured and thinned in 1925, 1928, 1938 (not thinned), and 1948. The Austrian pine had disappeared from the thinned plots by 1938 and from the check plot before 1948. In 1948 the average d.b.h. in thinned plots was 12.5 to 13.3 inches, and in the unthinned plot 10.8 inches. The average height of dominant trees was approximately 90 feet.

Deen, J. L. 1933. **A survival table of even-aged stands of northern white pine.** Jour. Forestry 31: 42-44.

Based on measurements of permanent sample plots in Massachusetts and southern New Hampshire, a table is presented that gives the percentage of trees (in each diameter class from 1 to 14 inches) that may be expected to survive the ensuing 10-year period. The table may be used to refine growth estimates and to reconstruct stocking in the past.

Donahue, Roy L. 1936. **The relation of soil character as expressed by certain soil types to the choice of land for forestry in the cut-over pine lands of northern Michigan.** Amer. Soil Survey Assoc. Bul. 17: 79-80.

Eight soil types were grouped into three classes of site for pine based on their general profile characteristics. A sandy loam texture is said to contribute toward good sites for pine; a yellow B layer, fine sand, or infrequent sandy clay lenses contribute toward fair sites; and a hardpan or coarse dry soil make for a poor site.

Dwight, T. W. 1926. **The use of growth charts in place of yield tables.** Jour. Forestry 24: 358-377.

Data from white pine stands in Ontario are used to illustrate the method of estimating growth on the basis of the present diameter of the trees. The advantages of this method over yield tables are discussed.

Einspahr, Dean, and A. L. McComb. 1951. **Site index of oaks in relation to soil and topography in northeastern Iowa.** Jour. Forestry 49: 719-723.

Site index of oaks was studied in relation to soil series, soil-profile characteristics, and topography on 108 site-index plots. The prediction of site index of oak for various soil series and land types seems to be practical. Where eastern white pine was growing in mixture with oaks, pine had higher site indices; the site-index differences were greatest on the poorest oak sites. On the same site, stands with white pine carried much greater volumes at the same ages.

Fenska, R. R. 1922. **Yield table for white pine.** Jour. Forestry 20: 593-597.

Yield table based on measurements of all known white pine plantations over 25 years old in Rhode Island, Massachusetts, and New Hampshire (range in age is from 27 to 63 years). The mean annual growth per acre increased from 400 board feet with a 25 to 35 year rotation to 600 board feet with a 55 to 65-year rotation. The maximum financial returns were with a 50-year rotation.

Gaiser, R. N., and R. W. Merz. 1953. **Growth of planted red and white pine in Ohio and Indiana.** U.S. Forest Serv. Central States Forest Expt. Sta. Tech. Paper 138, 14 pp.

In studies in old fields in the unglaciated regions of Ohio and central Indiana, the average height of dominants and codominants 25 years after planting was 51 feet for white pine and 38 feet for red pine, with d.b.h. of 8 inches and 6 inches, respectively. Red pine grew more rapidly in height and diameter in mixture with other species; white pine grew more slowly in height at first but after the 20th year trees in mixed plantations were taller than those in pure plantations.

Gibbs, J. A. 1953. **Planted white pine makes good growth at Mohican.** Ohio Agr. Expt. Sta. Forest Mimeo. 7, 1 p., illus.

Measurements made in a 20-year-old plantation of white pine on a typical abandoned hillside field showed average d.b.h. was 5.8 inches, average height 36 feet.

Hawley, Ralph C. 1918. **Does eastern white pine occur on sites IV and V?** Jour. Forestry 16: 341-343.

White pine does not normally grow or reproduce itself on sites IV and V as Recknagel (1917) contends. Hawley recognizes such sites as sterile sand plains or ridge tops above 1,500 feet elevation. The site-index values of Frothingham (1914) are used for discussion.

Hazard, Helen E. 1937. **Plant indicators of pure white pine sites in southern New Hampshire.** Jour. Forestry 35: 477-486.

Five indicator types and five subtypes are described and their relationships to the soil and the forest are discussed. In southern New Hampshire, the Cladonia, Vaccinum, and Maianthemum-Vaccinium types should reproduce white pine if there is a good seed source. The Maianthemum and the Rich Herbacious types are too rich to reproduce white pine in competition with hardwoods.

Heiberg, Svend O. 1933. **Factors influencing choice of species in artificial reforestation.** Jour Forestry 31: 311-317.

Particularly in New York and New England, the factors to be considered are planting-site quality and accessibility, site and silvicultural requirements, costs of establishment and protection, economic value, and available seed sources of the species that might be planted. As a valuable species but one expensive to plant and protect, white pine should be used only on the best and most accessible planting sites, where it can be managed intensively.

Henderson, W. M., E. L. Brown, and M. McKay. 1945. **A determination of yield on the University of New Brunswick woodlot.** Forestry Chron. 21: 196-204.

The forest is composed of mixed stands containing spruce, fir, hemlock, and white pine. About one-third of the board-foot volume is white pine, ranging in diameter from 6 to 20 inches. Regulation of the cut by a stand-projection method is explained and illustrated.

Herbert, P. A. 1924. **Sand ridge produces valuable timber.** Mich. Agr. Expt. Sta. Quart. Bul. 6: 177-180.

Ten years after planting on a ridge of very light wind-blown sand, ponderosa pine and eastern white pine transplants had grown more than 1 foot in height per year. Although the white pine grew somewhat faster in height than the ponderosa, the latter attained greater d.b.h. and volume and had somewhat better survival. Norway spruce and Douglas-fir have not been successful.

Hills, G. A. 1952. **The classification and evaluation of site for forestry.** Ontario Dept. Lands and Forest Res. Rpt. 24, 41 pp., illus.

Describes a site classification based on measurement and integration of physiographic, biological, and cultural features. Because of their stability, rather than their importance, physiographic features were chosen as the frame of reference for total site. The major physiographic features are eco-climate, soil-moisture regime, and nutrient regime. The application of the classification on a regional basis in Ontario is given as an example. White pine is shown to be an important component of the characteristic forests.

Husch, B. 1954. **Preliminary site index table for white pine in southeastern New Hampshire.** N.H. Univ. Dept. Forestry, Forestry Mimeo. 1, 2 pp.

Based on 30 sample plots, a site-index table and graph with reference age of 50 years is given, covering site indices from 45 to 75 and stand ages from 20 to 80 years.

Kimberly, J. T. 1933. **Growth rate of white pine in the southern Appalachians and New England.** Jour. Forestry 31: 946-947, illus.

For the two localities, the curves of diameter and of height over age were parallel and nearly parallel, respectively. There was a significant difference between them of about 3.4 inches in diameter and about 23 feet in height. The trees of the southern Appalachians were, of course, the larger. Only dominant and codominant second-growth trees were measured. Age was determined by borings at 4.5 feet above the ground.

Li, T. T. 1923. **Do thinnings actually increase growth per acre as compared to unthinned stands?** Jour. Forestry 21: 125-128.

Data from Hawley (1922) are retabulated to show loss through mortality. It is concluded that thinnings resulted in net periodic growth approximately 123 to 134% greater than the growth on the check plot. Of this increased net growth, 43 to 57% is attributable to utilization of material lost by death in the unthinned stand, and 42 to 57% to accelerated production in the thinned stand.

Lorenz, R. W., and J. Nelson Spaeth. 1947. **The growth of conifers on prairie soil.** Jour. Forestry 45: 253-256, illus.

Over a period of 70 years, the growth of white pine and three other conifers planted on prairie soil in Illinois has not lived up to expectations based on early development. At 20 years the site index of the white pine was 90; at 40 years it was 54; and at 70 years it was only 44 (based on Frothingham 1914). At 70 years the white pine plantations had an average diameter of 11 inches, a basal area of 137 square feet, and a volume of 22,800 board feet.

McConkey, Thomas W. 1953. **Growth behavior of white pine in an uncut stand in southwestern Maine.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Res. Note 25, 3 pp.

Measurements of growth in a mixed stand of white pine, hemlock, and scattered hardwoods over a 15-year period showed that some trees contribute more than three times as much to the stand growth as other trees of the same size and species. The years a tree needs to grow 1 inch in diameter is a good guide to its thrift and condition; pine and hemlock should grow 1 inch in diameter in less than 7 years.

Minckler, Leon S. 1946. **Old field reforestation in the Great Appalachian Valley as related to some ecological factors.** Ecol. Monog. 16: 88-108, illus.

In general, shortleaf pine, eastern white pine, yellow-poplar, and white ash were the most successful species to plant. Growth and survival of all species varied with soil type and aspect. Species with a good growth on a given site tended to have good survival also. A planting chart summarizes the site characteristics most suitable for the various species.

Mlodziansky, A. K. 1898. **Acre-yield of white pine.** Amer. Forestry Assoc. The Forester 4: 143-144, 163-165.

The volume of uncut white pine timber on 4 lots in Pennsylvania and 12 lots in the Lake States varied with stand condition and site from 12,000 to 67,000 board feet per acre.

Mulloy, G. A. 1943. **A practical measure of stock density in white and red pine stands.** Forestry Chron. 19: 108-118.

Determination of stand density by comparison of total basal area with that from normal yield tables is often impracticable. An index of density is required that is independent of both age and site. The index developed by Reineke (1933) was checked against records for 20 years of sample-plot data for thinned and unthinned red and white pine stands. In practice it is necessary merely to estimate the average diameter of the stand then the spacing for optimum development can be determined.

Mulloy, G. A. 1944. **Empirical stand density yield tables.** Canada Forest Serv. Silvic Res. Note 73, 22 pp.

The construction and usefulness of such yield tables is discussed and tables are given for the white and red pine, jack pine, and balsam-spruce cover types in the Timagami district. They show the method of construction and are only tentative. Volumes are expressed in total cubic feet.

Mulloy, G. A. 1947. **Empirical stand density yield.** Canada Forest Serv. Silvic Res. Note 82, 41 pp., illus.

An extension of work already reported (Mulloy, 1944) on the white birch-aspen-balsam-spruce type of New Brunswick. Evidence on the trends of stand-density index in thinned white and red pine stands at Petawawa is also presented. Development in density of stands after thinning will follow the same trends with age as would be the case had the stand reached this density naturally.

Pinchot, Gifford, and H. S. Graves. 1896. **The white pine; a study, with tables of volume and yield.** 102 pp., illus. New York.

An early work analyzing the growth and yield of white pine with remarks on its situation and occurrence in the forest and its relation to associate species. The observations and measurements were made in first-growth and second-growth pine stands in central Pennsylvania. Valuation surveys of a few groups in New York were used in yield-table construction. Volume tables, curves of yield, and other supplementary information are also included.

Recknagel, A. B. 1917. **More about sites.** Jour. Forestry 15: 929-930.

Measurements of the development of white pine stands on the Luther Preserve, Saratoga County, New York, are given to show that sites that would be classified as IV or V in Europe do occur in eastern United States.

Roe, Eugene I. 1935. **Forest soils—the basis of forest management.** U.S. Forest Serv. Lake States Forest Expt. Sta., 9 pp., illus.

In an extensive study based on some 4,700 miles of road traverse and 15,000 plots, generally good relationships of surface soil texture, character of subsoil, and depth of water table (as determined from mapped soil types) with the occurrence of forest types and site quality for some type species were found. Because few red and white pine stands were encounterd, they were grouped with jack pine in the forest type-analysis. White pine was one of five species for which site-quality relationships were analyzed.

Roe, Eugene I. 1953. **Comparative height growth of native conifers in northeastern Minnesota.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Notes 389, 1 p.

A rocky upland site was planted with 2-0 stock. Jack pine and tamarack averaged 15 feet in height after 10 years. Red and white pine had an average height of nearly 9 feet in the same period (maximum height was 14 feet for white pine and 12 feet for red pine). The spruces made the poorest growth, averaging less than 8 feet for black spruce and 6 feet for white spruce.

Skog, R. E. 1951. **Growth of mixed red and white pine plantations in the Upper Peninsula.** Mich. Agr. Expt. Sta. Quart. Bul. 34: 30-34.

Data collected in a 25-year-old alternate-row plantation of red and white pine show that red pine is growing well. White pine, partly as a result of weevil attacks, is becoming suppressed and is slowing down in diameter growth.

Stanley, Oran B. 1938. **Indicator significance of lesser vegetation in the Yale Forest near Keene, N.H.** Ecology 19: 188-207.

The relation of vegetation types to texture and moisture and nutrient content of the soil, and to light intensity, density, and growth rate in white pine stands was studied. As judged by the density and growth rate of the white pine stands, the *Maianthemum* and *Cornus-Lycopodium* vegetation types and the *Aspidium-Dicksonia* and *Mitchella-Pteris* sub-types are characteristic of the more productive soils of the region. The *Cladonia-Andropogon* and *Vaccinium-Gaultheria* types were grouped as characteristic of the less productive soils.

Stewart, G. 1935. **Criteria of fertility levels as a guide to planting old fields.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 17, 2 pp.

Sites of unusual fertility have a cover of Kentucky blue grass, bent grasses, and clover; hardwoods may be planted on these sites. Sites of average fertility will display mostly bent grasses with some Kentucky blue grass, Canada blue grass, red top, and sweet vernal; these sites are well suited to white pine and the spruce. On sites of low fertility, grasses will comprise less than half the cover and poverty grass will be the most important element. These sites will successfully support conifers adapted to the local climate.

Stoeckeler, Joseph H., and Gustaf A. Limstrom. 1942. **Ecological factors influencing reforestation in northern Wisconsin.** Ecol. Monog. 12: 191-212, illus.

Availability of soil moisture throughout the first growing season was the most important single factor affecting planting success with red and jack pine. In direct seeding of these species and white pine, soil moisture was still a critical factor but surface soil temperature, light, and biotic factors were probably of equal importance.

Stoehr, H. A. 1951. **Growth and yield from a 50-year-old white pine plantation.** Mich. Agr. Expt. Sta. Quart. Bul. 33: 426-436.

The Beal Pinetum, a 3-acre plantation, was established in 1896. In 1950 the stand averaged 13.2 inches d.b.h., 78 feet high, and contained 16,500 board feet per acre.

Wappes, L. 1934. **Wuchsleistungen der Weymouthskiefer.** Deut. Forstwirt 16 (74): 779-784.

Compares growth and yield of *Pinus strobus* in various regions of Germany with that of native Norway spruce, Scotch pine, and European beech. In 1896 and 1897, the author had previously published material on the silvics and yield of white pine. Results in 1934 show relatively good growth despite damage by blister rust. However, before white pine can be widely recommended, more information must be secured on the ultimate effects of blister rust.

Wilde, S. A. 1935. **The significance of soil texture in forestry and its determination by a rapid field method.** Jour. Forestry 33: 503-508.

The silt plus clay content of the soil is a measure of soil fertility or nutrient availability. It also affects moisture relationships. An acceptable planting site for white pine should have a silt plus clay content of 15 to 35% in the upper soil horizon. All soil horizons should be sampled for texture since the relative position of the fertile layers is also important, especially in estimating site for planting. A simple hydrometer method of texture determination is described.

Wilde, S. A., and W. E. Patzer. 1940. **The role of soil organic matter in reforestation.** Amer. Soc. Agron. Jour. 32: 551-562.

A study was made in central and northern Wisconsin of the effect of the organic-matter content of podzolized sandy soils upon the growth of young plantations of jack, red, and white pine, and white spruce. In these soils the organic-matter content showed a close relationship to the total nitrogen and the available phosphorus and potassium contents. Results suggest that the absolute minimum requirement of soil organic matter is 2.5% for white pine.

Wilde, S. A., F. G. Wilson, and D. P. White. 1949. **Soils of Wisconsin in relation to silviculture.** Wis. Conserv. Dept. Pub. 525-549, 171 pp., illus.

The forest soils of Wisconsin are discussed in three main groups: immature soils, soils of the podzol region, and soils of the prairie-forest region. Each of the major forest-soil types and the climax forest it supported are described. White pine was a component of the virgin forest on many of the soil types, most of them in the podzol region.

Worley, David, and H. Arthur Meyer. 1951. **The structure of an uneven-aged white pine-hardwood forest in Luzerne County, Pennsylvania.** Pa. State Forestry School Res. Paper 15, 4 pp.

Cruises of two essentially virgin stands disclosed that the diameter distributions are well balanced and can be expressed by an exponential distribution function. A volume of 5,000 cubic feet per acre could be maintained indefinitely. White pine, occurring primarily in the large and middle diameter classes, is gradually disappearing from the stands in favor of hemlock, maple, and beech.

Young, Harold E. 1954. **Forest soils-site index studies in Maine.** Soil Sci. Soc. Proc. 18 (1): 85-87.

The field, laboratory, and analysis technique employed by Coile in the South have been used in a study of 16 plots in 16 different white pine stands in the vicinity of Orono, Me. A regression equation that related site index with depth of the A horizon and the percent of stones in the Z horizon was developed. As both of these factors increase, the site index decreases. Successful field checks were made around Orono and in the southern part of the State. A regression equation for spruce-fir stands was also developed.

Forest Damage
Forest Protection

WEATHER

Basham, J. T. 1953. **Extensive tree mortality caused by hail in Quetico Provincial Park.** Canada Dept. Agr. Div. Forest Biol. Bimo. Prog. Rpt. 9 (5): 2.

Examination of a large area in which almost all trees were dead showed that they had been killed by a severe hail storm, probably during the 1951 growing season. All species were affected, but white pine was among the most susceptible.

Belyea, H. C., and H. J. MacAloney. 1926. **Weather injury to terminal buds of Scotch pine and other conifers.** Jour. Forestry 24: 685-690.

Coniferous plantations in Oswego County, N. Y., suffered leader damage by frost in 1917, 1921, and 1922. This was attributed by Belyea (1923) to white-pine weevil. The authors suggest that Scotch pine protects subdominant white pine by forcing higher and wider flight of adult beetles. Describes frost injury and ways to distinguish it from weevil injury.

Canada Department of Agriculture. 1954. **Condition of white pine *(Pinus strobus)* in the Sudbury District.** Canada Forest Insect Dis. Survey Rpt. 1953: 81-82.

In areas near the source of SO^2 in the atmosphere there was an increase in the number of trees showing foliage injuries, which corresponded with the increases in age of the foliage. There was a steady decline in increment on plots near the source of fumes and many young trees showed signs of sunscald.

Craighead, F. C. 1941. **An effect of drought on white pine.** Jour. Forestry 39: 618-619.

Near Carlisle, Pa., the drought of 1935-36 severely reduced current growth in a small white pine plantation. Needles were an inch or less in length and terminal growth was only 3 to 5 inches compared to about 20 inches on the same trees in previous years. All the trees recovered and made normal growth in succeeding years. A similar drought in 1939 had no affect on growth.

Curry, John R., and Thomas W. Church, Jr. 1952. **Observations on winter drying of conifers in the Adirondacks.** Jour. Forestry 50: 114-116.

In the winter of 1947-48 winter injury was severe throughout New York. In the Adirondacks the injury first appeared as a browning of needles that was most severe on the southern and western portions of exposed trees and on limbs just above snow line. Red spruce was most seriously affected, followed in descending order by hemlock, white pine, and balsam fir. In typical conifer stands nearly 50% of the trees had some winter injury.

Curtis, James D. 1936. **Snow damage in plantations.** Jour. Forestry 34: 613-619.

A white pine is occasionally subject to snow breakage if it is closely spaced and has a one-sided crown. The study embraced 22 species.

Curtis, James D. 1943. **Some observations on wind damage.** Jour. Forestry 41: 877-882.

Damage by the 1938 hurricane to forest stands in central New England was studied to find clues to better protection of stands from wind. Up to 25 years of age white pine appears to be more resistant to wind than either Scotch or Norway pine. Trees with a long crown, open crown, or small high crown and thin, flexible trunk are the most resistant to wind. Older, dense, even-staged stands are most susceptible to winds because they have high form points and poorly developed root systems.

Huberman, M. A. 1943. **Sunscald of eastern white pine, *Pinus strobus* L.** Ecology 24: 456-471, illus.

Sunscald seriously injures the cambium on the southwest side of exposed tree trunks, thus lowering tree value and reducing tree vigor. Sunscald was found on white pine averaging 4 to 10 inches in diameter, 31 to 51 years old, of intermediate crown class, and with bark thickness of 3.7 to 7.5 mm. It appears to be a winter injury, and rapid freezing the probable cause.

Krečmer, V. 1952. **Vliv sucha roku 1947 zejména na výškový přírůst lesních dřevin. (Effect of the 1947 drought, in particular on the height increment of forest trees.)** Sborn. čsl. Akad. zeměd. 25 (3): 243-260.

Presents the results of an investigation into the factors causing the characteristic dryness of the Brnik Forest District near Kostelec (Bohemia), and the damage brought about by the 1947 drought. The drought had an adverse effect on the 1947 height growth, particularly for white pine, which can be explained by the intensity of the drought and by its having started early in the spring after a not very favorable winter.

Lake States Forest Experiment Station. 1939. **Comparative resistance of native Wisconsin trees to snow breakage.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 152, 1 p.

A wet, heavy snow storm in the latter part of October 1938 caused considerable breakage, bending, and uprooting in the forests of northern Wisconsin. Very little white pine was damaged. In the 4-inch and smaller d.b.h. class, 2% of the white pines were broken or uprooted and in the 5- to 9-inch d.b.h. class 3% of the pines were broken. Larger pines were not damaged at all except for some breakage of smaller limbs.

Lake States Forest Experiment Station. 1936. **Winter injury to plantations.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 117, 1 p.

White pine and red oak planting stock of unknown origin had good survival and growth at Dukes, Mich., for the first few years but when they became more than 4 feet high (the average snow depth) they were repeatedly killed back by the extreme winter conditions. Many of the white pines eventually died. It is a mistake to plant stock of unknown origin.

Lake States Forest Experiment Station. 1935. **What trees withstand drought best?** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 97, 1 p.

Plantations of Norway, white, jack, and Scotch pine planted in 1932 on the Huron National Forest were severely damaged by the drought of 1933. In the southern part the drought was extremely severe and in the northern part the drought was less severe but the rainfall was below normal. White pine was most susceptible to both drought intensities.

Lake States Forest Experiment Station. 1935. **What rainfall factor causes drought damage?** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 98, 1 p.

Studies of white and other pines on the Huron National Forest indicate that the distribution of rainfall over a period of several months is important to survival. In 1933 there was an unusually wet spring followed by a warm, early summer. The trees produced long succulent shoots and as a result first-year planting survival was very low. The spring of 1934 was drier than normal, and consequently the trees produced short shoots only and first-year survivals were uniformly fair to excellent.

Mergen, François, and Herbert I. Winer. 1952. **Compression failures in the boles of living conifers.** Jour. Forestry 50: 677-679, illus.

Compression failures were reported in white pine in New Hampshire. Injured trees are susceptible to breakage during storms. Tall and slightly tapered young trees in dense poletimber stands are especially subject to this kind of injury after thinning.

Moss, A. E. 1940. **Effect on trees of wind-driven salt water.** Jour. Forestry 38: 421-425.

White pine appeared to be the species most sensitive to injury from wind-blown salt water even if diluted by heavy precipitation. The foliage turned orange-red. The effects may be felt at a distance of 45 miles from the ocean when wind velocities are over 100 miles per hour. The injury occurs only where the specimen is exposed to direct force of the wind.

Pirone, P. P. 1941. **Freak weather damages trees and shrubs.** N.J. Agr. 23 (3): 1.

In spring 1941 wilting and browning of many evergreen ornamentals, including yews, junipers, and white pine, was widespread in the Atlantic Seaboard region of the United States. The damage, which was most severe in recently transplanted trees and those with poor root systems or on unfavorable sites, was attributed to strong polar winds in March which caused leaves to transpire more water than could be replaced from the frozen soil, followed by exceptionally mild weather and a heat wave in early April.

Schantz-Hansen, T., and Philip N. Joranson. 1939. **Some effects of the 1936 drought on the forest at the Cloquet Forest Experiment Station.** Jour. Forestry 37: 635-639.

The differences between the average surface areas of the needles produced by jack, red, and northern white pine in the drought year 1936 and those produced during the more normal growing season of 1935 were, without exception, found to be highly significant. In a stand of red and northern white pine ranging from 30 to 40 feet in height and located on a thin soil underlain by rock, approximately half of the total number of trees (and nearly all the red pines) were killed.

Shirley, Hardy L. 1934. **Observations on drought injury in Minnesota forests.** Ecology 15:42-48.

A survey of reproduction losses due to drought was made in swamp and pine forests. In pine forests the losses decreased in severity with increasing height and density of reproduction, and with increasing density of brush and upper canopy. The unfavorable effect of root competition of older trees was more than offset by the beneficial effects of this shade. Losses of white pine were slight where the trees were 1.5 feet or more high and the stand was at least 45% stocked.

Stoeckeler, J. H., and Paul O. Rudolf. 1949. **Winter injury and recovery of conifers in the upper Midwest.** U.S. Forest Serv. Lake States Forest Expt. Sta., Sta. Paper 18, 20 pp.

A sudden, sharp frost following an abnormally warm period in February 1948 caused severe frost damage to trees. White pine showed extensive browning (up to 100% of needles killed) and some sunscald, but made good recovery by September. There was no white pine mortality and little deformity except in trees with very heavy defoliation.

Stone, E. L., Jr. 1952. **An unusual type of frost injury in pine.** Jour. Forestry 50: 560.

A mid-June frost was probably responsible for the distortion of 1950 terminal shoots in New York plantations of white, red, jack, and Scotch pine. The damage varied from a simple offset to a pronounced S-shaped crook in more than one place. Types of recovery from the injury are described.

Wallace, R. H., and A. E. Moss. 1939. **Salt spray damage from recent New England hurricane.** Natl. Shade Tree Conf. Proc. 15: 112-119.

White pine was one of the species most seriously injured by salt spray. Foliage of injured trees took on a bright orange-yellow hue, and the tips of injured needles were invariably killed. Conifers have not recovered well from the injury.

FIRE : ANIMALS

Aldous, Shaler E. 1939. **Pine in the diet of white-tailed deer.** Jour. Forestry 37: 265-267.

Deer browsing of pine was reported heavy in the Superior National Forest. Jack pine seemed to be the preferred species but white pine was eaten in large quantities, especially during the winter when jack pine was less available.

Banks, Wayne G., and James C. Rettie. 1949. **Restocking conditions on the burned-over forest lands of southwestern Maine, June 1949.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 30, 9 pp., illus.

Forest fires in 1947 burned over some 130,000 acres in the white pine region of Maine. Surveys made in 1949 showed 73,300 acres (56%) adequately stocked with pole timber or sawtimber or desirable seedlings, or with seed sources for natural regeneration; while 56,700 acres (44%) were non-stocked and lacking adequate seed sources. Of the latter, 34,000 acres was recommended as high priority for planting desirable conifers.

Banks, Wayne G., and Myron D. Ostrander. 1952. **The southwestern Maine fire area—4 years later.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Res. Note 18, 4 pp.

Four years after the 1947 fires in southwestern Maine only 5% of the burned area was completely unstocked but 16% had less than 40% stocking. Of the area stocked 40% or more with seedlings, only 14% was stocked with white pine and only on 3% of this area were the white pines dominant. White pine should be encouraged by cultural operations where it is already present but it does not seem advisable to plant pine until a crop can be made from the hardwoods now on the area.

Beall, H. W. 1934. **Diurnal and seasonal fluctuations of fire hazard in pine forests.** Forestry Chron. 10: 209.

In periods of good weather, fire hazard is greatest between 2 and 4 o'clock in the afternoon and lowest between 4 and 6 in the morning at the Petawawa Forest Experiment Station. Strong winds throughout the day cause a marked change in the diurnal hazard curve. Seasonal variation in hazard of pine stands is small compared to that of other forest types.

Cook, D. B., and S. B. Robeson. 1945. **Varying hare and forest succession.** Ecology 26: 406-410.

Observations on a population of varying hare or snowshoe rabbit *(Lepus americanus)* on Valcour Island, N. Y., indicate considerable selectivity in browse. White and red pine and white spruce seedlings less than 4 feet tall were killed outright; larger trees were trimmed as high as the hares could reach. It seems likely that the number of hares is kept down in the Northeast by the lack of low, dense coniferous cover; but the extensive coniferous plantations on abandoned farmlands may materially alter the situation, and the relation of the varying hare to forest succession may assume increasing importance.

Cope, J. A. 1925. **Grazing in pine plantations.** Jour. Forestry 23: 297-299.

In reference to Stickel and Hawley (1924), it is argued that there is no evidence that grazing reduces fire hazard and that, as shown in southern New York, 90% of the plantation will be ruined by trampling, if grazing is permitted. It is further pointed out that 2-0 white pine stock can compete as well as 2-1 stock with grass and weeds, even though the latter are knee-high.

Corson, C. W., and E. G. Cheyney. 1928. **Injury by rabbits to coniferous reproduction.** Jour. Forestry 25: 539-543.

Black spruce, balsam fir, and white pine (in the order named) were the least susceptible of the native conifers to rabbit feeding. On some plots 100% of the terminal and lateral buds were taken. Damage is greatest in late winter, near swamps, and in years just preceding a rabbit plague.

Craig, J. W. 1940. **Crow damage to conifers.** Jour. Forestry 38: 969.

Perching by the American or carrion crow on Scots, red, and white pine was observed to cause breakage or distortion of the terminal shoots and branches.

F(isher), R(ichard) T. 1918. **Second-growth white pine as related to former uses of the land.** Jour. Forestry 16: 253-254.

Suggests that the silvical and historical evidence in old-field white pine lots in central New England support the view that grazing is beneficial for pine reproduction if it is properly regulated.

Gottlieb, A. W. 1928. **Relation between subcortical temperatures and size of white pine (*Pinus strobus*) slash.** Ecology 9: 243-248.

To determine the relationship between the size of white pine slash and temperatures under the bark, a series of readings was made with a system of thermocouples. Sticks 4 to 6 inches in diameter reached the highest temperature. The variation indicates that temperature may be an imporant factor in the rate of decomposition of different sizes of slash.

Hosley, N. W. 1928. **Red squirrel damage to coniferous plantations and its relation to changing food habits.** Ecology 9: 43-48, illus.

During periods of deep snow when the red squirrels' usual food supply is cut off, they eat the buds of some conifers, thereby retarding the normal growth of the tree. With white pine, the squirrels clip the terminal shoots. Scotch pine apparently suffers most, with Norway spruce and white pine close behind. Intensity of injury varies directly with snow depth.

Krefting, Laurits W., and Joseph H. Stoeckeler. 1953. **Effect of simulated snowshoe hare and deer damage on planted conifers in the Lake States.** Jour. Wildlife Mangt. 17: 487-494.

Two sets of experiments were carried out in Wisconsin in which the leaders of young red, white, and jack pines and white spruce were clipped one to three times at intervals of 1 or 2 years. Susceptibility was rated in terms of mortality, height loss, and loss of form. Clipping affected height more seriously than mortality and there were no forked trees. The species are listed above in order of increasing resistance. Older trees, especially transplants, were the most resistant.

Lake States Forest Experiment Station. 1934. **Estimating fire damage in the Lake States.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 75, 1 p.

The relative dollar-per-acre value of second-growth stands is given for seven forest types in the Lake States as a guide to estimating total or partial losses due to fire. Such average merchantable values are shown by stand-size classes and three stand-density classes; these values have been discounted to the average age of the respective size classes.

Lake States Forest Experiment Station. 1934. **Relative hazard and estimated cost of protection by forest types—Lake States.** U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 78, 1 p.

The area burned over (in percent) and the cost for effective fire protection for the various types are estimated.

Lutz, H. J. 1930. **Effect of cattle grazing on vegetation of a virgin forest in northwestern Pennsylvania.** Jour. Agr. Res. 41: 561-570.

In a virgin hemlock-beech-white pine-red maple stand, grazing caused direct injury to the smaller vegetation by browsing, breaking, trampling, and pulling of small trees out of the soil. Compared to the ungrazed part of the forest, the grazed area had more seedlings, sprouts, and herbacious vegetation less than a foot high but fewer large seedlings and saplings, especially between 1 and 15 feet in height.

McConkey, Thomas W., and Donald R. Gedney. 1951. **A guide for salvaging white pine injured by forest fires.** U.S. Forest Serv. Northeast. Forest Exp. Sta. Res. Note 11, 4 pp.

From studies of fire-damaged trees on the Massabesic Experimental Forest in Maine, the authors offer some general guides on salvage priority, based on degree of root and crown injury. Completely killed stands should be cut first; then severely root-damaged stands should be cut. Authors suggest 25 or more seed trees (more than 12 inchest d.b.h. with only light root injury) per acre be left after salvage cuttings.

McQuilkin, W. E., and S. Little. 1952. **Deer repellent fails to protect pine seedlings.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Res. Note 15, 4 pp.

The repellent, in which the active ingredients are zinc-dithiocarbamate-amine complex plus polyethylene polysulfide, offered no protection to white pine seedlings in Pennsylvania and very little protection to pitch and shortleaf pine reproduction in New Jersey.

Mitchell, J. A. 1934. **Cover type as a factor in fire control.** Jour. Forestry 32: 96-97.

In Michigan over half of the area burned between 1928 and 1932 was in grass plains or second-growth aspen-birch forest. Only 0.8% of the burn was in second-growth red and white pine stands.

Ninman, H. J., and W. C. Thompson. 1927. **Effect of pasturage on white pine reproduction and on timber quality.** Jour. Forestry 25: 549-554.

In a dense stand of reproduction, nearly 27% of the white pines were injured in some respect by livestock. Injury was proportionately greater where the trees were more scattered. In a dense stand of small pine poles at least 40% of the trees were damaged by livestock. The present practice of over-pasturing the woodlots is highly detrimental to the timber. Neither a good grade of timber nor a high yield can be expected where excessive grazing is practiced.

Nutting, A. D., and John R. McGuire. 1948. **Observations on fire-damaged white pine in southwestern Maine, July 1948.** U.S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 19, 9 pp., illus.

An appraisal of damage 9 months after the forest fires of 1947. In partly burned stands expected signs of mortality were not conspicuous: unscorched crowns were still green; growth of new shoots was apparently normal; and insect attacks had not yet become serious. Discusses conditions influencing the fire damage, incoming reproduction, and stand treatment problems.

Petrides, G. A. 1941. **Observations on the relative importance of winter deer browse species in central New York.** Jour. Wildlife Mangt. 5: 416-422.

Report on browsing by northern white-tailed deer recorded during the winters of 1938-39 and 1939-40 near Ithaca, N. Y. White pine is listed as one of the chief emergency foods.

Prebble, M. L., and R. F. Fytche. 1950. **Value loss through degrade in fire-killed pine.** Canada Dept. Agr. Forest Insect Invest. Bimo. Prog. Rpt. 6 (2): 1-2.

A special study of mill output and grade of jack, red, and white pine lumber from trees killed in a May 1948 fire was made in November 1949. Heartwood decay, which antedated the fire and was responsible for cull or reduced grade, was common in jack and white pine. Post-fire deterioration was caused by larvae of wood-boring beetles and by sap-staining fungi. Value loss in white pine trees that were dying gradually during 1949 averaged only 2.4%. Value loss in white pine killed outright in May 1948 was related directly to the original quality and value of the lumber. The loss was about 12% on logs whose original value was $53 per 1,000 board feet, but the loss increased to 57% in logs that had an original value of $121.

Pryor, L. D. 1940. **The effect of fire on exotic conifers.** Austral. Forestry 5: 37-38.

Two factors that determine the survival of a tree after fire are bark thickness and ability to produce new foliage. Eastern white pine is listed as very susceptible to fire, only 5 others out of 29 being more susceptible.

Society of American Foresters, New England Section. 1929. **Grazing in relation to forestry in New England.** Jour. Forestry 27: 602-608.

Report of a special committee on the silvicultural, regulative, and economic aspects of woodland grazing. No kind of stock can be grazed in the forest without some damage; but damage can be reduced so that it is more than offset by the release of conifers in restocking area. The committee does not forsee the widespread use of grazing as a silvicultural tool, but some woodland owners may be able to use it to advantage.

Spaulding, Perley, and J. R. Hansbrough. 1944. **Decay of logging slash in the Northeast.** U.S. Dept. Agr. Tech. Bul. 876, 22 pp., illus.

Decay of slash was studied in relation to fire hazard. Slash disintegrated in an average of 15 years for hardwoods, 17 years for white pine, and 29 years for red spruce. Under favorable conditions, these times can be shortened by 20%. Fire danger of white pine slash becomes low in about 10 years but is high for the first 5 years.

Stewart, Guy R. 1933. **Forest plantations injured by roosting birds.** Jour. Forestry 31: 421-423, illus.

Defoliation and death of white pine trees in plantations used by large numbers of roosting birds is caused by accumulation of excessive amounts of nitrate nitrogen from bird droppings under the trees. Excessive amounts were found in all soil horizons, so recovery will take a long time. Means to control the birds are suggested.

Stickel, Paul W. 1932. **Weather and forest fire hazard with special reference to the white pine region of central New England.** Mass. Forestry Assoc. Bul. 153, 8 pp., illus.

Under mature white pine and hemlock, hazardous conditions develop much more slowly than in the open and, for equivalent hazard, significant weather elements must be much more severe. Alinement charts are given for estimating fire hazard.

Stickel, Paul W. 1938. **Northeastern forest-fire danger meters.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 25, 4 pp.

A description of seven fire-danger classes developed for white pine, spruce-fir, and mixed northern hardwoods. They are based on air temperature, relative humidity, time since last rain, and wind velocity. Administrative action in preparation for fire-control work is suggesed for each danger class.

Stickel, Paul W. 1940. **The effect of basal-wounding by fire on trees in the Northeast.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 30, 2 pp.

In white pine, two plots were examined annually for 3 years after a fire. Of some 1,300 trees examined, 70% were killed outright and 29% were alive but showed scorching or other injury right after the fire. In 3 years 32% of these injured trees had died and only 36% showed no open fire scar.

Stickel, Paul W., and Ralph C. Hawley. 1924. **The grazing of cattle and horses in pine plantations.** Jour. Forestry 22: 846-860.

In southern New England, regulated grazing in young white and red pine plantations is beneficial. It reduces fire hazard and reduces or eliminates the cost of weeding. Horses are more destructive to pine than cattle, and grazing in winter is more injurious than grazing from March to October. Grazing should be restricted to the period prior to crown closure.

Stickel, Paul W., and Ralph C. Hawley. 1925. **The grazing of cattle and horses in pine plantations.** Jour. Forestry 23: 389-391.

Refers to Cope (1925) and Stickel and Hawley (1924) in defense of the latter article. An example is presented of the intensity of fire in grazed and ungrazed plantations. Although complete destruction of pine plantations can result from overstocking with animals and on localized areas around water holes, salting grounds, and paths of travel, this damage can be held to a negligible amount by proper regulation of the grazing animals.

Sweetman, H. L. 1944. **Selection of woody plants as winter food by the cottontail rabbit.** Ecology 25: 467-472.

White pine was among 25 species seriously damaged by cottontails on the 3-acre lot examined. There were 100 woody species present.

Wright, J. G. 1932. **Forest fire hazard research.** Forestry Chron. 8: 133-151, illus.

From results of calorific and combustion studies on white and red pine duff, a method of rating inflammability of the white and red pine forest type in eastern Ontario and western Quebec has been worked out. It is based on the rate and intensity of duff burning when ignited with a match. This is also equated with the duff moisture content. Weather factors were also correlated with duff inflammability. The development of these studies and their results are summarized.

Wright, J. G. 1933. **Forest-fire hazard tables for mixed red and white pine forests.** Canada Forestry Branch, Forest-Fire Hazard Paper 3, 10 pp., illus.

These tables are designed for computing (from the daily record of rainfall, rate of evaporation, and relative humidity of the air) the degree of fire hazard that will prevail each day in mixed red and white pine forests in eastern Ontario and western Quebec.

Young, Vernon A. 1936. **Edaphic and vegetational changes associated with injury of a white pine plantation by roosting birds.** Jour. Forestry 34: 512-523, illus.

Starlings roosting during the fall of 1933 and 1934 mechanically injured the leaves during their roosting activities and deposited large amounts of droppings on the forest floor. Droppings increased nitrate, phosphorus, and potassium and apparently upset the physiology of the trees so that they died in a short time. In addition, some 68 species of plants with hard seed coats, including Ribes, germinated on the forest floor and established intense competition. These seeds were carried in the droppings.

DISEASES
White Pine Blister Rust

Anderson, Olof Campbell. 1939. **A cytological study of resistance of viking currant to infection by *Cronartium ribicola*.** Phytopath. 29: 26-40, illus.

Leaves of highly-resistant Viking, a Norwegian Red Dutch currant of unknown origin but probably in part derived from *Ribes petraeum*, were compared with those of three susceptible *Ribes* (*R. nigrum, R. sativum* hybrid var. American Red Dutch, and *G. hirtella*), all of which were similarly inoculated during 2 years with *C. ribicola*. Cytological investigation revealed that infection occurred through the stomata in young unhardened Viking leaves, but the resulting sparse hyphae died before the parasite could develop or produce spores.

Colley, Reginald H. 1918. **Parasitism, morphology, and cytology of *Cronartium ribicola*.** Jour. Agr. Res. 15: 619-659, illus.

The literature and the results of original studies are summarized, and the interrelations between the fungus and its hosts are discussed. The morphology of the mycelium, pycnia, and aecia on pine; and of the mycelium, uredinia, and telia on Ribes are described. So too are the formation and germination of the related spores. The cytology of the various fungal organs is explored, with emphasis on nuclear phenomena.

Cooper, William S. 1922. **The ecological life history of certain species of Ribes and its application to the control of the white pine blister rust.** Ecology 3: 7-16.

Outlines the successional development and climax vegetation of New England and the Adirondacks and the role of three native Ribes species in this flora. The most common Ribes habitat was in pastures and orchards, where they thrived. Next was mixed second-growth woodland, while old-growth forest had very few Ribes. Birds, especially those of open ground, feed on and spread Ribes seed. Invasion of open areas by forest reduces the abundance and weakens the Ribes progressively until they die out.

Detwiler, S. B. 1933. **General aspects of the white pine situation.** Jour. Forestry 31: 514-521.

As an aid to policy decisions, the author reviews the white pine situation since the advent of the white-pine blister rust: forest conditions, silvical characteristics of white pine, suitability for management, economic value, blister rust control problem, and costs. Urges that production of white pine be encouraged and that blister rust control be stepped up.

Filler, E. C. 1933. **Blister rust damage to northern white pine at Waterford, Vt.** Jour. Agr. Res. 47: 297-313.

Infection was greater on the larger-crowned trees, but death was greater among the less vigorous intermediates. Pines of all sizes from seedlings to merchantable trees were attacked.

Filley, W. O., and H. W. Hicock. 1922. **Control of white pine blister rust in Connecticut.** Conn. Agr. Expt. Sta. Bul. 237: 305-326, illus.

The history and nature of white-pine blister rust and its life cycle, the importance of white pine as a forest tree, state legislation, and early control work of Ribes eradication (1909-21). Also discusses the national situation, future control, new studies of the rust, and a survey of white pine in Connecticut.

Fivaz, A. E. 1931. **Longevity and germination of seeds of Ribes, particularly *R. rotundifolium*, under laboratory and natural conditions.** U.S. Dept. Agr. Tech. Bul. 261. 40 pp., illus.

Laboraory tests of *Ribes rotundifolium* and *R. cynosbati* seeds show that best germination is obtained in a neutral medium with a daily temperature range from 10 to 25° C. Field studies of Ribes in relation to stand history in the Adirondacks indicate that Ribes seeds may lie dormant in the soil for periods of as much as 70 years and germinate when distrubances such as windthrow, fire, or logging create the required variation in daily temperature.

Fracker, S. B., and R. A. Sheals. 1933. **The protection of forest nurseries from white pine blister rust infection.** Jour. Econ. Ent. 26: 641-648.

Changes in quarantine regulations relating to the shipment of nursery stock are reviewed. They make it permissible to ship anywhere in the country from nurseries where a protection zone 1,500 feet wide is kept clear of Ribes by annual working. In addition, *R. nigrum* must be destroyed in a zone extending 1 mile from the nursery.

Hahn, Glenn Gardner. 1943. **Blister rust relations of cultivated species of red currants.** Phytopath. 33: 341-353.

Cultivated red currants, usually lumped together in treating blister rust, actually fall into three groups, by origin from three European species. The small group related to *Ribes petraeum* is immune to blister rust. *R. rubrum* typifies another small group that is highly resistant to infection. The group descended from *R. sativum* is highly susceptible to infection.

Hirt, Ray R. 1935. **Observations on the production and germination of sporidia of *Cronartium ribicola*.** N.Y. State Col. Forestry Tech. Pub. 46, 25 pp., illus.

Discusses the results of controlled experiments on the optimum conditions for spore germination: a temperature of 12 to 16° C. and a relative humidity of 96 to 100% for teliospores, and a temperature of 12 to 18° C. and a relative humidity of 100% (direct contact with water) for sporidia. Exposure to direct sunlight for 8 hours did not kill teliospores but did lengthen the time required to produce sporidia. The same treatment killed sporidia but they remained viable during 8 hours of daylight if not directly exposed to sunlight. When sporidia germinated they produced either secondary sporidia or true hyphae.

Hirt, Ray R. 1936. **The progress of blister rust in planted northern white pine.** Jour. Forestry 34: 506-511, illus.

On each day from July 14 to September 29, 1927, 20 different nursery-grown white pine seedlings were exposed to blister rust infection for 24 hours. They were then planted out in a rust-free area at Warrensburg, N. Y. About 16% of them became infected—most of them during 2 short periods. Production of aeciospores on the infected trees began 3 years later and continued for at least 5 years but only a small proportion of infected trees produced them. Some infected trees will survive but the mortality was much higher than mortality in trees not infected. The proportion of infected trees dying increased yearly during the 8-year observation period.

Hirt, R. R. 1938. **Relation of stomata to infection of *Pinus strobus* by *Cronartium ribicola*.** Phytopath. 28: 180-190, illus.

Stomata probably have very little significance. No germ tubes were seen to enter the needles through the stomata but they did penetrate directly through the walls of the epidermal cells. Germ tubes from primary sporidia require approximately 10 hours of favorable weather to reach the mesophyll.

Hirt, Ray R. 1939. **Canker development by *Cronartium ribicola* on young *Pinus strobus*.** Phytopath. 29: 1067-1076, illus.

Report on studies made under natural conditions in the Adirondacks and in central New York. It should be possible by September of each year to estimate the intensity of infection from the preceding year. The average time for branch cankers to extend to the stem was 3 years, thus making it possible to detect and remove infected branches before the stem is invaded. Trees usually died 2½ to 6½ years after stem infection from a branch canker.

Hirt, Ray R. 1939. **The development of blister rust on young planted northern white pine.** Jour. Forestry 37: 967-969.

A single exposure of young white pines to telia-bearing bushes of European black current for 12 or 24 hours under natural conditions resulted in 4% of the trees becoming infected. Continuous exposure to the same Ribes throughout a summer resulted in as much as 69% infection. Within 5 years after infection, about one-third of the diseased trees died.

Hirt, Ray R. 1940. **Relative susceptibility to *Cronartium ribicola* of 5-needled pines planted in the East.** Jour. Forestry 38: 932-937.

Eleven species were planted and exposed to infection in a controlled experiment under natural environmental conditions in the Adirondacks and in central New York. White pine was found to be more susceptible than five other species but less susceptible than *Pinus monticola* and *P. flexilis.*

Hirt, R. R. 1942. **The relation of certain meteorological factors to the infection of eastern white pine by the blister rust.** N.Y. State Univ. Col. Forestry Tech. Pub. 59, 65 pp.

The minimum time required for pine infection under optimum conditions of moisture and temperature was found to be 11.5 hours, but the amount of infection increased after 19.5 hours. The optimum temperature range was apprixmately 50-65° F., and a constant temperature level of 68-69° F. was sufficient to inhibit infection. Rain was more important than either fog or dew as the source of moisture favorable to infection of eastern white pine, although fog and dew also tended to produce favorable conditions. Pronounced pine infection was restricted to relatively few periods when favorable weather happened to coincide with suitable stages in the development of the rust.

Hirt, Ray R. 1944. **Distribution of blister-rust cankers on eastern white pine according to age of needle-bearing wood at time of infection.** Jour. Forestry 42: 9-14.

Intensive studies of infection and canker development have shown that the majority of cankers develop on needle-bearing wood that was 1 year old at the time of infection. This was equally true of potted trees and those in undisturbed natural stands.

Hirt, Ray R. 1948. **Evidence of resistance to blister rust by eastern white pine growing in the Northeast.** Jour. Forestry 46: 911-913.

A brief progress report on the selection and testing of white pine at Syracuse, N. Y. Apparently resistant stock from various sources has been transplanted to Syracuse for testing. A number of trees appear to be immune or resistant, but efforts to propagate them by cuttings or grafts have not been very successful so far.

Hubert, Ernest E. 1935. **Observations on *Tuberculina maxima*, a parasite of *Cronartium ribicola*.** Phytopath. 25: 253-261, illus.

A brief review of European use of the so-called purple mold as a control of the white-pine blister rust introduces studies made in Idaho on this rust parasite. Field experiments and laboratory tests indicate a slow-growing and sensitive organism not easily established on its host. Once established, the purple mold is capable of slow spread and inhibits aeciospore production on blister rust cankers. The possibilities of its use as a biological control agency are remote.

Johnson, Albert G. 1947. **Some effects of 2,4-D on pines.** Jour. Forestry 45: 288-289.

Standard-strength solutions of 2,4-D were found to be highly effective in the destruction of wild black currant (*Ribes americanum*) in Wisconsin.

Lindgren, Ralph M., and A. Dale Chapman. 1933. **Field inoculations of *Pinus strobus* with sporidia of *Cronartium ribicola* in Minnesota.** Phytopath. 23: 105-107.

White pines, 3 to 7 years old, were inoculated with sporidia from *Ribes nigrum* and *R. cynosbati*. The former affected 23 branches on 8 out of 9 trees and the latter 1 branch on 1 out of 9 trees.

McCubbin, W. A. 1918. **Dispersal distance of urediniospores of *Cronartium ribicola* as indicated by their rate of fall in still air.** Phytopath. 8: 35-36.

The urediniospores averaged about 1½ minutes to fall 8 feet in still air, but many of the heavier ones took as long as 5 minutes. This means that dispersal distance for the spores should be considered in terms of miles, rather than of yards, as previously.

McCubbin, W. A., and G. B. Posey. 1917. **Development of blister rust aecia on white pines after they had been cut down.** Phytopath. 7: 391-392.

Observations at Cooks Town, Ontario, and Kittery Point, Maine, show that cankers on felled trees produce aeciospores prolifically, sometimes under the bark in drier stems. All infected cut material should be burned for effective sanitation.

McGinn, W. K., and A. G. Davidson. 1953. **Studies of white pine blister rust in Nova Scotia.** Forestry Chron. 29: 267-272.

In sample-plot studies no relationship was found between Ribes establishment and degree of cutting. Uncut stands where white pine predominates show evidence of producing a future pine crop Forest types supporting white pine appear to offer the best opportunities for pine reproduction where clearcutting has given the stand maximum opening. Results of the study to date do not show that blister rust is a major factor in retarding the establishment of white pine regeneration.

McIntyre, H. L. 1942. **White pine blister rust control policies in New York State.** Jour. Forestry 40: 782-785.

A resumè of blister rust activities in New York from 1920 through 1940. Effectiveness of control work has been continually improved. In dense woodlands or swamp areas where the pine is screened from Ribes a 50-foot, instead of the original 900-foot, protective zone is covered and in more open woodlands the width of the strip is 200 feet. The possession of European black currant is prohibited by law but the destruction of cultivated red currants beyond 300 feet from pine has been discontinued.

Martin, J. F. 1937. **Protect white pine from blister rust.** U.S. Dept. Agr. Misc. Pub. 22 (rev.), 8 pp., illus.

First issued as Misc. Circ. 40 in July 1925 and as Misc. Pub. 22 in 1928 (revised 1931 and 1937). States the importance of white pine, spread of blister rust disease, damage to pines, and control measures. Four of the eight figures illustrate, in color, the spread of blister rust and pine damage. This publication proved of great value in alerting the public to the dangers of and methods of control for this disease.

Martin, J. F. 1938. **Some economic aspects of white pine blister rust control.** Jour. Forestry 36: 986-996, illus.

Cost of Ribes eradication is affected by many factors: accessibility, topographic features, and ground cover; rates, quality, and source of labor; length of work day; and abundance of Ribes. Where pine is economically important, the costs are justified. As Ribes is intolerant, intensive control is necessary only in the early stages of succession.

Martin, J. F. 1940. **The application of surgery to blister rust infected trees of ornamental value.** Natl. Shade Tree. Conf. Proc. 16: 113-120.

The disease is described briefly and directions are given for the surgical treatment of infected pines. Under arboricultural conditions the cost of such treatment is often less than that of removing or replacing the trees. Surgical treatment is useless unless Ribes are cleared from the neighborhood to prevent re-infection.

Martin, J. F. 1944. **Ribes eradication effectively controls white pine blister rust.** Jour. Forestry 42: 255-260.

In white pine forest areas the blister rust can be effectively controlled by reducing the Ribes to an average of 25 feet of live stem or less per acre and subsequently keeping these plants suppressed. Complete eradication of Ribes can be justified only in pine stands of aesthetic or recreational importance, or forest-tree nurseries.

Martin, J. F., A. E. Stone, and R. A. Sheals. 1920. **How to distinguish and combat the white pine blister rust.** R. I. Bd. Agr. Ent. Dept. Bul. 1, 38 pp. (In coop. with U.S. Dept. Agr. Bur. Plant Indus.)

A discussion of the blister rust fungus and its mode of attack on white pine; contains good photographs of the stages of the fungus on pines and the alternate host Ribes. Also illustrates and discusses other tree diseases and insect injuries that might be mistaken for white pine blister rust. Control of the blister rust by Ribes eradication and the regulations for planting of 5-needled pines, currants, and gooseberries are given for Rhode Island.

Mielke, J. L. 1935. **Rodents as a factor in reducing aerial sporulation of *Cronartium ribicola*.** Jour. Forestry 33: 994-1003, illus.

Data are given on extent and results of rodent-feeding, both in eastern and in western North America. The removal of infected bark by rodents sometimes results in a considerable reduction in volume of aesciospores.

Mielke, J. L. 1943. **White pine blister rust in western North America.** Yale Univ. School Forestry Bul. 52, 155 pp., illus.

A thorough review of the whole blister rust problem, aimed particularly at western conditions, but much of it also applicable in the East. Included is material on origin and introduction of blister rust, white pine species, the rust on pines, the rust on Ribes, scouting for rust, rust situation in the West, and factors in the spread of rust.

Moir, Stuart W. 1924. **White pine blister rust in Western Europe.** U.S. Dept. Agr. Bul. 1186, 32 pp.

Blister rust was first found about 1860 in the Baltic Provinces of Russia. From 1880 to 1900 it was noted with increasing frequency in Western Europe. Most white pine plantings are 80% or more infected. Sugar, western white, limber, and Mexican white pines appear as susceptible to blister rust as white pine. Cultivation of black currant and gooseberries is widespread, and the rust on the former is particularly virulent. The cultivated Ribes are more highly regarded economically than are the exotic white pines, so effective control is unlikely.

Muller, R. 1936. ***Pinus strobus* rediviva.** Forstarchiv 12: 253-262.

In a discussion of the report of the white pine committee of the Deutscher Forstverein and von Tubeuf's criticism of it, it is concluded that white pine is a valuable tree for German silviculture, in spite of the blister rust, and that it should continue to be grown, under suitable conditions.

Perry, C. C. 1929. **Cost of blister rust control work. A "carrying charge" in the production of white pine.** Jour. Forestry 27: 50-54, illus.

Discussion of the cost of initial eradication of Ribes and periodic maintenance work in New England. Initial costs were 15.3¢ per acre on 4.7 million acres. Reworking costs are estimated at about half of initial costs. Computations show that it costs 12 to 40¢ per acre to protect pine, depending on the size of the blocks protected.

Pierce, R. G. 1917. **Early discovery of white pine blister rust in the United States.** Phytopath. 7: 224-225.

The earliest known collection of blister rust in the United States was made by Samuel N. Baxter from a nursery near Philadelphia in April 1905. The specimen was sent to the U. S. Department of Agriculture, where Mrs. F. W. Patterson, mycologist, identified it.

Posey, G. B., and E. R. Ford. 1924. **Survey of blister rust infection on pines at Kittery Point, Maine, and the effect of Ribes eradication in controlling the disease.** Jour. Agr. Res. 28: 1253-1258.

A patch of black currant (*Ribes nigrum* L.) plants introduced from England in 1897 created a primary infection center and caused infection of pine in the surrounding stands the same year. The annual rate of infection increased 20 times from 1901 to 1916. Destruction of all Ribes prevented the occurrence of new pine infection and permitted natural restocking with disease-free seedlings.

Radulescu, Theodor. 1937. **Beiträge zur Kenntnis der Baumkrankheiten. I. Untersuchungen über den Blasenrost der Weymouthskiefer.** Forstwiss. Centbl. 59 (19): 597-609, illus.

White pine shows wide individual variation—apparently hereditary—in susceptibility to blister rust. Of 73 trees felled in thinning a 0.14-hectare plot in a 52-year-old stand in Upper Bavaria, only 25 were infected, although the infection began 32 years before. In Upper Bavaria white pine stands, even when exposed to infected Ribes, may grow for decades without enough infection to necessitate cutting, and a reasonably full stand will reach maturity.

Riker, A. J., T. F. Kouba, W. H. Brener, and L. E. Byam. 1943. **White pine selections tested for resistance to blister rust.** Jour. Forestry 41: 753-760, illus.

Ten thousand seedlings and 1,000 veneer grafts from some 150 selected white pine, which had shown no blister rust after 15 to 20 years natural exposure to infected Ribes, were tested by both natural and artificial inoculation. Among the progeny from the first 63 selected trees, inoculated in September 1941, about 5% of the grafts and up to 100% of the seedlings showed infection.

Riker, A. J., T. F. Kouba, and B. W. Henry. 1947. **The influence of temperature and humidity on the development of white pine blister rust on Ribes leaves.** (Abs.) Phytopath. 37: 19.

Studies of the influence of environment on infection of Ribes by *Cronartium ribicola* in the greenhouse (controlled environment) and at the Wisconsin blister-rust nursery substantiate the observations (1) that telia seldom develop well on most species during hot weather, and (2) that hot weather improves the chances for white pine to escape infection.

Riley, J. E., Jr. 1930. **White pine blister control in Connecticut.** Conn. Agr. Expt. Sta. Bul. 314: 455-477.

A revision and up-dating of Conn. Agr. Expt. Sta. Bul. 237 (Filley and Hicock 1922), with added discussion of control methods, organization, cooperation, nursery sanitation, black currant eradication, status of control, and effectiveness. Describes insects and diseases often mistaken for blister rust, identification of Ribes species, and where to plant white pine.

Rusden, P. L. 1952. **Blister rust damage at Waterford, Vermont.** Jour. Forestry 50: 545-551, illus.

This longest available series of blister rust observations continued for 20 years in a heavily infected 2½-acre stand of merchantable white pine. Measurements of tree and volume losses among crop and non-crop trees at 5-year intervals are presented. Loss of volume (including potential growth on killed trees) is computed. The analysis shows that during the 20-year period the stumpage value per acre was cut about in half by blister rust mortality.

Schmid, R. 1954. **Über die histologische Spezialisierung von Blatt- und Rindenpilzen, mit besonderer Berücksichtigung ihrer Beziehungern zum Phloem.** Phytopath. Ztschr. 21: 407-432.

Describes, with photomicrographs and drawings, the development of the attack of various fungi in the tissues of the host. *Cronartium ribicola* attacks primarily the parenchyma and ray cells in pine. It grows readily in the sieve tubes and penetrates their walls. The harmful effect is specially noticeable in degeneration of the cambium. In later stages the bark tissue dies and the hyphae spread from the rays into and between the tracheids.

Snell, Walter H. 1919. **Observations on the relation of insects to the disemination of *Cronartium ribicola*.** Phytopath. 9: 451-464.

Many species of insects were found, some of them on both hosts, bearing aeciospores, urediniospores, and sporidia. The spread of the rust by insects from pine to Ribes or vice versa may be infrequent and accidental, but the spread of the uredinial stage upon Ribes probably occurs with some regularity.

Snell, Walter H. 1920. **Observations on the distance of spread of aeciospores and urediniospores of *Cronartium ribicola*.** Phytopath. 10: 358-364.

It is shown that the aeciospores of *C. ribicola* can be blown more than 1¼ miles and infect Ribes. Dry weather prevented a wide distribution of the disease by urediniospores during the summer of 1918 in Essex County, N. Y.

Snell, Walter H. 1931. **Forest damage and the white pine blister rust.** Jour. Forestry 29: 68-78, illus.

A detailed study of eight plots in New York revealed that there is no correlation between percentage of blister rust infection, mortality, and ultimate board-foot loss. Number of trees left, their crown development, other damage, branchiness, spacing, and the presence of trainers must also be considered.

Snell, Walter H. 1941. **The relation of cultivated red currants to the white pine blister rust in New York.** Jour Forestry 39: 859-867, illus.

A study was made in New York and New England of 72 cases where cultivated red currants grew within 900 feet of planted or native pine. There was very little evidence of infection by sporidia from the red currants and no evidence of damage to the pine, even when the currants were within 60 feet of the pine.

Snell, Walter H. 1942. **The production of sporidia of *Cronartium ribicola* on cultivated red currants in relation to infection of white pine.** Amer. Jour. Bot. 29: 506-513.

From data on number of leaves, total leaf areas, number of tilia, and number of sporidia per bush, it is shown that a garden row of red currants will produce at best only a small fraction of the sporidia produced by wild gooseberries and an even smaller fraction of the number produced by black currants.

Spaulding, Perley. 1922. **Investigations of the white pine blister rust.** U.S. Dept. Agr. Bul. 957. 100 pp., illus.

Presents all the essential facts known at the time about white pine blister rust, as determined from research. Covers origin and distribution, hosts, life history, overwintering, important dates in the life history, and control. A list of 180 references is given.

Spaulding, Perley. 1925. **A partial explanation of the relative susceptibility of the white pines to the white pine blister rust (*Cronartium ribicola* Fischer).** Phytopath. 15: 591-597.

Eastern white pine is susceptible to blister rust but not so much so as western white pine and a number of other species. There appears to be a general relation between degree of susceptibility and (1) the number of years leaves persist, and (2) the relative numbers of stomata on the leaves. Phloem thickness may also be a factor in susceptibility—the thicker phloem of the western pine seems more suitable for vegetative growth of the rust.

Spaulding, Perley. 1926. **The white pine blister rust in Germany.** Jour. Forestry 24: 645-652.

A review of the ideas of Harrer and Tubeuf (1914-1926) regarding the extended use, planting and protection policies, values, and relative blister rust susceptibility of the native and exotic 5-needled pines in Germany. Major policy questions concern the species to plant and whether or not blister rust protection is possible, especially with *Pinus strobus, P. monticola,* and *P. lambertiana.* Use of rust-resistant currants for cultivation is suggested. The author favors limiting the areas in which white pines may be grown and applying known methods of blister rust control within such areas.

Spaulding, P. 1929. **White-pine blister rust: a comparison of European with North American conditions.** U.S. Dept. Agr. Tech. Bul. 87, 59 pp.

A report on an investigation of the white pine blister rust *(Cronartium ribicola)* in various countries of northern and western Europe, in which a comparison was made between the conditions that influence the disease. Cultivated Ribes are common in Europe, and *R. nigrum*, a favorite, is found practically everywhere that the species will grow. Practically all the white pine infections seen in Europe were considered due to this host.

Spaulding, Perley, and Annie Rathbun-Gravatt. 1925. **Conditions antecedent to the infection of white pines by *Cronartium ribicola* in the northeastern United States.** Phytopath. 15: 571-583, illus.

The conditions necessary for the infection of white pines are many, and some of them are not known. It is known that there must be a period of sufficient moisture to germinate the teliospores, and that this must be followed by a period of high humidity for infection to take place. Temperaure appears not to be so important. Questions that need investigation are suggested.

Spaulding, Perley, and Annie Rathbun-Gravatt. 1925. **Longevity of the teliospores and accompanying uredospores of *Cronartium ribicola* Fischer in 1923.** Jour Agr. Res. 31: 901-916, illus.

Teliospores and accompanying uredosproes from eight Ribes hosts were stored under outdoor conditions and were germinated at 7-day intervals. The required germination period increased directly with duration of storage. The shortest life was 19 days for one collection from *Ribes rotundifolium*. Teliospores on *R. nigrum* lived 87 days and were germinating well when the tests ended.

Spaulding, Perley, and Annie Rathbun-Gravatt. 1926. **The influence of physical factors on the viability of sporidia of *Cronartium ribicola* Fischer.** Jour. Agr. Res. 33: 397-433, illus.

A pioneer study of the physiology of white pine blister rust spores. Methods of study and the effect on sporidial viability of drying, alternate wetting and drying, relative humidity changes, icing, sunlight, and constant wetting are described in detail. All factors except icing tended to decrease germination.

Stewart, F. C. 1906. **An outbreak of the European currant rust (*Cronartium ribicola*).** N.Y. State Agr. Expt. Sta. Tech. Bul. 2: 61-74.

Report on the discovery, in September 1906, of the fungus that causes white pine blister rust on currants (Ribes). Describes the fungus, and lists its geographical distribution and economic importance in Europe. Indicates the possible source of the outbreak at the New York State Agriculture Experiment Station, Geneva, N. Y. Discusses the control methods used and the danger to *Pinus strobus* and other 5-needled pines in North America. A bibliography of 67 references is given.

Temple, C. E., and H. E. Yost. 1943. **White pine blister rust control in Maryland.** Univ. Md. Ext. Serv. Hort. Dept. Bul. 98, 23 pp., illus.

Outlines the extent and value of white pine in Maryland, the history and spread of the white pine blister rust, the fungus life cycle, the characteristic appearance of the disease in both pine and Ribes, the extent of the damage, and the methods of control. Control by Ribes removal now covers most of the better stands of white pine in the State. Further reworking at 3- to 5-year intervals will be less costly. The State regulations for control of this disease are given.

Tubeuf, Carl von. 1933. **Studien über Symbiose und Disposition sowie über Vererbung pathologischer Eigenschaften unserer Holzpflanzen. 4. Disposition der fünfnadeligen Pinus-Arten einerseits und der verschiedenen Ribes-Gattungen, Arten, Bastarde und Gartenformen anderseits für den Befall von *Cronartium ribicola*.** Zeitschr. Pflanzenkrank. 43: 433-471.

Records inoculation tests of *Cronartium ribicola* on some 400 species, varieties, and hybrids of Ribes and Grossularia. Only a small number proved to immune, including 9 cultivated varieties and hybrids of Ribes and 11 species or varieties of Grossularia. Discusses susceptibility of the 5-needle pine species to blister rust, with a key to the species.

United States Bureau of Entomology and Plant Quarantine. 1949. **White pine blister rust control. Manual of field procedures and general information—Northeastern Region.** U.S. Bur. Ent. and Plant Quar., 112 pp., illus.

Describes white pine blister rust and its importance. field procedures for control area surveys, scouting, Ribes eradication, and work inspection. Includes descriptions of the host species and of other important pests of white pine.

Van Arsdel, E. P., A. J. Riker, and R. F. Patton. 1953. **Microclimatic distribution of white pine blister rust in southwestern Wisconsin.** Phytopath. 43: 487-488.

In southwestern Wisconsin, certain topographic features and vegetation patterns that lowered temperatures and increased humidities were correlated with blister rust distribution. In culture tests a constant temperature of 20° C. or less was optimum for all spores. Sites that had a saturated atmosphere several hours a day longer in late summer or fall than surrounding areas appeared to favor spore production.

Van Vloten, H. 1941. **Korte mededeeling over de proef met *Pinus strobus* van verschillende herkomst uit Noord-Amerika.** Nederland. Boschbouw Tijdschr. 14: 345-346.

Preliminary results from a test of 43 provenances of white pine exposed to as great a chance as possible of infection by *Cronartium ribicola* showed that although severe infection could be found in all provenances, not all developed aecia, and the percentage of plants showing aecia varied in different lots from 0 to 72. Only continued observations can determine whether the differences so far observed are in fact differences of natural resistance.

York, Harlan H., and Walter H. Snell. 1922. **Experiments in the infection of *Pinus strobus* with *Cronartium ribicola*.** Phytopath. 12: 148-150.

In infection experiments at North Conway, N. H., it was determined that sporidia become fully developed in 5 to 6 hours after dry teliospores are placed in favorable germination conditions. It takes at least 18½ hours of constantly favorable conditions for infection to occur on pine in close proximity to infected Ribes. Infection occurs on the seedling pines 12½ hours after the viable sporidia reach the needles.

York, H. H., W. H. Snell, and Annie Rathbun Gravatt. 1927. **The results of inoculating *Pinus strobus* with the sporidia of *Cronartium ribicola*.** Jour. Agr. Res. 34: 497-510, illus.

Inoculation experiments indicated that seedlings of all ages may be infected, that 1- and 2-year-old needles are equally susceptible, and that cankers developed on wood formed during the year of infection and during the preceding year. Mortality was higher among infected seedlings than among those not infected; seedlings could be killed within a year of inoculation.

Other Diseases

Abbott, F. H. 1915. **The red rot of conifers.** Vt. Agr. Expt. Sta. Bul. 191, 20 pp., illus.

The red rot caused by *Fomes pini* is most serious in unthinned pure white pine stands. Prevention is best effected by thinning, removal of diseased trees, and destruction of fruiting bodies. The weight and breaking and crushing strength of infected wood are reduced roughly in proportion to the permeation of the wood by the fungus.

Baldwin, Henry I. 1954. **Needle blight in eastern white pine.** U.S. Dept. Agr. Plant Dis. Rptr. 38: 725-727.

Reviews the history and symptoms of this blight. Primary symptom is a reddish-brown appearance of the foliage, usually extending from the tip back about one-third of the needle's length. Results of a survey made in southern New Hampshire in 1954 indicate that the blight is seldom fatal and is not associated with insects or disease.

Berk, S. 1948. **Inoculation experiments with *Polyporus schweinitzii.*** Phytopath. 38: 370-377.

Polyporus schweinitzii is very destructive to white and red pine planted on abandoned fields in New York State. Inoculation and fungus culture tests were made to determine whether the widespread occurrence of the disease was due to dissemination of spores from outside, or to persistence of the organism as a saprophyte in the soil or weakly parasitic on the roots of hardwood seedlings and herbaceous plants. Results indicate that *P. schweinitzii* is not capable of parasitizing roots of hardwood seedlings and grows well in autoclaved soils or duff. Probably *P. schweinitzii* becomes parasitic only when the host is growing under very favorable conditions.

Campana, Richard J. 1954. ***Corticium galactinum* does not cause white pine needle blight.** U.S. Dept. Agr. Plant Dis. Rptr. 38: 297-303.

The reported association of this fungus with the disease had led to speculation that its primary effect was the destruction of feeding rootlets. The author's observations give no indication that this fungus invades the roots; attempts to isolate it from inoculated roots were unsuccessful.

Cox, R. S. 1953. **Etiology and control of a serious complex of diseases of conifer seedlings.** (Abs.) Phytopath. 43: 469.

A tree disease complex on conifer seedlings in a Delaware nursery was due primarily to a soil-borne fungus, *Cylindrocladium scoparium*, causing damping-off, root rot, stem canker, and needle blight. White pine seedlings are seriously damaged under conditions of high humidity. Excellent control was obtained with formaldehyde for soil treatment and Bordeaux mixture plus a sticker spreader as a foliar spray applied monthly during the growing season.

Cox, R. S. 1954. ***Cylindrocladium scoparium* on conifer seedlings.** Del. Agr. Expt. Sta. Tech. Bul. 301, 40 pp., illus.

See above.

Dana, S. T. 1908. **Extent and importance of the white pine needle blight.** U.S. Forest Serv., 4 pp.

The disease was first reported at Concord, N. H., where a few trees showed the symptoms in 1905. By spring 1907 the disease was widespread, covering nearly all of the white pine region in New England. The symptoms are a reddish-brown coloration of the needle tips on the current year's growth only. Trees of all ages and sizes and conditions are affected, but trees are damaged as single individuals scattered through the woods rather than as groups of trees.

Davidson, Ross W., and Frances Lombard. 1954. **Brick red stain of Sitka spruce and other wood substrata.** Phytopath. 44: 606-607, illus.

The recently described *Ascocybe grovesii* is the fungus that was associated with brick red stain of airplane spruce. Its growth on other wood substrata such as white pine and its growth in pure culture on several media indicates it is not restricted to particular substrata.

Davis, W. C., G. Y. Young, and L. W. Orr. 1939. **Needle droop of pine.** Jour. Forestry 37: 884-887.

Abnormal needle drooping of the current season's growth of red pine, and occasionally of white pine, was observed in the Lake States in 1935, and subsequently in Maryland, Wisconsin, and Massachusetts; and also on ponderosa pine in the Northwest. The cause is not yet known, but it may be some abnormal physiological condition such as rapid needle growth, which preceded the 1935 injury. Frost appears to be a factor in some cases.

Dearness, John. 1928. **New and noteworthy fungi.** Mycologia 20: 235-246.

Among the new species listed are the following on eastern white pine: *Hendersonula pinicola* in North Carolina; *Leptothyrium stenosporum* in Georgia.

Delaware State Forestry Department. 1953. **A foliage disease of white pine seedlings.** Del. State Forestry Dept. Rpt. (1952-53), 21 pp.

Cylindrocladium scoparium, usually a saprophyte, has caused much damage to the foliage of white pine seedlings in the nursery. Manzate, Fermate, and Bordeaux mixture all gave satisfactory control without injuring the foliage. Mercurial compounds injure foliage and have been rejected.

Deuber, C. G. 1931. **White pine blight.** Natl. Shade Tree Conf. Proc. 7: 97-100.

Stunted white pines with short, yellow-green needles have been observed throughout southern New England. Swampy ground and dry hillsides seem to be the most common locations for them but wherever they are found they are intermingled with normal trees. Histological studies have shown that cells as well as size of needles are dwarfed. Microchemical tests showed deficiencies of iron and starch in diseased trees. Differences in root development were also found. No causative organism or condition has been isolated; the poor growth results from unfavorable environmental factors and unexplained physiological conditions.

Doolittle, Warren T. 1948. **White pine blight in relation to site and thinning.** Jour. Forestry 46: 928-929.

Fifty-year-old eastern white pine plantations at Biltmore, N. C., have exhibited white pine blight for 3 years. On dry sites, 18.6% of the pines were infected compared to 5.2% on moist sites. Growth rate of diseased trees was at least 33% less than that of normal trees, but there was no apparent difference in growth rate of diseased trees according to site or thinning treatment.

Faull, J. H. 1922. **Some problems of forest pathology in Ontario—needle blight of white pine.** Jour. Forestry 20: 67-70.

The distribution and symptoms of needle blight are discussed and the study of sample trees is described. Based on 4 years' observations it is concluded that young stands are not likely to be seriously depleted by needle blight, but that injury to heavily blighted mature stands may be so great as to be a deciding factor in determining the time of harvesting. In regions subjected to sulfur fumes, it is possible to differentiate between blight and sulfur-fume injury if the examination is made at the right time.

Faull, J. H. 1929. **A fungus disease of conifers related to the snow cover.** Jour. Arnold Arboretum 10 (1): 3-8.

The Phacidium blight is caused by a fungus very similar to, if not identical with, *P. infestans*. It is highly infectious and may have a rapid spread, causing browning and fall of white pine needles during the first summer. It appears most virulent on white spruce but attacks a number of native conifers. Control in the nursery with a dormant lime-sulfur spray applied in the fall is cheap and easy.

Fink, Bruce. 1911. **Injury to *Pinus strobus* caused by *Cenangium abietis*.** Phytopath. 1: 180-183, illus.

The type of injury, location of injured trees, and appearance of this Ascomycete on some white pines in Ohio is described. The disease appears to strike only occasionally and usually after drought years. Trees on high ground seem to be more often affected than those on somewhat lower ground.

Gifford, C. M. 1911. **Damping-off of coniferous seedlings.** Vt. Agr. Expt. Sta. Bul. 157, 171 pp., illus.

A species of *Fusarium* was isolated from 2-year-old white pine seedlings. This fungus may cause damping-off and root rot. It sometimes kills older seedlings by attacking roots and stems. Nursery beds may be disinfected with a 0.5 to 1% solution of formalin applied at the rate of ¾ gallon per square foot. It should be applied at least a week before the seed is to be sown.

Haddow, W. R. 1933. **Disease as a factor in transition of pine to stable types.** Forestry Chron. 9: 30-35.

Most pines that die, die of diseases. The root- and butt-rotting fungi, while of comparatively little importance as wood destroyers, are the first to cause the breaking up of the stand; and they continue to operate, accounting in the end for the destruction of most of the trees. There is an explainable relationship between the incidence of brown butt rot and site. Other rots are described.

Haddow, W. R. 1934. **An instance of early infection of white pine (*Pinus strobus* L.), by *Trametes pini*.** Forestry Chron. 10: 199-202.

Although heart-rots are generally regarded as diseases of mature or overmature trees, there is evidence that young trees may become infected. One such tree, 52 years old when discovered, suffered a broken top when 11 years old and became infected when 16 to 19 years old.

Haddow, W. R. 1938. **The disease caused by *Trametis pini* (Thore) Fries in white pine (*Pinus strobus* L.).** Royal Canad. Inst. Trans. 22: 21-80.

The disease is non-lethal yet very destructive. It is of widespread distribution. Normally it causes heart rot in the middle portion of the trunk, and is often responsible for decay in old trees. Detection is possible mainly through the occurrence of punk knots and associated symptoms. Several proposals for control are reviewed critically and the pathological rotation is discussed.

Hahn, Glen G., Carl Hartley, and Arthur S. Rhoads. 1920. **Hypertrophied lenticels on the roots of conifers and their relation to moisture and aeration.** Jour. Agr. Res. 20: 253-266, illus.

This condition was observed first on ponderosa pine, but has since been found on many pines, including pitch pine and eastern white pine. It appears to be associated with excessive soil moisture (or deficient soil aeration). The symptoms are decreased by top pruning and increased by root injury.

Hedgcock, George G. 1932. **Notes on the distribution of some fungi associated with diseases of conifers.** U.S. Dept. Agr. Plant Dis. Rptr. 16: 28-42.

These diseases are reported as associated with white pine: *Apospbaeria pinea, Asterina pinastri, Caliciopsis pinea, Chilonectria cucurbitula, Coccomyces pini, Cytospora pinastri, Hendersonula pinicola, Hypoderma brachysporum, Leptothyrium stenosporum, Lophodermium pinastri, Mollisia pinastri, Mollisia pinicola, Nectria* sp., *Nectria cinnabarina, Neopeckia coulteri, Ophionectria scolecospora, Pestalozzia funerea, Pestalozzia peregrina, Pezizella minuta, Phacidium planum, Phoma strobiligena, Sclerophoma pini, Septoria spadicea, Sphaeropsis ellisii, Valsa abietis, Valsa kunzei, Valsa pini,* and *Hypoderma lineare.*

Heiberg, Svend O., and Donald P. White. 1951. **Potassium deficiency of reforested pine and spruce stands in northern New York.** Soil Sci. Soc. Amer. Proc. 15: 369-376, illus.

Symptoms of the deficiency are general chlorosis followed by browning and dying of needles, decreased height and diameter growth, shortening of the needles and of their period of persistence. Application of potash at the rate of 200 pounds per acre increased annual height growth 46 to 104% and the effect continued at least 6 years.

Heiberg, S. O., E. L. Stone, and D. P. White. (1954?). **Potash and magnesium fertilization of young pine and spruce trees.** N.Y. State Univ. Col. Forestry and Col. Agr. 8 pp., illus.

Plantations on old fields or burns in and around the Adirondacks commonly have symptoms of nutrient deficiency. Lack of potassium results in sparse foliage or a yellow-green to yellow, or even brownish, color. Height and needle growth may be greatly reduced. Lack of magnesium shows up as a conspicuous yellowing of the needle tips. Symptoms appear in the fall and are most pronounced in early spring. Fertilizers to overcome deficiencies are listed, along with various methods of application.

Hepting, George H., and Albert A. Downs. 1944. **Root and butt rot in planted white pine at Biltmore, North Carolina.** Jour. Forestry 42: 119-123.

A high percentage of the trees (75%) in previously thinned white pine lots had root and butt rots. A smaller perceintage of those in the isolation strips around these plots were rotted, and a very much smaller part (4%) of the trees in previously unthinned plots were butt-rotted. Most of the rots were caused by *Fomes annosus*, some by *Polyporus circinatus* and *P. schweinitzii*.

Hirt, Ray R. 1959. ***Pinus strobus* L. A literature review and discussion of its fungus diseases in North America.** N.Y. State Univ. Col. Forestry Tech. Pub. 82, 90 pp. Syracuse.

Assembles the more important American references to the fungus diseases of *Pinus strobus* in North America. Provides an abstract for each reference to white pine disease, and includes personal comments on some of the more common diseases.

Hubert, Ernest E. 1935. **A disease of conifers caused by *Stereum sanguinolentum*.** Jour. Forestry 33: 485-489, illus.

The disease (commonly called the mottled bark disease) is described on white pine and a number of other conifers in plantations in Idaho. The damage appears to have been aggravated by drought conditions for several years. External characteristics of the disease are few and inconspicuous; it is suggested that pruning cuts be made close to the trunk so that the wounds will heal quickly as possible.

Ibberson, J. E., and H. Streater. 1952. **White pine blight responds to fertilizer applications.** Pa. Dept. Forests and Waters 4 (2): 30-31, 46.

Reports on an experiment in Cook Forest, Pennsylvania, to test the response of diseased trees to various fertilizer treatments. The disease appeared to respond definitely and rapidly to certain applications of complete fertilizer (10-6-4). But none of the applications of trace elements gave positive results.

Nemec, A. 1942. **Zur Kenntnis der Kali- und Magnesia-Mangel-erscheinungen bei Samlingen und Kulturen der Kiefer.** Forstwiss. Centbl. 64: 160-166.

In several localities in Czechoslovakia where the soil was deficient in potassium or in both potassium and magnesium, a yellowing of the needle ends in some Scotch pine and white pine seedlings was observed. Compared with unaffected plants growing in the same locality, those that were affected showed a lower potassium and magnesium content and a higher magnanese content in their needles, and sometimes in both needles and stem.

New Hampshire Forestry Commission. 1908. **The pine blight of 1907 and 1908.** N.H. Forest Comn. Bien. Rpt. 1907-1908: 7-15.

An account of the widespread occurrence of white pine needle blight in northern New England during 1907, and to a lesser degree during 1908. The yellowing of the needles was attributed to either a *Septoria* species or to winter root damage. A twig blight occurred in 1908 that was caused by *Pineus pinifoliae*.

Nobles, Mildred K. 1953. **Studies in wood-inhabiting hymenomycetes. I. *Odontia bicolor*.** Canad. Jour. Bot. 31: 745-749, illus.

Cultural methods have shown that *Odontia bicolor* is the cause of an important butt rot in white pine and other species in Canada. It is confined to the heartwood. In the incipient stages it is described as a pink to reddish-brown discoloration, while in the advanced stage it is a white pitted, stringy, or feather rot.

Owens, C. E. 1936. **Studies on the wood-rotting fungus *Fomes pini*. II. Cultural characteristics.** Amer. Jour. Bot. 23: 235-254, illus.

Agar cultures from 6 genera and 19 species could be placed into 3 groups according to their growth and development. The isolate from white pine occurred in the majority group characterized by rapid growth rate, producing a thick, fluffy, buff-colored mycelial mat.

Percival, W. Clement. 1933. **A contribution to the biology of *Fomes pini* (Thore) Lloyd (*Trametes pini* (Thore) Fries).** N.Y. State Col. Forestry Tech. Pub. 40, 72 pp., illus.

White pine is one of 59 species listed as hosts of *Fomes pini*. This report includes a history of the disease and its distribution, occurrence, and sporulation. Various culture experiments are reported. Among them red spruce was successfully inoculated with cultures from white pine; and white pine was one of five species successfully inoculated with a single culture from western white pine.

Ray, W. W. 1936. **Pathogenicity and cultural experiments with *Caliciopsis pinea*.** Mycologia 28: 201-208, illus.

Artificial inoculation experiments demonstrated that *C. pinea* is pathogenic and produces cankers on the trunks and branches of white pine. In pure culture experiments, spermagonia and mature stromatic columns containing asci and spores were developed.

Schantz-Hansen, T., W. H. Kenety, G. H. Wiggin, and E. C. Stakman. 1923. **A study of the damping-off disease of coniferous seedlings.** Minn. Agr. Expt. Sta. Tech. Bul. 15, 35 pp., illus.

Report on an extensive study of nursery practices that affect seedling germination and fungi that cause damping-off of white, red, and jack pines. Factors tested and discussed are time of sowing, seed covering, manuring, shading, watering, mulching, density of stocking, drainage, soil texture, seedbed sterilization, and use of fungicides. When recommended practices were followed with white pine, germination increased and damping-off decreased.

Sleeth, Bailey. 1938. **Pruning wounds as an avenue of entrance for *Stereum sanguinolentum* in northern white pine plantations.** U.S. Forest Serv. Allegheny Forest Expt. Sta. Tech. Note 22, 3 pp.

A reconnaissance was made of white pine plantations in Pennsylvania to determine the prevalence of sporophores on old pruning wounds. In general, the percentage of wounds bearing sporophores was greater among large wounds. Care should be taken in pruning dead branches to prevent injury to the live wood. Young pruned trees in which fungus is established are considered worthless long before they reach merchantable size.

Snell, Walter H. 1929. ***Dasyscypha agassizii* on *Pinus strobus*.** Mycologia 21: 235-242, illus.

Dasyscypha agassizii was very abundant on planted white pine in New York, especially on blister rust cankers. This fungus had been reported only on *Abies balsamea*, but collections are here noted from *Tsuga canadensis*, *Pinus monticola*, *Picea rubra*, *P. mariana*, and possibly *Pseudotsuga taxifolia*. The habitat of *D. agassizii* is apparently subboreal.

Spaulding, Perley. 1929. **Decay of slash of northern white pine in southern New England.** U.S. Dept. Agr. Tech. Bul. 132, 20 pp.

White pine slash rots about as follows: fruiting bodies of fungi, especially *Lenzites sepiaria* and *Polystictus abietinus*, begin to form in the 2nd year after cutting and cause most of the decay, which is well advanced by the 4th year. At about the 8th year the slash piles flatten to ground and by the 15th year most slash is well rotted. By the 20th year the material has formed a mat of fibrous mold under the litter.

Spaulding, Perley, and J. R. Hansbrough. 1943. **The needle blight of eastern white pine.** U.S. Bur. Plant Indus. Div. Forest Path. Mimeo., 2 pp.

The blight usually appears after prolonged periods of moist, cloudy weather which are followed by hot, dry days. It is more apt to occur when the needles are most tender and succulent. It is a symptom of inadequate moisture supply to the needles, probably because of a deficiency of active feeding rootlets. The condition is seldom fatal but recovery can be helped by mulching, fertilization in the dormant season, and crown pruning.

Spaulding, Perley, H. J. MacAloney, and A. C. Cline. 1935. ***Stereum sanguinolentum* a dangerous fungus in pruning wounds on northern white pine.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 19, 2 pp.

To avoid serious damage from attacks by this fungus, prune before branches exceed 2 inches in diameter. The exposed heartwood of larger branches was not well covered with protective pitch and so provided a favorable entrance for this fungus.

Stambaugh, W. J. 1952. **A study of the needle cast diseases of conifers in Pennsylvania.** Jour. Forestry 50: 944.

Four needle-cast fungi of Pines are common in Pennsylvania: *Bifusella linearis* and *Hypoderm desmazierii* are mildly parasitic on white pine; *Lophodermium pinastri* is a widespread saprophyte on all pine needles; and *Hypoderma lethale* is the most virulent but is confined to native hard pines. Needle-cast epidemics were found to be closely related to periods of high humidity. Trees of poor vigor are the usual victims.

Stone, Earl L., Jr. 1953. **Magnesium deficiency of some northeastern pines.** Soil Sci. Soc. Amer. Proc. 17: 297-300.

Magnesium deficiency of white, red, and jack pines on light-textured soils south and west of the Adirondacks caused a bright yellow coloration in the needle tips of the current year's growth. This symptom appeared in the fall. Only in extreme deficiency or where magnesium and potassium deficiency were combined did large reductions in shoot and needle growth occur. In such cases, fertilization gave statistically significant increases in height growth.

Strong, F. C. 1941. **Root and butt rot in the pinetum at Michigan State College.** Mich. Agr. Expt. Sta. Quart. Bul. 23: 159-163.

A dozen trees in a 44-year-old white pine plantation were windthrown by a gale. All of them had trunk or roots weakened by *Polyporus schweinitzii*, which was shown to have spread from an infected tree to adjacent ones. Thinning or fertilizing the stand to increase vigor should help contain the disease, but no economical way to eradicate it is known.

Swingle, Roger U. 1944. **Chlorotic dwarf of eastern white pine.** U.S. Dept. Agr. Plant Dis. Rptr. 28: 824-825.

This disease (common in 2- to 15-year old plantations throughout Ohio) is characterized by stunted roots, top, and foliage. The foliage is greenish-yellow to yellow, and second-year needles fall prematurely. No causal organisms or weather patterns are consistently associated with the disease.

Toole, E. Richard. 1949. **White pine blight in the Southeast.** Jour. Forestry 47: 378-382.

Reports increase of white pine blight in the Southeast. Needle dieback is accompanied by reduced growth rate and there may be appreciable mortality. Some of the possible causes of this disease are discussed. Needle fungi have been eliminated as a likely factor. Further work is needed to determine the significance of root fungi and root aphids, the latter either as a primary cause or as vectors of a virus.

Toumey, J. W., and T. T. Li. 1924. **Nursery investigations with special reference to damping-off.** Yale Univ. School Forestry Bul. 10, 36 pp.

Sulfuric acid applied at the rate of 3/32 fluid ounces per square foot of seedbed effectively controlled damping-off, gave higher survival of white pine, white spruce, and hemlock than heavier dosages—and greatly reduced weed growth. The acid delayed germination, reduced germination percent, and reduced top and root growth in porportion to the amount used. Formalin was not satisfactory for treating seedbeds. The tests were made during one season at New Haven.

Vermillion, M. T. 1950. **A needle blight of pine.** Lloydia 13: 196-197.

Provisional descripion of a disease of white pine seedlings, characterized by considerable browning and killing of needles. The disease seems to be the white pine needle blight caused by a species of *Pestalozzia*, probably *P. funerea*.

Walker, E. A. 1946. **Eastern white pine affected with needle blight in Maryland.** U.S. Dept. Agr. Plant Dis. Rptr. 30: 320.

Needle blight appeared in Maryland in July 1946 at several locations in Montgomery, Frederick, Carroll, and Prince George's Counties. The conditions under which it developed verify the statements by Spaulding and Hansbrough (1943).

Waterman, Alma M. 1943. ***Diplodia pinea* and *Sphaeropsis malorum* on soft pines.** Phytopath. 33: 828-831.

Observations and inoculation tests indicate that neither fungus is parasitic upon new leaves and twigs of young, vigorously growing white pine. Both fungi occasionally contribute to the unhealthy condition of soft pines weakened by other agents. Improved growing conditions and the protection and prevention of wounds will lessen the possibility of infection.

Wean, Robert E. 1937. **The parasitism of *Polyporus schweinitzii* on seedling *Pinus strobus*.** Phytopath. 27: 1124-1142, illus.

Sand culture experiments involving five nutritional conditions showed that phosphorus-deficient 1- and 2-year-old seedling white pines were highly susceptible to attack. Roots in nutrient solutions with pH 6 and 7 were also severely attacked. The fungus is a direct parasite capable of penetrating directly through living cortical cells of the roots. Parasitism of seedling roots indicates that this fungus can be spread by nursery stock.

White, L. T. 1953. **Studies in forest pathology X. Decay of white pine in the Timagami Lake and Ottawa Valley areas.** Canad. Jour. Bot. 31: 175-200, illus.

The study of decay and decay relationships of 1,012 white pine trees in ten 1-acre plots located in pure even-aged stands showed that 52% contained decay. A well-defined relationship existed between age and decay. The proportion of trees with decay increased gradually with age from 40% in the 60-year age class to 100% in the 220-year age class. The loss in merchantable volume increased from 4% at 60 years to 40% at 200 years.

Wycoff, H. B. 1952. **Methyl bromide controls soil organisms which cause mortality of eastern white pine seedlings.** U.S. Forest Serv. Tree Planters Notes 12: 11-14.

Soil sterilization with methyl bromide before sowing white pine seed on green-manured plots gave satisfactory control of damping-off.

York, H. H. 1932. **New disease on white and red pine.** Jour. Forestry 30: 505-506.

A new disease, apparently caused by a fungus, has been discovered in red and white pine plantations in the vicinity of Rochester, N. Y. The symptoms include a profuse exudation of resin at the base of the trunk, permeating the soil for several inches around each diseased tree. Examination of the infected parts (roots and lower trunk) reveal characteristic mottling and an enlargement and breakdown of resin pores. The disease apparently requires 3 to 5 years to kill a tree.

York, Harlan H. 1943. **Detecting pathological regions and nonconducting tissues in living pine trees by means of dyes.** (Abs.) Phytopath. 33: 20.

White, red, and Scotch pine were cut off near the ground and their butts placed in aqueous solutions of dyes for 36 to 72 hours. Certain dyes penetrated the trees to the needle tips. Regions of the stem where the dyes failed to penetrate were found to be infected with fungi and bacteria. Such lesions were more abundant in weak trees than in vigorous trees.

White-Pine Weevil

Barnes, T. Cunliffe. 1929. **An enquiry concerning the natural history of the white pine weevil (*Pissodes strobi*).** 4th Internatl. Congress Ent. Trans. 2: 412-413.

Oviposition is not possible until the spring after emergence when the ovarian tubes are large, flexed, and contain a prominent vitelarium. The spermary of the young males is advanced, but the glands do not mature until spring. Weevils leave the pine litter under trees when the mean temperature rises to 60° F. and fly readily if the day temperature rises above 70° F. Aestivation occurs in July at a mean temperature of 70° F.

Blackman, M. W. 1919. **Report on the white pine weevil.** Maine Forestry Dept., 12 pp.

Presents a general description of the insect, its life history, choice of food plants, method of attack, damage. Advises cutting and burning leaders for control, or better, Hopkins' disposition of cut leaders supplemented by systematic collection of adult beetles in spring and early summer. Comments on why virgin forests were free of weevil injury and suggests planting methods that might produce the same result.

Crosby, David. 1950. **Concentrated lead arsenate spray for control of white pine weevil.** Jour. Forestry 48: 334-336.

Reports results of a spray program for the control of white-pine weevil through the use of concentrated lead arsenate applied with a knapsack sprayer. This spray was applied to the leaders in the spring before the weevils became active. Percentage of weeviling for each year is given for a 5- to 7-year period after treatments. One treatment gave adequate protection for 4 years. Two well-timed treatments spaced 4 years apart should give a high degree of protection for 8 years. This period of protection should permit a high percentage of well-formed butt logs.

Crosby, David. 1954. **How to control the white pine weevil with a hand sprayer.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Res. Note 30, 3 pp.

Describes the types and preparation of materials and equipment needed to control weevil with lead arsenate. Spraying can be done in late winter or spring, but in Connecticut it should be completed by the end of April. The first treatment should be made when 2 to 5% of the trees are weeviled in 1 year and should be repeated when weeviling builds up to 10% annually. Seldom should more than two treatments be required to produce straight 16-foot butt logs.

Doolittle, Warren T. 1954. **Weevils attracted to bud-pruned white pine.** U.S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 63, 2 pp.

Alternate rows were bud-pruned in a white pine plantation beginning when it was 5 years old. Although pruned and unpruned trees were approximately the same height after 4 years of pruning, the bud-pruned trees had a significantly higher incidence of weevil attack. Bud-pruning white pine is not recommended.

Graham, S. A. 1918. **The white pine weevil and its relation to second-growth white pine.** Jour. Forestry 16: 192-202, illus.

Describes the life history of the weevil, the type of injury it causes, and its distribution by regions. The author studied the age class, stand density, and rate of growth of the white pines attacked. He found: (1) the upturned laterals were about one-third shorter than the weeviled terminals they replaced but that the differences became less as the leader lengths increased; (2) that fewer trees were weeviled as stand density increased; (3) that loss in average total height per tree and percentage of unmerchantable trees decreased with increasing stand density. Suggests control measures.

Graham, S. A. 1926. **Biology and control of the white-pine weevil, *Pissodes strobi* Peck.** N.Y. Agr. Expt. Sta. Bul. 449, 32 pp., illus. (Cornell.)

The biology of the insect and the direct and indirect methods of control are discussed. Experiments in New York and Minnesota indicate that young white pine need no longer to be seriously menaced by the white-pine weevil. The insect can be controlled under any condition in which a fully stocked (1,500 trees per acre) stand can be maintained the first 25 or 30 years of the rotation, or where white pine can be grown under the shelterwood system or some other system that will provide shade for the sapling pines.

Holdsworth, Robert P. 1943. **Some work on the white pine weevil.** Jour. Forestry 41: 143-144.

Since 1920 weevilled white pine tips have been removed annually from some 141 acres of white pine type on the Mt. Toby Forest in Massachusetts. Since 1936 the weevilled trees have been shaped by removing all except the best lateral at the base of the weevilled tip. This practice has reduced stem crook to a negligible amount. Number of tips collected each year declined from 1,400 in 1920 to only 26 in 1942.

Hopkins, A. D. 1907. **The white pine weevil.** U.S. Bur. Ent. Circ. 90, 8 pp., illus.

The insect, its life history, the species and kind of trees it attacks, and the type of damage done are described and illustrated. Recommends control by cutting off infested leaders in July. They should be kept in screened containers in the area for a year so that weevil parasites may escape. Treatment should be repeated at least 3 years in succession.

Kriebel, Howard B. 1954. **Bark thickness as a factor in resistance to white pine weevil injury.** Jour. Forestry 52: 842-845, illus.

Susceptibility of white pine to injury by the weevil is partly correlated with bark thickness at breast height. Among dominant trees of equal diameter in even-aged stands, trees with thin bark are weevilled less frequently than trees with thick bark. A significant proportion of the unweevilled trees are below average in bark thickness.

Littlefield, E. W. 1942. **White pine weevil damage reduced by close spacing.** New York State Conserv. Dept. Forest Invest. Notes 37, 1 pp.

Of two small plantations of white pine on loam soils, the one with an original spacing of about 3.5 x 3.5 feet showed 76% of the trees to have been weevilled in some degree and 79% of the weevilled trees to have made good recovery; in the one with a spacing of 6 x 6 feet, 96% of the trees were weevilled and only 4% of these showed good recovery.

MacAloney, Harvey J. 1930. **The white pine weevil (*Pissodes strobi* Peck)—its biology and control.** N.Y. State Col. Forestry Tech. Pub. 28, 87 pp., illus.

A comprehensive report on the weevil, including a description of damage to the host, historical notes, life history, and methods of control. Based on a study made from 1923 to 1928.

MacAloney, Harvey J. 1943. **The white pine weevil.** U.S. Dept. Agr. Cir. 221, 30 pp., illus.

Gives the life cycle of the weevil (*Pissodes strobi*, Peck). Insect population levels are partially controlled by age, height, and vigor of the trees; soil conditions; exposure; climatic factors; predacious animals, birds, and insects; amount of natural food; and stand composition. The only feasible control is to grow the host species in dense pure stands or in mixture with the better hardwoods. Many species are attacked; but white pine, Norway spruce, and jack pine (in that order) are favored.

Maughan, W. 1930. **Control of the white pine weevil on the Eli Whitney Forest.** Yale Univ. School Forestry Bul. 29, 37 pp., illus.

Weevilled tips should be removed before emergence of the weevil, beginning the first year of infestation and continuing each year until the crowns have closed, usually between 12 to 14 years of age. This reduces infestation and results in more acceptable stems per acre. On poor sites even this practice will not bring through enough acceptable stems. Cost data included.

Mott, Paul B. 1930. **An annotated bibliography of the white pine weevil, *Pissodes strobi* (Peck), for white pine blister rust workers and others.** N.J. Dept. Agr. Cir. 177, 37 pp.

Chronologically arranged, the references date from 1817, when Peck originally described the insect, to 1930, when MacAloney and Taylor published their treatments of the insect. The following articles are recommended: Hopkins 1907; Blackman and Ellis 1916; Davis 1920; Peirson 1922 and 1928; Graham 1918 and 1926; MacAloney 1926, 1929, and 1930; Barnes 1928 and 1929; Plummer and Pillsbury 1929; and Taylor 1929 and 1930.

Peirson, H. B. 1922. **Control of the white pine weevil by forest management.** Harvard Forest Bul. 5, 42 pp., illus.

Discusses the history, biology, damage, and control of this native pest by forest management and other measures. Dense stocking of young white pine limits forking after weevil attack; rapidly grown trees are less damaged than slow grown; mixtures of hardwoods in stand protect pines; native predators and parasites, sprays, and removal of infested leaders assist in control.

Plummer, C. C., and A. E. Pillsbury. 1929. **The white pine weevil in New Hampshire.** N.H. Agr. Expt. Sta. Bul. 247, 32 pp., illus.

Integrates the results of various original experiments and observations on the life history and habits of the white-pine weevil. The damage it inflicts on pine and methods of control, both direct and indirect, are also discussed.

Potts, S. F., A. C. Cline, and H. L. McIntyre. 1942. **The white pine weevil and its control by the application of concentrated sprays.** Jour. Forestry 40: 405-410, illus.

The application of concentrated spray to 65 acres of white pine plantations 8 to 13 years of age gave excellent protection against the white-pine weevil. An effective mixture was (by weight): lead arsenate, 1 part; water, 10 parts; adhesive oil, 0.3 part — with or without 0.02 part of spreader. About 5 gallons of mixture per acre is applied to the leaders late in March or during April wtih a compressed air sprayer. The sprayer and accessory equipment are described.

Schenefelt, Roy D. 1951. **A further note on the control of the white pine weevil.** Jour. Forestry 49: 575-576.

A block of some 41,000 white pine trees was ground-sprayed with lead arsenate and other insecticides. Three years after spraying, only 0.5% of the leaders were infested and there appeared to be little need for another spraying. Recommends that lead arsenate be used in ground spraying because it is easy to see, remains for as long as 5 months on the leaders, does not have a contact action on the parasites, and is safer to use. Some observations on weevil epidemiology.

Steiner, G. 1930. ***Neodiplogaster pinicola* n. sp., a nema associated with the white pine weevil in terminal shoots of the white pine.** Jour. Agr. Res. 41: 125-130.

A new nema is described. It may be of economic importance as an enemy of the white-pine weevil for it probably preys on the eggs and larvae.

Taylor, Raymond L. 1928. **The arthropod fauna of coniferous leaders weeviled by *Pissodes strobi* (Peck).** Psyche 35: 217-225.

In a study of the bionomics of the white-pine weevil, the author bred 16 species of Arachnida and 79 of Insecta from weeviled white pine leaders. Many of them apparently have no definite relationship with the weevil. An annotated list is given, eliminating species known to be parasites or predators. Many of the species listed are not pine feeders; they used the weevil burrows only as places to hibernate.

Taylor, Raymond L. 1929-30. **The biology of the white pine weevil, *Pissodes strobi* (Peck), and a study of its insect parasites from an economic viewpoint.** Ent. Amer. 9: 167-246; 10: 1-86, illus.

A comprehensive review of previous work and new studies on the white-pine weevil, with particular reference to population dispersion, numbers, survival, and parasitism. The primary and secondary parasites, which destroy about 16% of the mature weevil larvae, are discussed in detail. Possibilities of control by native or introduced parasites are poor but should be explored.

Taylor, Raymond L. 1930. **The natural control of forest insects. I. The white pine weevil, *Pissodes strobi* Peck.** Jour. Forestry 28: 546-551.

Using material from a more complete report (Taylor 1929-30), the author summarizes factors acting in the natural control of the white-pine weevil according to stages in the insect's development. Tables show the effectiveness of birds and the computed effectiveness of parasites.

West, A. S. 1947. The effect of the white pine weevil on plantations on the University of New Brunswick forest. Forestry Chron. 23: 291-296.

Presents tabulations of annual weevilling (1932-45) of four plots in plantations totaling about 2 acres. Shows frequency of weevilling, average height and diameter growth, frequency of forked trees, mortality by periods, and incidence of blister rust. The plots were subjected to many adverse conditions, but the very poor condition of these plots is largely the result of weevilling and blister rust.

Other Insects

Anonymous. 1945. Insect control: pests of pines. Amer. Nurseryman 81 (10): 22-23.

Gives formulas and spraying instructions for chemical control of pine-leaf scale *(Chionaspis pinifoliae)*, pine bark aphis *(Pineus strobi)*, and pine sawflies *(Neodiprion lecontei* and *N. abbotti)*.

Atwood, C. E., and O. Peck. 1943. Some native sawflies of the genus *Neodiprion* attacking pines in eastern Canada. Canad. Jour. Res. Sec. D: 109-144, illus.

In eastern Canada, sawflies of at least 12 species of the genus *Neodiprion* have been causing damage to white, red, and jack pine by eating the needles. Keys are given for identifying adult females of 11 species and larvae of 10 species. Two of the species are described as new. The sawflies can be distinguished by their habits, notably oviposition, feeding, and overwintering.

Baker, W. L. 1941. Effect of gypsy moth defoliation on certain forest trees. Jour. Forestry 39: 1017-1022.

Injury by the gypsy moth in New England has been most severe to oaks and white pine during the period 1912-21 when records were made of defoliation, mortality, and loss of diameter increment. Percentage of defoliation and mortality were roughly equivalent — about 30% for highly favored food trees and about 10% for those unfavored. Greatest mortality occurred before 1915 among trees weakened by heavy defoliation, drought, and *Agrilus bilineatus* activity.

Baker, W. L., and A. C. Cline. 1935. A study of the gypsy moth in the town of Petersham, Mass., in 1935. Jour. Forestry 34: 759-765.

Feeding preferences of the gypsy moth larvae is the key to control of the insect. Oaks, poplar, gray birch, alder, willow, and apple are highly favored food sources for larvae of all ages; but white pine is favored by later instars, and maple will be fed upon in these later stages. Specific protection recommendations are made for a variety of stand conditions. Protection of coniferous plantations by weeding and clearing of isolation strips should be given first preference in any silvicultural control program.

Balch, R. E., and G. R. Underwood. 1950. **The life-history of *Pineus pinifoliae* (Fitch) and its effect on white pine.** Canad. Ent. 82(6): 117-123.

A detailed life-history of *Pineus pinifoliae*. Unusual abundance of the insect was first noted in 1942 in New Brunswick. Spruce is little affected, but drooping of affected shoots of white pine results in some crookedness at the nodes and reduced growth. In sample-plot experiments, white pine mortality was slight and was confined to small trees, but loss of growth was considerable and tended to favor competition by spruce and red pine.

Baldwin, H. I. 1948. **Pales weevil damage after fire and logging.** N.H. Forestry and Recreation Comn. Fox Forest Notes 37, 1 p.

Of more than 1,000 seedlings tallied, 12% had been killed and an additional 35% severely injured by the Pales weevil in the first season after logging. White and Norway pine planted the spring after logging suffered even heavier losses — 60 to 70% were killed and an additional 20 to 30% injured. Trees planted the spring after fire showed a loss of 30% if the burned timber had been salvaged and 13% where the timber was not salvaged. Four-year-old stock was damaged least.

Baldwin, H. I. 1953. **Prevention of bark beetle attack in conifers.** N.H. Forestry and Recreation Comn. Fox Forest Notes 51, 2 pp.

Most bark beetles attack only dead and dying trees, slash, stumps, green logs, and lumber. Prevention can be accomplished by keeping the trees in vigorous growing condition, using sanitation to prevent accumulation of breeding material, and spraying uninfested trees or products with benzene hexachloride.

Bess, Henry A., Stephen H. Spurr, and E. W. Littlefield. 1947. **Forest site conditions and the gypsy moth.** Harvard Forest Bul. 22, 56 pp.

Resistant stands occur more commonly on soils that have an adequate supply of moisture and organic matter, and are characterized by full stocking and relatively vigorous growth. They are also found on the poorer sites where there has been a minimum of disturbance. White pine types are listed as resistant to gypsy moth — not likely to be defoliated unless badly abused or surrounded by susceptible types.

Carter, E. E. 1916. ***Hylobius pales* as a factor in the reproduction of conifers in New England.** Soc. Amer. Foresters Proc. 11: 297-307.

In New England, white pine reproduction has seldom been obtained promptly after the removal of the same species; this has been generally attributed to the competition of hardwoods. But careful investigations have shown that the Pales weevil kills large quantities of young seedlings. Therefore, cutover lands should not be planted until the third and preferably the fourth season after logging. The injury done by this weevil is an added argument against the use of shelterwood or strip methods in the reproduction of white pine.

Craighead, F. C. 1950. **Insect enemies of Eastern forests.** U.S. Dept. Agr. Misc. Pub. 657, 679 pp., illus.

About 40 different insects are listed as attacking white pine, although most of them are of minor economic importance to white pine. These insects are described, together with a description of the damage they cause. Critical points in the life history are discussed and control measures are described briefly.

DeGryse, J. J. 1943. **Note on *Marmara fasciella* Chambers.** Canad. Ent. 75: 40.

Marmara fasciella Chamb. has been found to construct long linear mines in the phloem of the trunk and branches of white pine and is probably distributed over the entire species range. The adults emerge in late May and early July and oviposit on the bark. The larva penetrates into the phloem through the underside of the egg, constructs about half of the mine during late summer and autumn and hibernates there; it resumes feeding early in the spring, completes its mines in May or June, and then spins its cocoon. Parasites noted.

Dingler, Max. 1928. **Chalcographus-frass in Weymouthskiefern.** Forstwiss. Centbl. 50: 357-360, illus.

The bark beetle *Pityogenes chalcographus*, a common enemy of *Picea excelsa*, also attacks white pine planted in mixture with spruce.

Dumbleton, L. J. 1932. **Report on spruce aphis investigation.** New Zeal. Jour. Sci. and Technol. 13: 207-220.

The biology of *Neomyzaphis abietina* Walker on spruce in New Zealand was studied. Data are given on the seasonal variation in numbers of aphis on spruce, the length of the developmental stages, and the reproductive capacity. No sexual forms were noted and no alternate hosts found. Laboratory experiments showed that the alates can reproduce on white pine, and in one case white pine was successfully infested with apterous aphids.

Easterling, George Riley. 1934. **A study of the insect fauna of a coniferous reforestation area in southeastern Ohio.** Ohio Jour. Sci. 34: 129-146, illus.

A survey of densely spaced conifer plantations, aged 2 to 24 years and containing 12 species, showed that an association of insects typical of coniferous forest had been established. The most serious pests were white pine aphid *(Adelges pinicorticis)* and pine leaf scale *(Chionaspis pinifoliae)*, which attacked the older white pines.

Friend, R. B., and H. H. Chamberlin. 1942. **Some observations on Pales weevil injury to white pine plantings in New England.** Conn. Agr. Expt. Sta. Bul. 461: 530-537.

Small plot studies of Pales weevil behavior at Keene, N. H., indicate that, in continuously logged regions, pine may be planted the second spring after logging rather than the third spring if as much as 15% weevil damage is acceptable. In regions where there has been little commercial pine logging, such as around New Haven, Conn., weevil population is low and pine may be planted the first spring after logging with little or no risk of damage.

Graham, Samuel A. 1935. **The spruce budworm on Michigan pine.** Mich. Univ. School Forestry Bul. 6, 56 pp., illus.

White pine is seldom severely attacked by the spruce budworm.

Heinrich, Carl. 1931. **A new pine moth from Connecticut.** Wash. Ent. Soc. Proc. 33: 196-197.

Eucosma gloriola breeds in tips of twigs of white pine; descriptions of larva and adults are given.

Henry, H. K. 1942. **Injury to pines by a leaf-chafer.** N.Y. State Conserv. Dept. Forest Invest. Notes 41, 1 p.

Pachynetbus oblivia, a pine leaf miner, is found on rare occasions attacking white pine in New York, and perhaps more frequently in Minnesota. Hard pines are the normal host. The insect feeds on needles just above the fascicle, and nearly cuts them off. The needles then turn brown and drop in July.

Hosley, N. W. 1928. **A preliminary study of borer damage in stacked white pine lumber.** Jour. Forestry 26: 888-891.

The pine sawyer (*Monochamus scutellatus* Say.) can cause serious damage to round-edge plank if uncontrolled. Lumber sawed between September 1 and March 1 in central Massachusetts was not infested with the borer. If sawing must be done during the danger period, damage may be avoided by sawing square-edge plank, by kiln-drying the lumber, or by making up the lumber into the finished product as soon as frass begins to appear.

Kamp, H. J. 1953. **Der Halsgrubenbock, ein gefährlicher Holzschädling.** Holz-Zentbl. 79 (152): 1626.

Describes the attack of *Criocephalus rusticus* on white pine in Germany. One tree (d.b.h. 40 centimeters) was infested from ground level to a height of 50 centimeters; another, 60 years old, showed infestation from ground level to 2 meters, the tunnels penetrating to a depth of 15 centimeters and reaching into the heartwood.

Kojima, Toshibumi. 1931. **Further investigation on the immature stage of some Japanese cerambycid-beetles with notes on their habits.** Imp. Univ. Tokyo Col. Agr. Jour. 11 (3): 263-308, illus.

Includes a description and account of habits of *Megopis tesserula*, for which white pine is listed as one of the hosts.

Lentz, G. H. 1929. **Further light on "tree seed farms".** Jour. Forestry 27: 424-425.

In at least 5 of 7 years a small beetle, *Conophthorus coniperda*, destroyed practically all of the 1-year-old cones in a virgin white pine stand at Warrensburg, N. Y., preventing the maturing of any useful quantity of seed.

MacAloney, H. J., and N. W. Hosley. 1934. **Experiments in simplified control of mound-building ants in forest.** Jour. Forestry 32: 1003-1006.

Carbon disulfide or ethylene dichloride, if properly used, will control the mound-building ant, *Formica exsectoides* Forel. One to two pounds of these chemicals are necessary for each mound. Treatment should be made in late fall or early spring when all ants are in the mound.

McGuffin, W. C. 1943. **New descriptions of larvae of forest insects. VII. *Pero, Nepytia, Caripeta* (*Lepidoptera, Geometridae*).** Canad. Ent. 75: 186-190.

Two of the three species described, *Pero morrisonarius* and *Neyptia canosaria*, have white pine as one of their less important hosts.

Minott, C. W., and I. T. Guild. 1925. **Some results of the defoliation of trees.** Jour. Econ. Ent. 18: 345-348, illus.

Growth and survival in relation to defoliation of oaks and white pine by gypsy moth was observed during a 10-year period. On the average, white pine was defoliated 10% annually with little loss of growth; but when a pine is completely defoliated, it nearly always dies.

Mitchell, H. L. 1939. **Preliminary notes on a method for the prevention and control of white grub infestations in nursery soils.** Black Rock Forest Papers 1 (14). 2 pp.

A series of tests showed that a solution of 0.8% acetic acid, applied at the rate of 0.75 quart per square foot of seed bed, is effective in controlling white grub infestation both before sowing and during the growing season. This treatment does not harm after-ripened white pine seed or seedlings. In addition, such treatments will control damping-off.

Monro, H. A. U. 1935. **Observations on the habits of an introduced pine sawfly *Diprion simile* Htg.** Canad. Ent. 67: 137-140.

White pine is the preferred host of *Diprion simile*, but this sawfly also attacks red, jack, and Scotch pines. In the severe winter of 1933-34, mortality was complete in cocoons more than 3 feet from the ground, and was least in those on the ground.

Parr, Thaddeus. 1943. **Voltage gradients in trees as an indicator of susceptibility to insect attack.** Jour. Forestry 41: 417-421.

Field and laboratory tests of voltage gradients were made on white and red pines, red spruce, pitch pine and beech. Healthy trees and those damaged by insect attack, partial uprooting, suppression, or other causes were studied. In healthy trees the gradient reached highest positive value in early spring, dropped fairly regularly to zero in August and dropped to negative values after that. Size, age, and species differences in healthy trees were slight, but trees of subnormal vigor showed divergence of voltage gradients in phase and degree.

Peirson, H. B. 1921. **The life history and control of the Pales weevil (*Hylobius pales*).** Harvard Forest Bul. 3, 33 pp.

Describes the life history, food habits and damage done to white pine seedlings by this insect. Chief attack is on seedlings 2 to 3 years old; 1-year seedlings are not damaged; and those 4 years or more are less seriously damaged. Pales weevil breeds in stumps, slash, logs, or lumber. Control is by prompt removal of logs and burning slash over stumps; advises to delay planting at least two growing seasons after cutting.

Peirson, H. B. 1922. **Mound-building ants in forest plantations.** Jour. Forestry 20: 325-335.

The death of trees and other vegetation surrounding these mounds is caused by the ants in their efforts to provide full sunlight on the nests. The pines are killed by injection of formic acid; other species are killed by this and other means. Control may be obtained by fumigating the nest with carbon bisulfide.

Perry, George S. 1930. **Tree damage by the red spider.** Jour. Forestry 28: 864-867.

Red spiders (*Tetranychus telarius* and other species) have often caused serious damage in Pennsylvania forest nurseries. One case of damage with 8% mortality is reported on a 14-year-old white pine stand with trees 10 to 20 feet high. Hot dry weather favors increase of the spiders; shade and irrigation help control them, and any contact insecticide is effective.

Plumb, G. H. 1950. **The adult feeding habit of some conifer-infesting weevils.** Canad. Ent. 82: 53-57.

Magdalis austera and *M. hispoides* were found feeding on the needles of white pine. The adult beetle emerges just as the young needles are breaking out of the sheath and drills through the scales into the succulent young needles, leaving a series of punctures. The part of the needle turns yellow and bends down at the point of injury. Later it falls off, so that the needles appear to have been fed on by lepidopterous or sawfly larva.

Schaffner, J. F., Jr. 1943. **Sawflies injurious to conifers in the Northeastern States.** Jour. Forestry 41: 580-588.

During the past decade, 14 species of sawflies have been abundant, at least locally, for one or more years. White pine is a preferred food species for three of these: *Acantholyda erythrocephala*, *Diprion simile* (introduced pine sawfly), and *Neodiprion pinetum* (white pine sawfly). A key to identification and a brief summary of the life history and general habits of the more important species are given. Control can best be maintained by silvicultural practices leading to fully stocked mixed hardwood-softwood stands.

Schimitschek, E. 1941. **Die Massenvermehrung des Kiefernspanners, *Bupalus piniarius* L., und seine Bekämpfung im Jahre 1940 in der Westslowakei.** Centbl. f. das Gesam. Forstw. 67: 25-46, 53-59.

An outbreak of *Bupalus piniarius* occurred in 1937 to 1940 in west Slovakia in pure even-aged stands of white pine, overstocked and unthinned. The attack was aggravated by an outbreak of the pine sawfly, *Diprion pini*, and many trees were killed. More than five healthy *Bupalus* pupae per square yard marked the danger limit and stands with double that figure were dusted by airplanes with two proprietary insecticides. Parasitism is also discussed.

Underwood, G. R. 1953. **Biennial cycle of injury by pine leaf chermes.** Canada Dept. Agr. Div. Forest Biol. Bimo. Prog. Rpt. 9 (3): 1.

Studies of *Pineus pinifoliae* in New Brunswick since 1946 reveal a biennial cycle of abundance and injury to white pine related to the pest's complex 2-year life cycle. A winged form (gallicola) goes from red spruce to white pine one year, and another winged form (sexupara) returns to the spruce the next. There are intermediate wingless forms.

Underwood, G. R. 1954. **Damage to white pine (*Pinus strobus*) by pine leaf chermes (*Pineus pinifoliae*).** Canada Dept. Agr. Div. Forest Biol. Bimo. Prog. Rpt. 10 (3): 1.

Measurement of increment cores from 186 white pines known to have been attacked since 1947 showed an average reduction in ring width of about 60% from 1943 to 1952. The pattern follows the biennial cycle of abundance of the insect, the decrease being limited to rings formed in the years after heavy attack.

United States Bureau of Entomology. 1927. **The relation of insects to slash disposal.** U.S. Dept. Agr. Circ. 411, 12 pp.

Slash attracts insects to cutover areas and serves as breeding material. The value of slash disposal in insect control is considered in each of the economically important forest-type insect complexes. Slash burning in white pine by the usual methods is held to have little value.

West, A. S. 1952. **Notes on Leconte's sawfly.** Canad. Ent. 84 (2): 59-61.

Notes on a heavy infestation of *Neodiprion lecontei* on white and red pine in Ontario. In 1946 both species were attacked; in some cases white pine was heavily infested, while neighboring red pine was free or nearly so ,indicating selective oviposition. In 1947-48 the infestation was extremely light and was limited to white pine.

Wood Technology and Utilization

STRUCTURE AND PROPERTIES

Aleksandrov, V. G., and K. Iu. Abesadze. 1927. **[Developmental sequence of bordered pits in pine tracheids.]** Russ. Bot. Obshch. Zhur. 12 (1/2): 183-196, illus.

Reports studies on wood structure of white pine and other pine species. (In Russian.)

Alvarez-Novoa, Jose C., Holger Erdtman, and Gosta Lindstadt. 1950. **Constituents of pine heartwood. XVIII. A note on cryptostrobin, an isomer of strobopinin from the heartwood of *Pinus strobus* L.** Acta Chem. Scand. 4. 390-391.

The process by which the new compound was isolated is described briefly, together with some of its properties. The compound may exist in the heartwood of white pine, but this is not certain.

Anderson, Ernest, Joseph Kesselman, and Emil C. Bennett. 1941. **Polyuronide hemi-celluloses isolated from the sapwood and compression wood of white pine, *Pinus strobus* L.** Jour. Biol. Chem. 140: 563-568.

These hemi-celluloses are common in hardwoods. White pine compression wood yielded larger amounts of them than normal sapwood. They were a complex mixture — apparently of two types. No definite conclusions could be reached about the size and structure of the molecules in the cell wall. A pectic material, probably a pectinic acid, was also isolated. It was apparently the same as that obtained from hardwoods.

Baker, Gregory. 1954. **The durability of Maine woods for fence posts—progress report.** Maine Univ. Forestry Dept. Tech. Note 33, 2 pp.

Data on white pine indicate a higher degree of durability than might be expected. The stock was cut from slim suppressed trees. In the outer 1-inch of radius the ring count ranged from 30 to over 40 rings per inch and the sapwood averaged less than 1/2 inch in thickness. After 8 years of service, only 20% of the white pine posts (4 to 4.5 inches in diameter at the ground) had failed.

Betts, H. S. 1929. **The strength of North American woods.** U.S. Dept. Agr. Misc. Pub. 46, 17 pp.

Actual and comparative values of wood properties for eastern white pine (from Shawano County, Wis.) and 128 other native American woods. Includes weight per cubic foot in green, air-dry, and kiln-dry condition, specific gravity when oven-dry, volume, radial and tangential shrinkage from green to oven-dry condition, bending strength, strength in compression parallel and perpendicular to the grain, stiffness, hardness, shock-resisting ability, and shearing strength parallel to the grain.

Brown, H. P. 1928. **Atlas of the commercial woods of the United States.** N.Y. State Col. Forestry Bul. 18, 6 pp., illus.

To assist all users of wood in species identification, photographs of the transverse sections of 57 tree species are shown at a magnification of 15 diameters. Plant No. 1 is *Pinus strobus*.

Brown, H. P., and A. J. Panshin. 1940. **Northern white pine, eastern white pine, white pine. *Pinus strobus* L.** *In* Commercial Timbers of the U.S.: 371-373. New York.

A brief description of general characteristics and properties, minute anatomy, and uses of white pine wood.

Brown, H. P., and A. J. Panshin. 1940. **The wood anatomy of northern white pine.** *In* Commercial Timbers of the U.S.: 94-109. New York.

Describes the anatomy as seen in the radial, tangential, and cross sections of white pine. Volumetric data for white pine wood and a detailed description of the longitudinal tracheid.

Burns, George P. 1920. **Eccentric growth and the formation of redwood in the main stem of conifers.** Vt. Agr. Expt. Sta. Bul. 219, 16 pp.

In white pine, redwood (compression wood) and eccentric growth usually occur together but not necessarily. Compression does not act as a stimulus causing the cambium to divide more rapidly and produce redwood. Pressure may be a factor in the differentiation of the annual ring into spring- and summer-wood, even in white pine and spruce where normally such differentiation is not especially marked. Production of redwood seemed in these experiments to be a morphogenic response to gravitation stimulus.

Carderera, E. 1950. **Estudio del *Pinus strobus* L. para su aprovechamiento celulosico.** Inst. Forest. de Invest. y. Exper. Bol. 23 (60): 19. Madrid.

Results of chemical and histological investigations are presented, including data on wood density, moisture content, and cellulose content, all of which indicate a good pulping species. Whie pine has already been planted in the coastal forests of northern and northwestern Spain. Wider use of it is recommended.

Carpenter, Charles H. 1931. **An atlas of paper-making fibres.** N.Y. State Col. Forestry Tech. Pub. 35, 7 pp., illus.

Photomicrographs of the fibres, including the tracheids, of eastern white pine.

Cockrell, Robert A. 1933. **A study of the screw holding properties of wood.** N.Y. State Col. Forestry Tech. Pub. 44, 28 pp., illus.

Ten species, including white pine, were studied to determine the effect of variable wood quality on the holding power of flat-headed, 1-inch No. 6, 8, and 10 screws. Maple ranked first in holding power; and white pine was next to last. This property is proportional to the first power of the specific gravity of the wood. Dry wood was 50% stronger than green in screw-holding strength. Data are given by species, showing force in pounds for side, end, and shear pulling of screw positions in wood.

Condon, E. U. 1945. **The self-ignition temperature of partially charred wood.** U.S. Bur. Standards, 6 pp., illus.
Results with grooved, partially charred white pine blocks and other materials were compared with results of previous tests on uncharred materials. The self-ignition temperature of white pine was 217° C. if partially charred, and 264° C. if uncharred. Test procedures are described.

Coppick, S., and E. C. Jahn. 1943. **Nitrated wood: fractionation and molecular magnitudes.** Indus. Engin. Chem. 35: 890-894.
A laboratory study of wood fractions found in nitrated wood of eastern spruce and white pine and of various pulp products of these species. A combination of solution and precipitation methods in water, acetone, alcohol and other organic solvents showed that crude nitrated wood of 5% lignin content had viscosities and average equivalent molecular weights comparable to those of nitrated bleached cotton linters. However, the material of large molecular size in wood can be broken down further by bleaching, or extraction by hot water and hot alcohol. This indicates easily severed linkages between cellulose and lignin, carbohydrates, and possibly glucosides and hemicelluloses.

Findlay, W. P. K. 1942. **Resistance to decay of *Pinus strobus*.** Emp. Forestry Jour. 21: 134.
Results from standard laboratory tests indicated that there is little difference in the resistance to decay of the timber of white pine and *P. silvestris;* it is concluded that timber of white pine should be classified as moderately resistant to fungal decay.

Forsaith, C. C. 1926. **Eastern white pine.** *In* The Technology of New York State Timbers. N.Y. State Col. Forestry Tech. Note 18, 285-287.
A brief description of white pine wood anatomy.

Fowler, W. F., and W. M. Harlow. 1940. **Infra-red photo-micrography reveals plant cell wall structure.** Paper Indus. 21: 1159-1160, illus.
In infrared microphotographs of the sapwood of white pine, stained with neocyanine, it was possible to distinguish clearly the primary cell walls and the true intercellular substances as separate components of the compound middle lamella.

Garratt, George A. 1931. **The mechanical properties of wood.** 276 pp., illus. New York.
Tabulates for white pine and about 50 other commercial species the tensile and compressive strength perpendicular to the grain, compressive strength parallel to the grain, shearing strength parallel to the grain, results of static and impact bending, hardness, and cleavage strength tests. Gives specific gravity, weight per cubic foot, percentage of shrinkage on drying. Working stresses are tabulated for joists, planks, beams, stringers, and columns under various use conditions. All measurements were made on unseasoned wood.

George, Harry O. 1933. **The effect of low temperature on the strength of wood.** N.Y. State Col. Forestry Tech. Pub. 43, 18 pp.
In tests with the wood of white pine, black ash, and sugar maple it was concluded that wood is stronger in a frozen state than at ordinary temperatures. Influence of cold on strength of wood is largely a matter of change of state of the moisture contained in the cell walls. Strength increase due to freezing is greater above than below the fiber saturation point. Ice damage to standing timber may be attributed entirely to excessive load and wind effects since the influence of cold is to lessen the danger of breakage.

Greguss, P., and I. Varga. 1950. **Xylotomischer Bestimmungsschlüssel der Pinus-Arten.** Univ. Szeged. Bot. Inst. 162 pp.

The transverse, tangential, and radial sections of the xylem of 68 pine species are briefly described. On the basis of ray tracheid wall and pit characteristics, the species are divided into nine groups typified by: *Pinus cembra, P. strobus, P. aristata, P. massoniana, P. radiata, P. pinea, P. sylvestris, P. banksiana,* and *P. ponderosa.* Both Cembra and Strobus have smooth-walled ray tracheids with one and sometimes two or three circular to rectangular pits in the radial walls. The tangential walls are usually pitted. In Cembra the pits occur one over the other, but in Strobus they occur side by side.

Hausbrandt, L. 1953. **(Comparative investigation on the anatomical structure of the wood of the native and some foreign pines grown in Poland.)** Rocz. Dendrol. Polsk. Tow. Bot. 9: 1-64.

The nine species of pine investigated include white pine, which is characterized by: (1) smooth-walled ray tracheids which are few in number, (2) one or two semi-bordered pits in the common radial wall of ray parenchyma and longitudinal tracheids.

Lewis, Frederic T. 1935. **The shape of the tracheids in the pine.** Amer. Jour. Bot. 22: 741-762, illus.

Reconstruction from serial transverse sections of the wood and cambium of white pine show that the constituent cells have an average of 18 to 22 contacts with neighboring cells, and present a geometrical form deducible from the effects of tension in their walls. Their basic shape is that of a 14-hedral fiber, oriented with *edges* above and below (prosenchyma, as contrasted with parenchyma, which has *facets* above and below). By an outward buckling of the shafts of the fibers, or an inward growth of the extremeties, the 14-hedral fibers cross one another at their tips, becoming 18-hedral or 22-hedral, according to degree of curvature.

Markwardt, L. J. 1930. **Comparative strength properties of woods grown in the United States.** U.S. Dept. Agr. Tech. Bul. 158, 38 pp.

Supplements Newlin and Wilson (1917) by tabulating comparative values or indexes for mechanical properties of the important commercial woods, including white pine. Working stresses are also tabulated.

Markwardt, L. J. 1941. **Aircraft woods: their properties, selection, and characteristics.** Forest Prod. Lab. Mimeo. R1079, 51 pp., illus.

Strength values of various woods for aircraft design for a 15% moisture condition and a 3-second duration of stress are given, and various factors affecting these values are discussed. The toughness-test method of selecting wood is discussed and a table of acceptance values for several species is included. White pine is among the species that may be considered with red, sitka, and white spruce for use in highly stressed parts such as wing beams.

Matzke, Edwin B., and Robert L. Hulbary. 1942. **An analysis of the wood of the three commercial species of white pine.** Torrey Bot. Club Bul. 69: 573-582, illus.

The pits of the ray parenchyma cells in contact with the tracheids are described in detail. Figures show that they are large and oblong in *Pinus strobus*, somewhat smaller and lemon-shaped in *P. lambertiana,* and intermediate in *P. monticola.* In ray parenchyma pit characters, *P. monticola* is a little closer to *P. lambertiana* than to *P. strobus.* In other features, both gross and microscopic, *P. monticola* is intermediate between the other two.

Myer, J. Edson. 1930. **The structure and strength of four North American woods as influenced by range, habitat and position in the tree.** N.Y. State Col. Forestry Tech. Pub. 31, 39 pp.

The texture and strength properties of wood samples of white pine, hemlock, sugar maple, and white oak did not differ by geographic range; but position of sample within the tree affected these properties. In white pine, texture was not coarse at the 16-foot point and became finer toward the stump and top. Specific gravity of pine decreased rapidly from stump to 16-foot level. Strength of pine woods under compression was not greatly affected by position in the tree.

Newlin, J. A., and R. C. Wilson. 1917. **Mechanical properties of woods grown in the United States.** U.S. Dept. Agr. Bul. 556, 47 pp., illus.

The mechanical properties of the wood of some 50 commercial species, including white pine grown in Wisconsin, are reported. Small clear pieces from 16 white pines were used in the tests on air-dry wood and pieces from five trees were used for the green condition tests.

Olson, A. R., N. V. Peletika, and H. W. Hicock. 1947. **Strength properties of plantation-grown coniferous woods.** Conn. Agr. Expt. Sta. Bul. 511, 27 pp.

Tests show that in most cases plantation-grown wood is slightly weaker than forest-grown wood. If young plantation wood is to be used where strength is a factor, it may be necessary to specify larger dimensions (computations shown). The relative weakness results from a lower specific gravity caused by rapid diameter growth. As plantations grow older, the strength of the wood will improve.

Pillow, M. Y. 1953. **How growth of white pine affects its properties for matches.** U.S. Forest Prod. Lab. Rpt. D1950, 4 pp., illus.

Matchsticks consisting only of spring-wood have very little strength; hence fast grown lumber with three to five rings per inch should not be used for matches. The ideal match block should have uniform growth of 10 to 15 rings per inch. Some types of compression wood, with larger angles of fibre strands, also should be avoided because of brittleness.

Risi, J., and M. Brule. 1946. **Utilization of conifer branches.** Perfumery and Essential Oil Rec. 37 (3): 78-79. (Abs. from Amer. Perfumer and Essential Oil Rev.)

A table is included showing the physiochemical properties of the needle oils of *Thuja occidentalis, Pinus strobus, Abies balsamea, Picea mariana,* and *Tsuga canadensis.*

Rol, R. 1932. **Note sur un essai de classification du genre Pinus d'apres des caracteres tires de l'anatomie du bois.** Rapp. 65eme Congr. Soc. Savantes 1932: 333-341, illus.

Studies of pine-wood anatomy provide a species and section classification based on medullary-ray characters and pits in summer-wood tracheids. White pine and species in the section Strobus have few smooth-walled ray tracheids, thin-walled ray parenchyma, single (rarely as many as two or three) large subrectangular pits in the cross-field with the longitudinal tracheids and numerous pits in longitudinal tracheids in the summer-wood.

Schall, W. M. 1943. **An investigation of the presence of siliceous rods in the secondary wall of woody tissue.** Madroño 7: 8-14.

From studies with white pine and a variety of other species it is concluded that silica, in the form of continuous siliceous skeletons, is not present in the secondary wall of woody tissue, and that the silica content of such tissue is such a small percentage of the total weight of the wood that it could not have an effect greater than that of other minerals on the differential swelling or shrinking of wood.

Steiner, A. J. 1944. **Fire-hazard classification of building materials.** Underwriters' Lab. Res. Bul. 32, 34 pp.

Results of limited and preliminary fire-hazard classification tests are given for untreated and surface-coated white pine and other materials. Classification factors were established for maximum flame spread, fuel contributed, and smoke density. The results are compared on a numerical basis with the performance of untreated red-oak lumber classified as 100 and asbestos-cement board as 0.

United States Forest Products Laboratory. 1952. **Shrinking and swelling of wood in use.** U.S. Forest Prod. Lab. Rpt. R736, 10 pp.

A general account of dimensional variation in wood and some of the effects of shrinking and swelling. Shrinkage values of some 40 softwoods (including white pine) and 90 hardwoods are given. How to minimize dimensional variation during and after manufacture is discussed, and recommended moisture contents for various wood items at the time of installation in different climatic areas are tabulated.

United States Forest Products Laboratory. 1952. **The white pine group.** Forest Prod. Lab. Tech. Note 215, 3 pp.

A brief description of the wood properties of the three principal white pines.

Venet, J. 1951. **Etude de la resistance mechanique des bois de bois de mine.** Ecole Nat. des Eaux et Forets Ann. 12: 323-408, illus.

White pine is one of many species tested extensively for suitability as mine timber. The effect of origin, season of cutting, storage period, defects, percent sapwood, width of annual ring, and other structural characteristics on static bending strength and compressive strength parallel to the grain are given in tables and charts. Notes were made of deformations within the elastic limit and of those affecting fibers after rupture.

Wershing, Henry F., and I. W. Bailey. 1942. **Seedlings as experimental material in the study of "redwood" in conifers.** Jour. Forestry 40: 411-414.

Young seedlings of white pine form redwood during their first season of growth and are favorable material for the study of redwood under controlled conditions. The application of indole-acetic acid to the hypocotyledonary stem of such seedlings produces directly or indirectly (1) enlargement of cortical cells, (2) accelerated cambial activity, and (3) a much modified type of tissue differentiation in the xylem. The xylem formed by the stimulated cambium is commonly of the redwood type.

Anonymous. 1954. **White pine production and export.** Timber Canada 14 (5): 22-23.

In 1909 the annual production of white and red pine in Canada was 1.3 billion board feet. By 1932 production had dropped to a low of 180 million board feet. Since then the production of white pine alone has increased irregularly to 392 million board feet in 1949 and more rapidly to 449 million in 1951. Ontario has always produced the bulk of Canadian white pine. About one-third of the total production is exported to the United States. The United Kingdom annually takes about 25 million board feet, mostly pattern stock; and the Caribbean area is the other major export market.

Cronk, C. P. 1936. **Forest industries of New Hampshire and their trend of development.** 237 pp. N.H. Forest and Recreation Comn.

A survey of forest industries, showing the changes since 1912. A detailed list of all wood-using plants is included. The number and variety of small firms that depend on white pine is shown. The difficulties arising from low-quality pine and poor manufacturing are also discussed.

Erickson, E. C. O. 1950. **New England eastern white pine as a house-framing material.** U.S. Forest Prod. Lab. Rpt. R1241, 4 pp., illus.

Second-growth white pine, when properly braced and nailed, makes wall panels that are comparable in stiffness and rigidity to the denser southern pines. Diagonal sheathing is most desirable but a system of let-in, continuous-piece, diagonal bracing in combination with horizontal sheathing is nearly as good. With 8-inch sheathing, three 8-penny nails should be used at each stud crossing.

Fernow, B. E. 1905. **The movement of wood prices and its influence on forest treatment.** Forestry Quart. 3: 18-31.

A discussion of the progress of wood prices in world and local markets, with remarks on the behavior of eastern white pine prices.

Hill, Arthur. 1898. **The pine industry in Michigan.** Mich. Polit. Sci. Assoc. Pub. 3 (4): 110-120.

Of historical interest, this paper briefly reviews the course of the pine industry, the volumes cut and remaining, the increasing cost of the lumber, and the position of the industry. A plan is set forth for the State to take ownership and reforest pine stumplands.

Jahn, Edwin C., and C. V. Holmberg. 1939. **Relation of lignin content to the strength of paper and boards. I. Literature survey and progress report.** Paper Trade Jour. 109 (13): 30-35, illus.

Reviews literature on structure and chemical composition of the cell wall and their relation to pulping and paper-making quality. Gives a brief progress report on experiments to determine how method and degree of delignification affect the chemical composition of white pine pulp and the strength characteristics of sheets made from standard pulps.

Jensen, Victor S., C. E. Behre, and A. O. Benson. 1940. **Cost of producing white pine lumber in New England.** U.S. Dept. Agr. Cir. 557, 40 pp., illus.

Production cost per thousand board feet declines rapidly with increase of tree size, levelling off at 20 inches in diameter. Partial cutting does not increase operating costs in accessible stands. Value of graded lumber from pruned logs is 50% greater than from unpruned logs. Square-edged lumber reduces mill scale about 21%, but increases sale value about 28%. Graded-lumber values exceed mill-run prices.

Kingsbury, R. M., F. A. Simmonds, and E. S. Lewis. 1949. **Bleaching groundwood pulps with hypochlorites.** Pulp and Paper Mag. Canada 50 (5): 98-102.

Calcium hypochlorite is a satisfactory bleaching agent for groundwood pulp of various hardwoods but not for that of white pine.

Kitazawa, George. 1946. **A study of adhesion in the glue lines of twenty-two woods of the United States.** N.Y. State Col. Forestry Tech. Pub. 66, 55 pp.

Resorcinol-formaldehyde glue lines with eastern white pine rated fair in comparison with other species. Ureaformaldehyde glue lines rated poor with eastern white pine. An analysis is made of the shear strength of the woods at failure and of the types of failure.

Ladell, J. H. 1953. **High-temperature kiln-drying of Canadian woods: report of exploratory investigations—softwoods.** Forest Products Lab. Canada 0-170. 11 pp., illus.

Seasoning tests at temperatures over 212° F. were made on boards of white pine and four other species. Drying was 3 to 6 times faster than by conventional methods. Seasoning defects were negligible, apart from case-hardening, which was uniformly severe; but conditioning treatment after the cooling period gave fairly satisfactory results. Moisture-content variation was outside acceptable limits. In bending-strength tests, white pine showed a 5% reduction in strength.

Larson, Agnes M. 1949. **History of the white pine industry in Minnesota.** 432 pp., illus. St. Paul, Minn.

The growth and decline of the industry is considered in detail. The impact of the industry on social and economic developments in northern Minnesota is well illustrated, and it is shown that these influences extended throughout the Middle West. The numerous sources of material are indicated in footnotes.

Levy, John, and Edwin C. Jahn. 1939. **Effect of mechanical gelatinization on the solubility of wood in cuprammonium solution.** Paper Trade Jour. 109 (23): 45-49.

The solubility of white pine mechanical pulp in standard strength cuprammonium solution was increased by mechanical gelatinization, which increased the surface area of the wood; and by alkaline treatment, which softened and swelled the wood particles and removed slight amounts of lignin and hemicelluloses.

Marquis, Ralph W. (n.d.) **Lumber used in manufacture—1940.** Summary tables. U.S. Forest Serv., 48 pp.

Wood used in manufacture is summarized three ways: by products and kinds of wood, by States and kinds of wood, by products and States. Each summary shows the amount of lumber, veneer, logs and bolts, and total board feet of wood used. In the first two summaries, northern white pine (including red and jack pine) is shown separately. Selected statistics are compared with equivalent statistics for 1928 and 1933 taken from earlier reports.

Merrick, Gordon D. 1951. **Wood used in manufacture—1948.** U.S. Dept. Agr. Forest Resource Rpt. 2, 66 pp.

A report on the fourth of a series of similar surveys; others were made in 1928, 1933, and 1940. U. S. Wood consumption for fabricated products during 1948 is tabulated by product, state, and kind of wood. The total consumption of eastern white pine (including red and jack pine) was 678 million board feet. Tabulations show the amounts lumber, veneer, and bolts used, by products and by state.

National Lumber Manufacturers Association. 1935. **Lumber grade-use guide for softwood and hardwood lumber in building and general construction. Pamphlet X. Northern white pine, Norway pine, eastern spruce manufactured and graded under rules and supervision of Northern Pine Manufacturers Association.** Nat. Lumber Mfr. Assoc., 8 pp., Minneapolis.

The recommended grade of lumber for about 200 use-items in 14 separate groups is given with descriptions of the standard grades and tables of standard thickness and widths.

Northeastern Lumber Manufacturers Association. 1939. **Grade-marking of northeastern softwoods. Grade-use recommendations for northern white pine and eastern spruce.** Northeast. Lumber Mfr. Assoc., 8 pp., illus.

The regulations governing grade marking of northeastern softwoods, effective September 1, 1939, are set forth; and specific grades are recommended for many use-items arranged in 17 groups.

Northeastern Lumber Manufacturers Association. 1950. **Northeastern white pine: its grades and uses.** Northeast. Lumber Mfr. Assoc., 38 pp., illus.

A presentation of the uses of white pine and the volumes produced. Includes photographs and descriptions of typical boards in each grade of white pine lumber.

Raney, William F. 1935. **Pine lumbering in Wisconsin.** Wis. Hist. Mag. 19: 71-90, illus.

Exploitation of white pine in Wisconsin began along Lake Michigan and on the State's eastern rivers about 1835. Large-scale operations began on the Wisconsin, Black, Chippewa, and St. Croix Rivers about 1850. The development of the industry in each of these drainages is discussed. By 1875 white pine was practically exhausted and the mills shut down, moved farther west, or turned to hemlock and hardwoods.

Reynolds, R. V., and A. H. Pierson. 1937. **The aggregate cut of American lumber, 1801-1935.** Jour. Forestry 35: 1099-1101.

The total cut of lumber during this 135-year period is estimated as 2,200 billion board feet with a total value at cutting time of about 36.5 billion dollars. Of this total, about 459 billion board feet was eastern white pine, with some red and jack pine intermixed. Half of the white pine was cut in the Lake States.

Risi, J., and L. P. Amiot. 1948. **Etude de la penetration de solutions aqueuses d'uree-dimethylolurée dans les principaux bois Quebecois et de l'influence de ce traitment sur quelques-unes de leurs proprietes mecaniques.** Quebec Min. Terres et Foret Bul. 13, 38 pp.

Eight softwoods and 12 hardwoods from Quebec province were impregnated with urea and dimethylolurea and tested for penetration of the resin and for changes in some mechanical properties. A uniform penetration was practically impossible to achieve. Among the most easily impregnated species was white pine. Increased resistance to compression parallel to the grain was noted. All species showed a considerable increase in hardness. Resistance to shock was decreased in all cases.

Risi, J., and M. Brule. 1945. **Etude des huiles essentielles tirees des feuilles de quelque coniferes du Quebec.** Quebec Min. Terres et Forets Bul. 9, 52 pp.

A report of experiments in the distillation of essential oils from the needles of white pine and four other conifers native to Quebec. Details are given of the methods and equipment used. Recommendations are made covering commercial distillation. Maximum yields are obtained from January to April. Average yield from white pine is 0.6 to 1.0%. The quality of oil obtained in Quebec is as good as that obtained from the same species elsewhere.

Risi, J., M. Brule, and M. Picard. 1945. **Etude de quelques proprites des charbons de bois du Quebec se rapportant a leur utilisation comme carbinant dans les Gazogenes.** Quebec Min. Terres et Forets Bul. 6, 30 pp.

Eastern white pine was among 16 species studied. The charcoal from all coniferous species is much more friable than that from hardwoods and is therefore unsuitable for use as producer-gas fuel.

Rogers, J. S. 1949. **Tannin from northeastern barks.** Paper Trade Jour. 128 (16): 21-23.

The tannin content of the bark of nine Northeastern species was determined. That of white pine was less than 6% — not enough to justify commercial processing.

Salomon, M. 1953. **The accumulation of soil organic matter from wood chips.** Soil Sci. Soc. Amer. Proc. 17: 114-118.

Experiments on the addition of wood chips of white pine and black oak in combination with nitrate nitrogen to Merrimac sandy loam seem to show that the treatments have no practical effect on soil properties or plant growth. Analyses for organic content, available nitrogen, pH, and growth of beets and spinach in the soil are presented.

Schafer, E. R., and A. Hyttinen. 1949. **Groundwood pulping of five common northeastern farm woodland species.** U.S. Forest Prod. Lab. Rpt. R1743, 5 pp.

Groundwood pulps were made from white pine, yellow birch, red and white ash from a naturally occurring mixture of the hardwoods, and from a mixture of the pine and the hardwoods. White pine gave a pulp equal in strength and brightness to commercial groundwood pulps. The strength and brightness of the mixed pine and hardwood pulp showed that groundwood suitable for newsprint might be made by grinding mixtures containing up to 35% hardwoods by volume.

Schwartz, H., and C. Greaves. 1944. **Production of pine tar by the destructive distillation of Canadian softwoods.** Canada Forest Prod. Lab. 14 pp., illus.

Laboratory and commercial-scale tests revealed that pine tar of a quality suitable for use in the manufacture of tires from natural rubber could be obtained in commercial quantities from selected resinous Douglas-fir and white-pine waste wood. However, the supply of suitable white pine waste wood at eastern mills was not sufficient to justify commercial production.

Skoggard, C. O., and C. E. Libby. 1946. **Experimental sulphite pulping of eastern white pine (*Pinus strobus* L.).** Paper Trade Jour. 123 (4): 41-46.

Best results were obtained in a single-stage process using a sodium-base liquor. The pulp was characterized by high bursting strength, good folding endurance, low tearing resistance, and high ether solubility. Higher screened yields and slightly easier bleaching pulps were obtained than with the other liquors tested.

Steer, Henry B. 1948. **Lumber production in the United States 1799-1946.** U.S. Dept. Agr. Misc. Pub. 669, 233 pp., illus.

Tabulates, by years, the volume and value of lumber production of the states and regions. Tabulations by species also.

Treen, E. W. 1936. **The northeastern lumber industry.** Jour. Forestry 34: 755-758.

Discusses the steps being taken by the Northeastern Lumber Manufacturers' Association to improve and strengthen the markets for northeastern lumber. These steps include stabilization of grading rules for white pine and spruce, contact wih public purchasing agencies, adjustment of freight rates, promotion and publicity, national affiliation, and conservation.

United States Forest Products Laboratory. 1938. **Pertinent facts on salvage of New England timber.** U.S. Forest Prod. Lab. R1183, 28 pp.

A preliminary guide for handling salvaged material. It covers log storage, lumber conversion and seasoning, log grades, scales, cutting specifications, marketing, preservative treatments, and other subjects. Special attention is given to white pine.

Wangaard, Frederick F. 1935. **The strength and behavior of mortise and tenon joints at different moisture contents.** N.Y. State Col. Forestry Tech. Pub. 47, 30 pp.

White pine, black cherry, and sugar maple were used in the tests. Mortise and tenon joints should be assembled at the average moisture content the joint will experience in use — 9% in New York State.

Wentling, J. P. 1907. **Woods used for packing boxes in New England.** U.S. Forest Serv. Cir. 78, 4 pp.

Nearly 82% of the lumber used in New England's 344 box factories in 1905 was white pine. The total consumption for this use was more than 600 million board feet. Other statistics for the box industry are also given. Although a severe shortage of second-growth white pine was not imminent in 1905, it was urged that plantations be established on waste land to be available when present supplies are exhausted.

White Pine Bureau. 1917. **Classified recommended uses for white pine in house construction and white pine standard grading rules of the Northern Pine Manufacturers Association, Western Pine Manufacturers' Association, and the White Pine Association of the Tonawandas.** 197 pp. The White Pine Bureau, St. Paul.

Compiled for architects' use in specifying white pine lumber, the book contains recommendations for grade of lumber in each of the classified uses and for three classes of cost within each use. The standard grades are described and illustrated, distinguishing features are set forth, recommended uses listed.

White Pine Bureau. 1917-20. **The white pine series of architectural monographs.** Vols. 3-6, The White Pine Bureau, St. Paul.

Devoted to early American houses and other building constructed of white pine, this series is primarily photographic, with short texts and sometimes specifications for the buildings. The series aims to promote the use of white pine in housing.

Williams, Charles T. 1906. **Cursory review of lumber conditions as they have affected the box manufacturing business in the past ten years.** South. Lumberman 51 (603): 54.

From 1896 to 1906 the supply of white pine timber in the Lake States shrank from plentiful to near the point of exhaustion. In 10 years the price of No. 4 box lumber increased from $6 to $18 and the quality has become much poorer. In the same period the price of boxes rose only 65%. White pine is still the mainstay of the box industry and the supply is still good in New England, but the use of wood from the South, Pacific Coast, and Canada is increasing.

SEASONING : PRESERVATION QUALITY AND GRADES OF PRODUCTS

Baker, Gregory. 1951. **The effect of log storage time on development of brown stain in northern white pine (during kiln seasoning).** Maine Univ. Forestry Dept. Tech. Note 8, 1 p.

No stain developed in wood sawed and seasoned within 24 hours of felling. Logs piled on skids in the woods for 42 days or more developed a considerable amount of brown stain. Depth of penetration increased with increased storage time.

Baldwin, H. I. 1953. **Control of borers in green logs.** N.H. Forestry and Recreation Comn. Fox Forest Notes 52, 2 pp.

Benzene hexachloride at the rate of 1¾ pounds of the pure gamma isomer in 50 gallons of No. 2 fuel oil will protect logs and bolts 3 to 4 months. Addition of 2% pentachlorophenol will give better control of sap stain. About 12 gallons of solution are required per thousand board feet of logs.

Berry, A. G. V., and J. C. Cater. 1945. **Interim report on trials of copper naphthenates and mercuric naphthenates as wood preservatives.** Empire Forestry Jour. 24: 233-235.

Reports the 6-year results (1939-45) of tests of these metallo-organic salts that were dissolved in gas-oil, a petroleum distillate, and applied by the open-tank method. White pine was effectively protected against termites and fungi by these chemicals and partly protected by gas-oil alone.

Bess, Henry A. 1944. **Insect attack and damage to white-pine timber after the 1938 hurricane in New England.** Jour. Forestry 42: 14-16.

Discusses the abundance of and damage done by bark beetles, borers, bark weevils, and ambrosia beetles to white pine logs and trees. Standing timber and trees uprooted but with many roots intact suffered little or no damage by 1940. Water storage and piling logs on dry sites at some distance from wind-felled trees gave good protection. Chemical sprays and covering decked logs with straw and boughs gave some protection, but costs were greater than benefits.

Brophy, M. J. 1941. **Prevention of checks in air-seasoning thick white pine.** Canada Forest Prod. Lab., 4 pp. Ottawa.

In addition to the established practices in air-seasoning, the author believes these points should help to prevent checks: (1) box-pile lumber of uneven lengths to prevent an overhang at the rear of the pile; (2) pile a variety of widths close together (but not touching) at the sides of the pile, leaving a single center flue 8 to 12 inches wide; (3) use relatively thin cross pieces; and (4) take special precautions with lumber that is cut in the autumn, when it is more susceptible to checking than in the summer.

Brown, Frederick L. 1953. **Mercury-tolerant penicillia causing discoloration in northern white pine lumber.** Forest Prod. Res. Soc. Jour. 3: 67-69.

Two fungi isolated from timber treated with mercury compounds were shown to be the cause of a deeply penetrating blue discoloration of white pine sapwood. These fungi, *Penicillium cyclopium* and *P. crustosum*, were found to be several times more tolerant of mercury than *Ophiostoma coeruleum*. The fungi caused no significant decrease in toughness of discolored specimens and seemed to destroy only epithelial tissue.

Davis, E. M. 1940. **Lumber from old-growth vs. lumber from second-growth in *Pinus strobus*.** Jour. Forestry 38: 877-880.

Second growth from New England produced about one-fourth as much select lumber and one-half as much high-common lumber as did the old-growth from Minnesota. The medium-common yield was about the same for both but the second growth produced more than twice as much of the marginal low-common. Shake and decay were common defects in old growth but almost negligible in second growth. Knots were sounder and larger in second growth, these being the determining defects in most of the second growth.

Desjardins, A. 1945. **Des sechoirs et due sechage artificiel des bois de construction.** Quebec Min. Terres et Forets. 23 pp.

A general account of the design and operation of kilns and the process of seasoning. Schedules are given for kiln-drying white pine and other native softwoods and hardwoods of various dimensions.

Fritz, C. W. 1929. **Stain and decay in lumber-seasoning yards, with special reference to methods of prevention.** Canada Dept. Int. Forest Serv. Cir. 27, 15 pp., illus.

Discusses the requirements of good seasoning-yard practices and points out conditions that are conducive to decay and stain. Although applicable to any species, this circular was written particularly for the white pine industry of eastern Canada where losses due to blue stain alone run up to $1 million a year (1928).

Harkom, J. F. 1942. **Creosote treatment of white pine piles.** Amer. Wood Preserv. Assoc. Proc. 28: 149-150.

Tests indicate that it should be possible to treat white pine piles with 12 pounds of creosote per cubic foot of wood after 4 to 8 weeks of air-seasoning. There was no checking in the heartwood as is usually the case with red pine treated in this way.

Henderson, H. L. 1932. **Dry kiln practice.** N.Y. State Col. Forestry Tech. Pub. 38, 196 pp.

A manual on the operation of kilns, including kiln schedules for eastern white pine and many other species.

Hodson, E. R. 1906. **Rules and specifications for the grading of lumber adopted by the various lumber manufacturing associations of the United States.** U.S. Forest Serv. Bul. 71, 127 pp.

Presents, among other rules and specifications, the 6th edition (1906) grades and rules for grading pine lumber. These were developed by the Northern Pine Manufacturers' Association. Although these standard grades were used chiefly for white pine; they were also used for red pine and hemlock produced in the upper Mississippi Valley and Wisconsin regions by members of this association.

Long, George S. 1925. **An old report on the grading of white pine lumber.** Amer. Lumberman 2619: 46.

A lumber inspection report made in the Lake States in 1880 is presented and discussed. This report, which showed up the wide discrepancy in lumber grading at various mills, led ultimately to the setting up of standard northern white pine grades.

Lorenz, Ralph W. 1946. **A convenient method for cold-soaking fence posts in a pentachlorphenol solution.** Jour. Forestry 44: 520-522, illus.

Specifications and costs for the construction of a plant to treat fence posts by the cold-soaking method are presented with brief comment on the effectiveness of pentachlorphenol solutions in preventing decay of white pine posts. The posts in service remained sound for at least 3 years, while untreated posts were no longer serviceable after 2 years.

MacAloney, H. J. 1935. **Prevention of damage to round-edged white pine lumber by wood-boring insects.** U.S. Forest Serv. Northeast. Forest Expt. Sta. Tech. Note 21, 2 pp.

Three species of borers are involved: the sawyer beetles *Monochamus scutellatus* Say and *M. notatus* Drury and the black-horned pine borer *Callidium antennadum* Newm. The first two attack green logs and lumber; the other attacks seasoned or partially seasoned material. Lumber sawed in fall and winter should be used the next spring and early summer; lumber sawed in spring should be used before September. No sawing should be done in June, July, or August unless there is immediate use for the material.

Mississippi Valley Lumberman's Association. 1904. **Rules for the grading of pine and hemlock lumber . . . adopted by the Mississippi Valley Lumberman's Association and the Wisconsin Valley Lumberman's Association, and Western Pine Shippers' Association.** Ed. 5, 72 pp. Minneapolis.

Gives early lumber-grading rules for pine and hemlock; describes standard grades, giving examples. The association was organized in 1891 and published the first edition of rules in February 1895. After the 6th edition in April 1906 the Mississippi Valley and Wisconsin Valley Lumbermen's Associations were merged to form the Northern Pine Manufacturers' Association. These rules were used as models for standardizing lumber grading throughout the country.

Nash, Robley W. 1954. **Protection of logs and round-edge planking from wood borers by benzene hexachloride sprays.** Maine Forest Serv. Forest Insect Note 1, 4 pp.

Large-scale applications of benzene hexachloride as emulsions, solutions, and suspensions were made in 1953 on white pine logs and round-edge planking to prevent damage by wood borers. Applications of 1 pound of gamma isomer of benzene hexachloride in 50 gallons of mixture were made by high-pressure hydraulic sprayers. A complete analysis of the results was not made, but careful observations showed that very good control was obtained.

Northeastern Lumber Manufacturers Association. 1937. **Standard grading rules for northern white pine (*Pinus strobus*—northeastern type) and Norway pine (*Pinus resinosa*—northeastern type).** Revised 1948. Northeast. Lumber Mfrs. Assoc., Inc., 39 pp., illus. New York.

Gives lumber specifications for three select grades, five common grades, knotty pine, No. 1 cuts, log-run square-edge, log-run round-edge, and round-edge box sides. Supplementary instructions and definitions are included and standard lumber sizes and milling patterns are described.

Northern Hemlock and Hardwood Manufacturers Association. 1947. **Official grading rules for northern hardwood and softwood logs, tie cuts, box bolts, shingle bolts, chemical logs, bolts, and cordwood.** North. Hemlock and Hardwood Mfrs. Assoc., 12 pp. Oshkosh, Wis.

Describes method of grading and rules for four grades of white pine logs, giving dimensions and defects allowable. Grading rules for other products are given.

Northern Pine Manufacturers' Association. 1948. **Standard grading rules for northern white pine, Norway pine, jack pine, eastern spruce, western white spruce, balsam, tamarack, aspen lumber.** (Reissued 1951.) North. Pine Mfrs. Assoc., 36 pp.

The grades include five select grades, six common grades, three special lumber grades, five dimension and timber grades, as well as two shop, two door, and two lath grades.

O'Neil, William J. 1953. **Hurricane break in New England conifers.** Jour. Forestry 51: 290.

"Hurricane break," a lateral fracture of wood fibers, caused degrade of white pine lumber produced by the New England Timber Salvage Administration following the 1938 hurricane. Overall, the degrade amounted to only 1%, but it varied from place to place and was as much as 10% in some yards. Careful inspection of logs and rough boards did not reveal the damage, but it was evident in planed boards.

Simpson, L. J. 1949. **Borer injury in burned timber.** Canada Dept. Agr. Forest Insect Invest. Bimo. Prog. Rpt. 5 (3): 1.

Spring fires result in the greatest amount of borer damage (from *Monochamus scutellatus*) in fire-killed spruce, balsam fir, and white pine in New Brunswick. Trees burned in late summer or autumn are generally too dry for borers to attack them next spring; but trees killed in the spring, if left standing, are subject to further severe boring early in the following season. Damage is more severe in white pine than in spruce or balsam, and after ground fires than after crown fires. Timber burned before August should be salvaged immediately and white pine should have the highest priority.

Spurr, Stephen H., and Roger B. Friend. 1941. **Compression wood in weevilled northern white pine.** Jour. Forestry 39: 1005-1006, illus.

Development of compression wood was studied in 19 weevilled sections of white pine. The pith offset was always greater than the external offset because of eccentric growth. Compression wood was formed just below the weevilled node under the new leader. It was a serious defect in the lumber sawed from the center of the sections. There was a well correlated direct relation between the offset of the pith and the horizontal extent of the compression wood. It is emphasized that the more rapidly the bole straightens after weevilling, the less the defect.

Walters, Charles S. 1943. **Treating fence posts with pentachlorphenol-fuel oil solutions.** Jour. Forestry 41: 265-268.

White pine and a number of other softwood and hardwood species have been successfully cold-soaked in equipment usually available to a farmer at reasonable cost. A post about 5 inches in top diameter and with a volume of 1 cubic foot will absorb ½ gallon of the 5% solution. Care should be taken to protect hands and arms from the solution.

Walters, C. S. 1948. **Preservative treatment of white pine fence posts at low temperatures.** Jour. Forestry 46: 180-183.

Fifty round white pine posts were peeled, dried, and cold-soaked 144 hours in a 5% solution of pentachlorophenol in light fuel oil. Air temperature ranged from −18 to 22° F. and that of the solution from 14 to 26° F., but there was little evidence of sludging or precipitation in the solution. Absorption was 2.90 pounds per cubic foot after 48 hours and 3.70 pounds after 144 hours. Deep penetration of the sapwood was essentially complete after 48 hours.

Walters, C. S., and H. W. Fox. 1952. **Hand-peeling fence posts compared to mechanical peeling.** Ill. Univ. Agr. Expt. Sta. Forestry Note 31, 2 pp., illus.

A total of 530 white pine poles were barked, 271 by hand and the rest on the Illini post peeler, a revolving-head abrasion barker. The machine was twice as fast as hand-peeling, but neither method was practical on frozen wood.

Walters, C. S., and W. L. Meek. 1951. **Report on project 301-A. Preservative treatment of fence posts by cold soaking in pentachlorphenol-fuel oil solutions.** Ill. Univ. Agr. Expt. Sta. Forestry Note 28, 4 pp.

Two lots of treated white pine posts were still free of decay after more than 8 years' service. The greatest percentage of decayed posts (44%) was in a lot cold-soaked only 6 hours.

Zabel, Robert A. 1953. **Lumber stains and their control in northern white pine.** Jour. Forest Prod. Res. Soc. 3 (3): 36-38.

Staining is generally common in logs and lumber between May 15 and September 30. Logs should be pond-stored or treated with chemical preventative within 24 hours of cutting. Lumber should be treated with preventatives within 24 hours after sawing and should be stacked quickly for rapid drying, with protection from rain. Solid piling is permissible for several weeks if chemical concentrations are doubled.

Zabel, Robert A., and Clifford H. Foster. 1949. **Effectiveness of stain control compounds on white pine seasoned in New York.** N.Y. State Col. Forestry Tech. Pub. 71, 17 pp.

A comparison was made of the relative effectiveness of 13 common sap-stain preventatives, using 1,000 test sticks (1 x 1 x 12 inches) and 20,000 board feet of lumber, all freshly sawed. The most effective chemicals or chemical mixtures were ethyl mercury phosphate with sodium pentachlorophenate, and sodium pentachlorophenate with borax. Poor piling and wane on boards will result in stain regardless of treatment.