BIBLIOGRAPHY OF RESEARCH AT THE HARVARD FOREST

Harvard University

Petersham, Massachusetts

1907-1936

October 1936

MANAGEMENT OF HARVARD FOREST

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FP J.D. Black

SUMMARY OF RESEARCH AND OTHER ACTIVITIES AT THE HARVARD FOREST

Harvard University

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1907-1936

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FOREST MANAGEMENT

As a demonstration of practical, sustained yield forest management, the Harvard Forest has been in existence for almost thirty years. Each year during that period there has been a cut of sawtimber and cordwood from about 250,000 to 400,000 board feet. Nevertheless there is more timber now than there was when the Forest was acquired and there is a better distribution of age-classes.

Starting with an estimated ten million board feet of timber, mainly pine and largely mature, the Forest has been built up to an estimated volume of twelve million board feet with an increasing percentage of hardwoods in its composition. From an initial annual growth rate estimated to be 250,000 board feet, there has been an increase to 400,000. During the same period the Forest has acquired a much better representation of young and middle-aged stands, so its production can be more uniformly maintained. A set of card records has been developed which summarizes the amount, quality, and condition of the timber in each of about 700 distinct stands on the Forest. A detailed record system has also been worked out for all silvicultural operations and cuttings, so that there exists a complete silvicultural history of the Forest, supplemented by several thousand photographs.

In the field of general forest management, the work has been mainly in studying successful forests on private lands and making the results available. In several cases, estimates have been made of the growing stock on private properties and recommendations laid down for management.

MANAGEMENT OF HARVARD FOREST

Fisher, R. T. 1911 — An account of operations in the Harvard Forest, '08-'09. Harvard For. Club Bull. 1: 1-10.

Fisher, R. T. 1921 — Management of the Harvard Forest. Harvard For. Bull. 1.

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SILVICULTURE

When the Forest was established in 1907, there were no examples of silvicultural practice in the region, except for a few coniferous plantations. In fact, to the lay mind forestry consisted almost wholly in planting pine seedlings on idle farm land. By contrast, at the present time, such treatments as weeding, thinning, pruning, and reproduction cutting have been applied to tens of thousands of acres of "natural" second growth forest, to say nothing of the continued practice of planting. To this truly remarkable development and application of the art of growing tree crops, the Forest has been fortunately able to contribute substantially. Under the guidance of the late Director, Richard T. Fisher, a soundly conceived philosophy of silviculture, based on a harmonization of man's efforts with natural tendencies, together with the accumulation of a large body of factual information resulting from both research and practice on the Forest, has now become thoroughly ingrained in New England forestry, and a part of the professional equipment of hundreds of practising foresters.

Nor has the influence of the Forest in the art of silviculture been limited to the New England region. The general conceptions of the superiority of mixed over pure stands of trees in their influence upon soil fertility and upon crop security and yield, the frequent admonitions concerning the indiscriminate planting of conifers and the failure to appreciate the timber crop potentialities of volunteer second growth, and the strong stand in favor of a policy of high quality wood crop production have substantially influenced silvicultural policies and practices throughout the country.

Perhaps the greatest single contribution to regional silviculture has been the development of a complete system for converting "old field" white pine, a temporary forest type inherently poor in quality and conducive to soil impoverishment, into a vastly more stable mixture of valuable native hardwoods or of hardwoods with pine, having singularly beneficial effects on soil fertility, affording a high degree of crop security, and promising attractive financial returns from a final crop of excellent quality. In the course of developing this system, the Forest became the leading exponent of the art of utilizing the existing volunteer growth on cutover lands for a future timber crop, more specifically, of the art of forest weeding, which has for its purpose the elimination of the bad elements in the stand and the preservation of the good. The former have enormously increased in numbers in recent years through the combined effects of farm abandonment, clear-cutting, and fires. The control of forest weeds in existing volunteer stands, rather than the planting of new stands on open land, has now come to be recognized as the most needed and profitable cultural treatment for New England forests and the principal weapon to prevent their further deterioration.

SILVICULTURE

Carter, E. E. 1915 — Notes on the relation of planting methods to survival. Proc. S.A.F. 10:9-17.

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SILVICS

Silvics deals with the underlying principles which control the life of forest trees, thus furnishing the scientific bases on which the art of silviculture rests. In many instances, publications by the Harvard Forest unavoidably have contained a mixture of both the science and the art, for in the early developmental stages of silviculture an author can explain the outcome of silvicultural treatment and recommend a given practice only by frequent reference to the observed habits and behavior of trees in response to their environment.

By living continuously in close touch with the Forest itself, staff and students have been able to accumulate a body of silvical knowledge of local tree species and of the whole complex of climatic and biological factors operative in central New England forests which exceeds that available for any other forest region in the United States. And it is only by means of such painstaking observations over a period of many years that the Forest has contributed in such a significant way to the foundations of American silviculture.

The following list of titles is by no means inclusive of the work done in the field of silvics. Many other Forest publications, listed under related subjects, contain paragraphs or pages dealing essentially with the growth habits and behavior of the great variety of both coniferous and deciduous tree species which constitute the forest communities of the region.

SILVICS.

Jack, John G.
1911
Trees and other woody plants found in the Harvard Forest, 1908-09. Harvard For. Club Bull. 1:10-26.

Kimball, G. W.
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FOREST ECOLOGY

Successful practice and teaching of silviculture at the Harvard Forest has been materially aided by a study of the line of descent of the local types of forest. Thus, the old field pine forests present problems quite different from those connected with forests originating on land which has never been cleared. These problems are most effectively comprehended when oriented in the scheme of dynamic changes shown by successive generations of forests.

The Pisgah Tract of original forest in New Hampshire, one of the few remnants of the primeval forest of the region, has furnished vital clues to the manner in which forests maintain themselves naturally. Their life histories can be read in the composition of the stands according to species, in the changing rates of growth of the individual trees, and in the character of the soil. Quite different types of forest may succeed each other as each reaches maturity. Each succeeding stand tends towards a higher proportion of shade-enduring species, such as hemlock and beech. But in the case of a catastrophe involving destruction of the stand and especially of the soil, the succession reverts to an earlier stage. From the forester's point of view there is sometimes an economic advantage in doing this, or in arresting the natural succession at a given point. Study of natural forest successions reveals the places where the forester is attempting "to go against nature", and the conditions under which he may intervene and return an area to a forest type characteristic of an early place in the series.

FOREST ECOLOGY

Fisher, R. T. 1925	Descent of the white pine woodlot. Introduction to Harvard For. Bull. 8.
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Fisher, R. T. 1933	New England forests: biological factors. Am. Geo. Soc. Sp. Pub. 16.

SOILS, NUTRITION, AND LIGHT

To the knowledge of the changes in soils under the quite different influences of coniferous and broadleaf forests, the Forest has made a special contribution. It has been shown that the activity of earthworms and soil-inhabiting insects is favored by the hardwood leaves, which provide preferred food. The maceration of the debris is the first step in returning it to the soil. By mixing the organic and mineral material together, the earthworms produce the excellent tilth found in forest soils where they are abundant. The needles of conifers are fed upon to a smaller extent by the larger earth-working insects, and scarcely ever by earthworms. The soils under conifers, therefore, exhibit a quite different condition from that under hardwoods. In the absence of maceration and the admixture with mineral material, the decomposition of the needle debris depends upon fungal and bacterial action. The organic material is stratified on the top of the mineral soil, preventing its full use in maintaining the potential fertility of the soil because the chemical action is localized, as shown by a sterile zone formed in the top of the mineral soil. Evidences of this decreased soil fertility have been demonstrable very early in the life of pure coniferous stands in the Harvard Forest.

For the study of forest soil fertility and the related factors of the environment, a continued project has been maintained at the Forest for fourteen years. The work started with the study of the effect of variation in light intensity on the growth of tree seedlings. At the time when the study was begun, the methods for the measurement of light were unsatisfactory. Work at the Forest contributed to the final form of the "pyrheliometer" which is now the standard instrument of the U.S. Weather Bureau for measuring solar radiation.

The interaction of radiation intensity and the supply of certain of the nutrients (nitrogen, potassium, phosphorus) have been studied in pot cultures under screens admitting various light intensities. Under these simplified conditions, regular relations have been discovered. They can be expressed in formulae estimating within 2% the weights achieved by the seedlings under the various conditions. By the various fertilization of seedlings in nursery beds, both theoretical knowledge and practical information result. Further tests of the conclusions from the pot experiments are being made on a large scale at Enfield in a state nursery.

In nature, the conditions of tree nutrition are complicated by the kind of organic matter and the manner in which the nutrients are bound in the soil. Heath plants and trees exhibit a peculiar development of the fine roots caused by the invasion of the thread-like tissues of mushrooms. The "mycorrhizae" thus formed are a characteristic feature of the tree roots. There is an unsettled controversy as to the part they play in the nutrition of trees. Evidence from a series of experiments started at the Forest indicates that they are favorable under certain conditions, and probably exceedingly important in the initiation of natural forest reproduction.

SOILS NUTRITION AND LIGHT

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FOREST PROTECTION

Protection against such destructive agencies as fires, insects, and diseases constitutes an essential part of the administration of every organized forest, and requires a thoroughgoing knowledge of the factors involved, particularly so since protection costs must be kept within low bounds. The costly measures of direct control, such as may be employed in public parks or small private estates, are not available to managers of large tracts of commercial timber. The Forest has long appreciated the manifold advantages of indirect or silvicultural control through altering the character of the forest itself, and has taken a leading part in studying the habits of important insects and fungi in relation to environmental conditions. In several instances the highly destructive nature of forest pests was traced to the temporary and unstable composition of the existing volunteer stands on abandoned farms or cutover land, or to an unwise choice of species in the establishment of new stands by planting. Thus the seeding of old fields and pastures to pure white pine and the planting of additional thousands of acres to the same species brought about a concentration of food supply which resulted in enormously increased damage by the white pine weevil. A long series of studies led to the development of practicable measures of silvicultural control and important changes in former planting policies. Similarly, the early discovery of a member of the Forest staff of the destructive feeding by an insect (the Pales weevil) on coniferous seedlings planted on areas recently logged for pine gave rise to a new planting practice which prevented further losses.

FOREST PROTECTION

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MENSURATION - STUDIES IN GROWTH AND YIELD

The approach to the science of forest measurement in the Harvard Forest has been dynamic as contrasted with the common one of the analysis of measurements as such. Our studies have been largely correlated with silvicultural practice, aiming to interpret by means of mensuration methods the growth relations of trees throughout their lives. One of the main contributions has been in the little known field of the growing space needed by red oak and white ash at various ages for the best growth and the highest quality of timber. Another line of investigation has been with white pine, duplicating the growing space work and developing a method for determining the rate of taper of the stem from measurement taken from the ground of crown width and length of the bole on which branches were dead. Rate of taper is a very important factor in accurately determining the volume of standing trees, and accurate volume measurement is in turn essential to forest management. Tables of volumes were made up on this new basis.

It has been known for some time that hemlock would recover from suppression after being released, but it remained for Marshall to show that the growth rate of individuals long suppressed was fast enough to reach sizes at later ages that were greater than those of trees free to grow for the same length of time.

In 1930-31, the growth and development of each of the one hundred odd plantations on the Forest were measured. This information based on many species, some of which are exotic, and on varied soil and cultural conditions, has already been of great value. As the stands get older, this study if repeated will become increasingly valuable.

MENSURATION - STUDIES IN GROWTH AND YIELD

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ECONOMICS AND UTILIZATION

The science of forest economics permeates the whole structure of forest production and utilization, in the broadest meanings of these terms, controlling the extent to which they shall be brought to serve human needs at any given time or place, and governing the ebb and flow of the myriad of commercial transactions incident to the distribution and consumption of forest products.

To date the Forest has scarcely touched upon the broadest fields of economics; but it has made noteworthy contributions to the solution of a number of regional problems having to do with the manufacture and marketing of forest products, the future of the forests owned by wood-using industries, and the conservative use of land for the sustained production of wood crops. Several important surveys of wood-using industries have been conducted, which were of benefit not only in providing timber growers and lumber manufacturers with a better knowledge of consumer demands, but in bringing into sharp focus the many weaknesses of the lumber business in New England. Publications by the Forest were among the very first to point out the need for better sawing, grading, and seasoning of native lumber, for improved selling practices, for cutting only larger, older trees, for growing higher grade timber for the future, and for creating cooperative associations of timber growers. While many of the weaknesses in utilization and of the maladjustments between production and consumption still persist, they are now at least commonly recognized and means for their correction are gradually becoming available.

During the current year the Forest has assisted in formulating forestry practices for farm woodlands under the Agricultural Conservation Program of the Federal Government. It is believed that only through some form of public aid can the depleted and deteriorated farm woods of New England be restored to productiveness, and the Forest's long experience with regional conditions is proving to be of great usefulness in furthering this important program.

ECONOMICS AND UTILIZATION

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WILDLIFE

The work with wildlife in the Harvard Forest has grown out of the obvious interdependence of forests and the animals living in them. Wildlife work has largely been developed either empirically by those who believed that simple measures such as restrictive legislation are all that are necessary for the production of abundant wildlife or by zoologists who were interested mainly in the animals as such and not particularly in their environment.

Of late years a newer conception of the problem has developed, the manipulation of the environment to provide the many necessities for the protection, nutrition, and reproduction of the animal species. It is along this line that the work at Petersham is being conducted. Many silvicultural practices can, by proper planning and arrangement, be made to favor wildlife. A start has been made toward evaluating these practices from the standpoint of wildlife production and toward determining the reverse effect of the animals on the woodlands. Studies have covered the use for food and cover of the various forest types by the white-tailed deer and the ruffed grouse. The production of wildlife foods in the various forest types according to age, density of stocking, and cultural treatment are being analyzed at the present time, and a two-year study of the red fox as a forest animal has been started.

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PROFESSIONAL AND PUBLIC EDUCATION

From 1907 to 1914, instruction in forestry consisted of a general professional training covering the requirements of a practising forester and leading to the degree of Master of Forestry. It became gradually apparent, however, that the Harvard Forest had unique facilities for advanced, specialized training and research which could in the long run make a far more important contribution to forest conservation than a continuance of general "practitioner" training, an already overcrowded field. In 1914, therefore, the general curriculum was abandoned, entrance was restricted to students already possessing the bachelor's degree in forestry, and instruction thenceforth took the form of advanced research projects in forestry or in contributory fields such as entomology, soils, and game management, leading to the master's or doctor's degree. The unique quality of forestry education at the Harvard Forest remains what it has always been - an overwhelming emphasis on learning in the woods rather than largely from lectures and books. The great and increasing range of silvicultural treatment and of research projects in forestry and contributory sciences gives an unrivalled collection of "cases" for this time-tested method of instruction. In all, 137 students have studied at the Harvard Forest.

The educational influence of the Forest has extended far beyond the training of its students. An average of about 300 visitors come to the Forest each year, and many thousands have already viewed the Forest models at Cambridge. Lectures, articles, and bulletins by members of the staff have reached in the aggregate a very large audience. Staff members have given technical advice to many forest land owners and in some cases have made and supervised the execution of detailed forest management plans for such owners. Training courses have been given at Petersham to many forestry foremen of the Civilian Conservation Corps in "stand improvement", and a member of the staff supervised the silvicultural work in 12 CCC camps for several months, thus greatly extending the practical application of silvicultural principles derived from the Harvard Forest.

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SAMPLE PLOT WORK IN THE HARVARD FOREST

Forestry is a young profession in America and many of the facts most needed for the intelligent management of our native timber species are still lacking. In addition many exotics are now being used and what they did in their native habitat is no criterion of what can be expected of them here. With a crop which matures as slowly as timber, it is necessary to lay out definite areas or "sample plots" and study the trees on them in detail over a long period to determine the best kind of silvicultural treatment.

Some of the ways in which permanent sample plots are most useful are in showing

1. The growth and yield of a given type of forest under a given set of conditions.

2. The effects of silvicultural treatment on survival, growth, form of the trees, and quality of the wood produced, and

3. Types of trees and growth rates resulting from seed of a given species from different sources.

Some of the more important plots now being studies in the Forest are;

1. Thinning and pruning in Norway spruce, P.H. V.

This set of plots was established in a twenty-four-year old plantation to determine the best method for thinning and whether pruning is advantageous or not. Two plots were pruned and given different grades of thinning and a third left untreated as a check. Detailed measurements were made for each tree.

2. Thinning in European larch, P.H. VII.

A plot was thinned in a plantation twenty years old and detailed records made. A remeasurement at twenty five-years showed the results in terms of increased growth.

3. Thinning and pruning in red pine, P.H. VI.

In the oldest red pine stand in the Forest, planted in 1915, a series of treated and untreated plots was started at the age of 19 years. Varying intensities of thinning are contrasted and crop trees have been pruned on some of the plots. Tree by tree records are being maintained on three treated plots and a control. A second thinning was carried out at an age of twenty-five years.

4. Spacing experiment, white pine, P.H. III.

In 1916 approximately half-acre contiguous areas on a uniform slope were planted with spacings of 3' X 3', 4' X 4', 5' X 5'

and 6' X 6' by exact measurement. This experiment was made to determine the effect on tree form, quality of timber produced, and amount of white pine weevil damage in these various densities of planting. Thinnings and crop tree prunings were carried out in the two closer spacings at nineteen years of age and the treated plots were thinned and pruned in all spacings at twenty-four years. Detailed records are being kept on the eight treated and untreated plots.

5. Pruning, white pine, S.C. XI.

Two plots were pruned and an untreated area left for contrast when this densely stocked natural stand was twenty-two years old. The pruning was extended up the trees in two later operations to a height of about seventeen feet at ages of twenty-five and twenty-seven years.

6. Growth of natural, managed hardwoods, T.S. II.

To show what can be expected in volume production and quality of timber in a managed, natural stand of hardwood containing an abundant stocking of sawtimber species, three plots, with untreated check plots, were established and measured in detail at the age of twenty-one years. The treated plots were thinned at twenty-six years and remeasured.

7. Reclamation of a severely weeviled white pine plantation, P.H. I.

This plot was established in a twenty-three-year old stand which appeared to be hopeless for sawtimber production as a result of weevil damage. Pruning of the best formed trees and girdling to kill the worst individuals was carried out and repeated at the ages of twenty-six and twenty-eight years.

8. Comparison of degrees of pruning, P.H. III.

To determine the effect on growth of removing varying amounts of green branches, four plots were treated when this 6'X6' planting was twenty years old. Pruning varied in intensity from the removal of only dead branches to a very drastic removal of green ones.

9. Reproduction and growth of red spruce, P.H. II.

Two plots were established in 1913 to trace the development of the reproduction and sapling-size spruce occurring in a natural spruce swamp in a stand about forty years of age.

10. Seed source planting, white pine, P.H. I.

To determine the effect of the type of "mother tree" on the offspring, a plantation of 925 trees was established in 1924 with three-year seedlings. The seeds came from six trees ranging in form from the clear, tall, virgin forest type to the open grown, "scrub" in an open field. Yearly height growth measurements have been made.

In addition to these there are some twenty-five minor plots established for shorter periods and special objects such as seeding experiments with paper birch, a comparison of the results of different girdling methods in killing undesirable trees, etc. There are also six permanent plots in the Black Brook property of the Forest at Hamilton, Mass., to determine the effects of thinning in white and Scotch pine and in Japanese and European larch. There are also some half dozen plots established by the Forest on the property of others, mainly to determine the results of different treatments in given stands.

COOPERATIVE RESEARCH

For many years the Forest has cooperated with both public and private organizations in the conduct of research, particularly with the Northeastern Forest Experiment Station of the U.S. Forest Service, the Division of Forest Insects of the U.S. Bureau of Entomology and Plant Quarantine, and the Division of Forest Pathology of the U.S. Bureau of Plant Industry. Much has been gained thereby, for almost invariably neither party was equipped to attack the problem at hand effectively without the aid of the other. The Forest has benefited from the contributions of experts in the biological sciences, logging and lumbering, marketing and the like, while these specialists and the organizations they represent have profited by the knowledge possessed by members of the Forest staff in related forestry subjects. Furthermore, such joint conduct of research has given both parties a much better understanding and appreciation of one another's problems, of differing points of view and scientific disciplines, and has served to increase most substantially the reliability and usefulness of the results.

Out of the long list of cooperative undertakings, one might mention especially those dealing with the control of insect pests and diseases, the applicability of forestry practices to the holdings of certain commercial forest owners, the marketing of lumber in Massachusetts and in New Hampshire, weather conditions affecting the start and spread of forest fires, and the factors involved in underwriting forest fire insurance for New England forests.

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