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THE RESTORATION OF WATERSHED FORESTS IN THE HURRICANE AREA

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Despite the statement once made to me by a prominent engineer that his first choice of a cover for a certain watershed in New England would be a tin roof, I believe that for existing conditions of run-off in this region nothing ever will be found more satisfactory than a good cover of trees. Furthermore, I feel certain that many water supply boards envisage the eventual development of watershed forests that will be not merely covers to prevent soil erosion and to regulate run-off, but productive forests yielding annual harvests of wood products, creating gainful employment and providing an income to the community. At least, as a forester, I shall assume that such is an ultimate objective.

That this objective seems far removed at present is due in part to the character of the cover on many of our watersheds at the time of their acquisition: open or brush-covered land devoid of trees of desirable species and requiring nothing short of planting in order to establish a forest cover. If it were not for the present generally depleted condition of our forests, progress in forestry undoubtedly would be much more rapid, and our practices would center more around conservative cutting methods and less around planting.

In addition to the time element involved in starting with bare ground, planting has in many instances brought about a condition of artificiality: even-aged stands of uniform spacing, generally coniferous, and not infrequently composed of exotic species whose fitness for the particular site on which they are planted is largely a matter of chance. Such stands are especially subject to insect pests and diseases, and the expense of protecting them may be so great that all hope of profitable wood production is sooner or later abandoned. Such costly treatments as spraying, cutting off weeviled leaders and creosoting egg masses, together with the poor form and early decline of trees poorly adapted to the site, are a recurring source of discouragement to those who would have the watershed forest show a profit from the sale of wood products. I presume that so much plant-

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ing around reservoirs has contributed to some extent to the popular but false notion that forestry is largely planting; and evidently some forest managers are not above being influenced by the same well-intentioned propaganda that has popularized this apparently sure and simple way of starting a forest. For even in cases where young, natural stands of potentially good timber already are present on cutover lands I have observed a tendency to cut down the existing growth and replace it with planted conifers in pure stands.

And while I am mentioning some of the common practices in publicly-owned forests I should include the treatment to which many older stands of natural origin are subjected: a treatment for which I can think of no better term than "park-making," a process that takes the form of cutting all the seedling reproduction and sapling understory, in effect destroying the basis for a future crop, and increasing the exposure of the soil to the action of the elements. Perhaps such a practice is carried on for the purpose of fire protection, as in the case of pruning each and every tree in plantations, regardless of the size or shape of the individual tree or of the fact that scarcely more than one-tenth of the number of trees planted at the beginning should be carried through to the final stand. Or perhaps in some instances such drastic treatments are due to an oversupply of relief workers untrained in the more refined silvicultural practices and useful only in such jobs as cutting and piling brush and wholesale pruning.

But I suspect that another reason why these practices are so common today, especially on the smaller forests that cannot afford to employ a forester, is that few people untrained in the art of forest production appreciate the vitally important relation of the make-up of the forest, that is, the mixture of species, the spacing of the trees, and the variety of ages and sizes present, to its security against destructive agencies, its ease of maintenance and its economic outcome. A forest that is allowed to grow up naturally over a long period of time is a most complex community of plant and animal organisms, each individual of which contributes something to the whole and plays a part in creating a favorable environment for the continued life and reproduction of the community. In departing too far from a policy of working in harmony with Nature one may find himself confronted with the same sort of problems as those common to the production of other artificial crops. It is well to recall that only by means of poison sprays, fertilizers and painstaking care and cultivation is modern farm crop production possible. For instance, no one would think of growing apples without spraying several times each

season. But forest crops cannot stand these high costs of care and protection and still show a profit. You may remember my remarks on this point when addressing you on a previous occasion, on the subject of the control of the gypsy moth; more specifically, the statement that costly, recurring expenditures for spraying and creosoting destroyed all hope of showing a profit on wood crop production.

Of course, we must admit that back of the current extravagance in managing our publicly-owned forests in this part of New England lies the fact that most of us living in this section are not forestry-minded to begin with. We are fish and game-minded, park-minded, and recreation-minded, but all too frequently we have failed to gain an appreciation of the possibilities of forest management from the standpoint of producing wood products on an economic basis. There is no reason why watershed forests cannot fulfill all the needs for protection of the soil and regulation of run-off, provide a limited amount of recreational use, and at the same time yield annual or periodic cuts of timber and other products. Continuous production, or sustained annual yield, as it is known to foresters, is chiefly a matter of developing a forest growing-stock in which there is such a distribution of trees of all ages and sizes, from seedlings to mature trees, that a certain proportion of the growing stock reaches economic maturity and is ready for cutting every year, this proportion being equal to the annual growth on all the trees. It makes no difference whether the forest is large or small. By maintaining a proper distribution of ages, annual harvests may be carried on indefinitely, barring such catastrophies as hurricanes, of course.

Before coming to the specific recommendations for forest treatments in the hurricane area, I wish to refer once more to the desirability of dealing with the forest as a whole: a community of trees, shrubs, ground plants, animals, and microorganisms in the soil, all interrelated and mutually dependent, and not simply as rows of trees set out orchard-fashion in an open field. In this connection I should like to quote some advice given recently by the Committee on Silviculture of the New England Section, Society of American Foresters,¹ as follows: ". . . the forester should at all times be guided insofar as possible by an understanding of the composition (species present) and ecological relations of the climax (virgin) forest for the particular locality in question. He should appreciate the character of the natural associations of plant organisms, and should follow natural tendencies unless he is reasonably sure that his information justifies

¹Journal of Forestry, 37, 1, January, 1939.

departure therefrom. Cutting aimed at reproducing stands should give full consideration to natural site potentialities and tendencies. Plantings likewise should be based on creating conditions of maximum stability and security consistent with the objectives of ownership. Even though such deterioration may have taken place in the soil, as a result of farming, repeated clear cuttings or fires, as to make impossible the immediate reestablishment of many of the valuable but exacting species which once occupied the site, we should plan on their gradual introduction as improved conditions of cover and soil permit." So you see in dealing with the task of forest restoration we should delve more deeply into the fundamentals of tree growth and not be content to base our accomplishments on the number of trees we have planted.

Not only do the so-called "natural" mixtures of tree species afford the greatest security against destructive agencies and the least costly maintenance, but a study recently conducted at the Harvard Forest by Goodell² indicates that the natural associations of trees are most effective in moderating run-off and streamflow. For example, for conditions of light winter snowfall, but heavy rains and cold weather, such as are characteristic of southern New England, the results of the study suggest that hardwoods, the most common natural cover in this part of the region, may be preferable to conifers. The reason for this is that the absence of a protective blanket of snow over the ground tends to permit the water-soaked soil to freeze deeply. The chief deterrent to such deep and long-continued freezing is full exposure to the sun's rays which, in the case of hardwood trees bare of leaves, are allowed to reach the ground with little hindrance. Furthermore, the warmth aids in early thawing of the soil in the spring, increasing its absorbtiveness at a time when heavy rains occur. In northern New England, on the other hand, where there is a heavy blanket of snow in the winter and generally a coniferous cover, the thick canopy of foliage tends to retard the melting of the snow in the spring, thus moderating run-off.

Needless to say, in citing these findings I have assumed that heavy spring floods are something to be avoided on all watersheds and that a more equable flow of water throughout the year is to be desired.

There is still another basic consideration that I should like to mention, and that is the form of forest which is best adapted to watersheds. I believe there is no doubt that the answer to most

²Goodell, B. C. A Study of Spring Flood Factors as Influenced by Forest Cover Types in Central New England. Unpublished Manuscript, 1937.



STAND A

Harvard Forest Photos.

STAND B

FIG. 1.—THE INFLUENCE OF DENSITY OF STOCKING ON THE FORM AND QUALITY OF THE STAND.

Both stands are the same age, but Stand A is densely stocked while Stand B is poorly stocked. The extreme crookedness of white pine when grown at wide spacings is due to attacks by the white pine weevil, an insect which kills the leader. The larger branches on the more open grown trees are due to the greater room available for lateral expansion of the crown. On open land white pine should be planted at a spacing not greater than 5 feet. With such a spacing weeviled trees are forced to straighten and branches die while still small.

forest management problems on watersheds lies in the all-aged or selection form, in which trees of all ages and sizes are growing together, either singly or in small groups. With a forest of this sort, clear cutting, with resultant exposure and drying out of the soil, increased fire hazard, and more rapid run-off, is avoided. Instead, under the selection method, cutting takes the form of the yearly or periodic removal of a relatively small number of the older trees, these trees being distributed throughout the stand rather than concentrated in one place. This form of forest provides the greatest possible protection of the site, for, with the exception of the small openings made in logging, the ground is completely covered at all times. The restriction of cuttings to single trees or small groups keeps fire hazard at a minimum; there is no need for resort to planting, since seed trees are abundant and seedlings become established naturally in any openings; aesthetic values are retained in the fullest degree; and the conditions of shade and moisture characteristic of an all-aged form of forest favor the more valuable, long-lived species of trees. These advantages seem to be particularly applicable to the smaller watershed forests near centers of population, where protection against fire and avoidance of unsightly cutting are of great importance. To be sure, time will be required to develop such forests, but if the objective of an all-aged form of forest is constantly kept in mind, all current treatments may be made to contribute towards that end and its attainment hastened. I wish to emphasize this point especially in view of the present tendency to plant even-aged stands, to cut the undergrowth of young trees in older stands, and to harvest by clear cutting, all of which result in even-aged rather than all-aged stands.

In the treatment of conditions as we find them after the hurricane there exists an excellent opportunity to adopt new and better practices, to bring about some reforms as it were and not merely to replace that which was blown down. In discussing post-hurricane practices I wish to deal first with the stands that were either completely destroyed or severely damaged and then with the young stands that escaped injury.

Stands of Middle Age or Older. In the case of older stands that were completely blown down, whether softwood or hardwood, or mixtures, the prompt salvage of the merchantable logs and cordwood, followed by the piling and burning of the slash, will serve to eliminate the fire hazard and to leave the ground in a favorable condition for natural regeneration of the forest. Although hardwood slash constitutes much less fire hazard than softwood slash, and, in any

case, decays within a few years, especially if in contact with the ground, I have assumed that on most of the smaller watershed forests it will be found possible and desirable to burn it. Otherwise, hardwood slash may be lopped and scattered to good advantage.

There is every reason for cleaning up the debris as soon as possible. Not only will the fire hazard continue for several years to come where no cutting or burning is done, but uncontrolled fires will destroy most of the young growth and thus greatly increase the cost of establishing a new stand. Furthermore, the down trees and slash will serve as breeding places for insects and fungi, some of which may be expected to attack any standing living trees.

During the process of slash disposal any hardwood saplings that have been badly damaged but still remain firmly rooted should be cut close to the ground. The remaining stumps will send up sprouts the first growing season after cutting, and many of them will be sufficiently straight and well-formed to make desirable timber trees. I should recommend the policy of cutting all spindling, bowed over, broken-topped, or otherwise injured small hardwood trees. There is almost no danger of killing the trees. Our New England hardwoods are noted for their sprouting ability.

In general, no planting will be necessary in cases of the complete blow down of old stands. The excellent crop of pine seed last fall should in many cases result in an unusually dense reproduction of pine, which will be supplemented on the heavier soils by an abundance of hardwoods. Not only is there a large amount of viable seed stored in the top layer of the soil, but thousands of small hardwood seedlings and saplings present beneath the older stands, even though broken or cut off, will sprout up again and make rapid growth under the new conditions. Cutover pine lots in particular are noted for the dense thicket of hardwoods that becomes established a few years after logging, except on the lightest and driest soils. The finest young hardwood stands in the Harvard Forest owe their origin to the clear cutting of pure pine stands. Much of the area of blow down may be treated the same as cutover land, which in this part of the country may be depended upon to restock itself naturally, provided destructive fires are prevented. In the past, much money was wasted in the needless planting of cutover land and, indeed, not a few of such plantations were so completely and quickly overgrown by the new volunteer stand that the plantations have since been abandoned, and properly so. In any event there should be no haste in deciding whether planting is necessary. Four or five years is not too long

to wait, particularly in the case of the more fertile soils or where seed trees are still standing.

On the light, sandy soils or on dry ridge tops, planting may be the only solution, but even here it will prove advantageous to allow a few years to pass, thus permitting what growth does come in, be it what it may, to shade the ground and afford some protection to the planted trees. In any case, it is unsafe to plant young conifers on cutover pine land until the third season following cutting, because of the Pales weevil, an insect that is attracted to fresh pine cuttings and feeds upon and kills coniferous seedlings. This same insect will destroy a portion of the natural pine seedlings resulting from last fall's seed, but enough will survive to form, along with the hardwoods, fairly well-stocked mixed stands.

The young mixed hardwood, or pine and hardwood stands, that we may expect to come in on areas of blow down will require little more than one or two weeding treatments during the first ten years in order to free the most desirable trees from overtopping inferior trees and to lay the foundation for a valuable timber crop. In selecting the species to be favored one should take into account the various factors of site and soil, susceptibility of the various species to insect pests and diseases, their influence upon one another when growing together in mixtures, and all that goes towards building up a safe, easily maintained stand of valuable trees.

In the case of older stands in which only part of the trees blew down, there is even less reason for resort to planting and greater assurance of a satisfactory restocking by natural means. Although bark beetles and exposure may kill some of the trees that thus far have escaped damage, in all probability enough will survive to act as sources of seed, the resulting seedlings supplementing those originating from seed stored in the duff. In any event, these older residual trees should be saved, if possible, not only for their seed but for the protection they afford the soil and the young trees. On the drier sites, the establishment of a satisfactory stocking of seedlings in the openings between the older trees may be promoted, where not too rocky, by scarifying the soil with the aid of a spike-toothed harrow, or some similar device for breaking up the leaf litter and duff and mixing them with the mineral soil. Frequently the results of such seed bed preparation exceed all expectations in the way of a dense catch of seedlings. Incidentally, you will doubtless observe during the next few years that in the depressions, where bare mineral soil has been exposed by the uprooting of the old trees, seedlings of certain

hardwood species have come in abundantly. The same will take place on the beds of charcoal where slash has been burned. In fact, a scarcity of natural reproduction is more likely to be due to an unfavorable condition of the seed bed rather than to a lack of seed.

On areas where the former stand was completely blown down, the ensuing stand will of course be even-aged, but where a part of the stand remains there is an excellent opportunity to make a start towards the development of the all-aged form of stand, which is so ideally suited to watershed purposes. Although the newly established generation will be essentially even-aged, the sprouts resulting from the cutting of bent over or broken saplings will forge ahead of all the seedlings thus forming what later will appear to be an intermediate age.

Young Coniferous Stands. Coniferous plantations, even though scarcely older than twenty years, proved highly susceptible to wind-throw, and in many of them the trees now lie prostrate or sharply inclined like a field of grain flattened by a summer storm. The task of slash disposal is a difficult one, but there appears to be no better way than to lop off the branches and burn them, then cut the stems near the base, so that they will come in close contact with the ground and their decay thereby hastened.

Because of the lack of a seed source, natural regeneration cannot be expected. But in turning to a replanting of the area as the solution, there should be no hesitation in departing from earlier procedures. To the fullest extent possible, pure coniferous plantations should be replaced with mixtures of species having such habits of growth and requirements as to be mutually beneficial when growing together. Few indeed will the cases be where a marked improvement cannot be made in the composition, spacing or arrangement of the new stand. While a great many questions remain to be answered relative to the mixing of conifers under the various conditions of climate, topography and soil, and especially so in connection with the use of exotic species, it has been definitely established that pure stands are particularly and highly susceptible to both insects and diseases. Exceptions should be made, of course, in the case of native species occurring naturally in pure stands. I need not tell you that the majority of white pine plantations in this part of New England have been reduced to rows of bushes by the repeated killing of the leaders by the white pine weevil, or that red pine is now being attacked in Connecticut by the European pine shoot moth. In eastern Massachusetts red pine has been attacked more recently by an as yet unidentified sawfly that strips off the needles. There may be those among



Harvard Forest Photos.

FIG. 2.—THE ALL-AGE OR SELECTION FORM OF STAND IS IDEALLY SUITED TO WATERSHED PROTECTION

Cutting is restricted to individual trees or small groups, thus reducing fire hazard to a minimum; there is no need for resort to planting, since abundant seedling reproduction is naturally established in any openings; aesthetic values are retained to the fullest degree; and conditions of shade and moisture are favorable for tree growth and encourage the more valuable species of tree.

In the photograph the small opening in the foreground resulted from the cutting of a group of mature trees. This opening will soon be restocked with natural reproduction. Middle-aged groups of trees appear in the background.

you who already have been obliged to resort to spraying to control this newest pest. Yet such remedies as poison sprays are purely temporary. Within the next few years another spraying may be necessary in order to avoid serious damage.

Time does not permit discussion of the subject of pure *versus* mixed stands, or detailed recommendations for planting new stands in place of those blown down. Such decisions as are called for under the present circumstances fall within the province of silviculture, and I would suggest that you seek the advice of a competent specialist in this field. While many persons set about planting forest trees with seemingly as little concern as though planting cabbages or some other

annual crop, the fact of the matter is that the creation of a forest that will remain healthy and vigorous over a period of many decades and yield sound, valuable timber requires the utmost skill and foresight. Many plantations appear promising while still in the juvenile period, but this is no criterion of later vigor or long life.

Because hardwood plantations have seldom, if ever, proved successful on open land in this region, partly on account of frost damage during the seedling stage, I have referred only to conifers for use on areas of complete blow down. However, studies being currently undertaken at the Harvard Forest indicate that hardwoods may be successfully planted beneath the protective canopy of older coniferous stands, or in small openings made by cutting one or more trees, after the conifers have attained sufficient height. This may be a means, at some later date, of introducing certain hardwood species into coniferous stands to form a very desirable uneven-aged mixture, at the same time getting rid of poorly formed individual conifers that are not worth retaining as crop trees. Further research needs to be done before definite recommendations are possible.

Young Hardwood Stands. Just a few words regarding the young hardwood stands that survived the hurricane. And I presume you have noticed that, on the whole, hardwoods withstood the wind much better than conifers. There are thousands of acres of young hardwood stands in the formative period, on watersheds and elsewhere, that have originated on cut-over land and that a comparatively small outlay would put in satisfactory condition for profitable timber production. Generally, the possibilities of improving these young wild stands have in the past been completely overlooked. Through weeding and improvement cuttings, trees of inferior species, form or condition can be eliminated from the stand in favor of the more promising trees of the more desirable and valuable species. Here again I cannot hope to describe the technique employed in such silvicultural treatments, but I should like to say that anyone who enjoys working with stands of trees will obtain the greatest satisfaction in weeding young stands in the sapling stage. The work goes rapidly; one can see the marked change as he goes along, and within a few years he will witness the quick response that has been made by the better trees, once overtopping inferior trees are out of the way, and the generally improved appearance of the young stand. Weeding is the most needed and profitable treatment that can be applied today to the large area of cutover and naturally restocking wild land. The improvement of young volunteer stands should be a prominent part



STAND A

Harvard Forest Photos.

STAND B

FIG. 3.—On the better grades of soil excellent stands of hardwood may be developed simply through weeding the volunteer sapling growth on cutover areas. The object of weeding is the favoring and freeing of the most desirable future crop trees from over-topping inferior trees. The photograph of Stand A shows the first weeding being carried out in a young hardwood stand on cutover land. The workman is cutting a rank-growing sprout clump from a large stump in favor of well-formed seedlings of oak and ash. The photograph of Stand B shows how a properly weeded stand appears at 25 years of age. Only trees of desirable species, form and quality make up the main stand.

of any program of forestry in the region, regardless of the new problems introduced by the hurricane.

As a final thought may I suggest that in the general plan of forest restoration in the hurricane area a little more emphasis be placed on growing hardwoods, a little less on conifers. Though I am not inclined to be influenced in choice of species by the possibility of another hurricane, it is true that conifers are more subject to windthrow than are hardwoods. And certainly they are much more subject to complete destruction by fire during early life. But, more important than either of these considerations, I believe, is the fact that over the larger part of southern New England hardwoods are favored by Nature to a greater extent than conifers. By allowing ourselves to be guided by natural tendencies in the establishment of our new forests I believe we shall save a great deal of later trouble and expense, produce better forests, and best meet the needs of watershed protection.

DISCUSSION

Roger W. Estey.* In one of the illustrations a hardwood growth contained a lot of large trees and some smaller ones. How should that be thinned out?

Mr. Cline. I should let the young trees take care of themselves for the time being and just pay attention to the better individuals among the older trees, to see that these have enough room for healthy, vigorous growth. It is a matter of having sufficient room for the expansion of the tree's crown. Crown expansion and growth in diameter of the bole go hand in hand. By thinning the stand, the rate of diameter growth is increased and thereby the time required to produce logs of a given size shortened. On the other hand, groups of young trees should be kept quite dense, since restricted room forces the tree to grow straight, kills the lower branches before they become large and hastens natural pruning.

A Member. I want to ask Mr. Cline if he can tell us the relative amount of water used by the different trees, because that might be important on watersheds, where the need is water rather than trees.

Mr. Cline. I am afraid I am not prepared to give you any figures on the relative evaporation rate of the different species. Of course, it is much greater in the case of hardwoods than conifers. You all know that conifers will grow on dry, sandy soils, whereas many of the hardwoods require rich, moist soils. But I think to answer your question fully one needs to consider the month by month run-off

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throughout the year as influenced by all the factors of soil and cover, and not merely the rate of transpiration. There is a great deal of difference between the soils found under conifers and those under hardwoods as regards permeability, water-holding capacity, depth of freezing, and other characteristics which determine in some degree what portion of the total precipitation will find its way into the reservoir. Much more research is needed before this question can be satisfactorily answered.

A Member. We have several stands of pine in several stages of growth from last year's setting-out to fifteen years of age. When is the proper time to start pruning?

Mr. Cline. I do not know just what your objective is in pruning but, leaving out of consideration that of fire protection, the time to start pruning is when the trees are about 3 to 5 in. in diameter and around 15 to 18 ft. in height, the reason being that the smaller the knotty core in the center the larger the surrounding cylinder of clear wood. And in the case of white pine there is an excellent reason for waiting until the trees are log high. Due to attack by white pine weevil many trees are ruined by forks and crooks. If you prune too early, you may waste time pruning trees that you later find are so severely damaged by weeviling as to be worthless. So in the case of white pine it is always well to hold off pruning until the trees are at least 12 ft. high—until you can tell what the butt log is going to be. I am speaking from the standpoint of producing high-quality lumber, at least in the butt log, and not protecting the plantation from fire. There is a great deal of wholesale pruning in watershed forests, and I must say it is a rather painful sight to foresters to see so much money spent in pruning trees, when we know that no more than from one-sixth to one-tenth of those trees should end up in the final stand. It seems that you have wasted a lot of money pruning trees which will never reach maturity.

A Member. What is your idea of the best way to thin trees, to girdle or to cut?

Mr. Cline. In a plantation?

The Member. Yes.

Mr. Cline. I should say that in coniferous plantations on most watersheds the undesirable trees should be cut. A girdled conifer will dry out and remain standing for many years, constituting quite a fire hazard as well as being unsightly. There is nothing wrong with girdling, as such, as a means of reducing congestion in the stand, but I think from the standpoint of fire protection you will be much better

pleased to have these trees cut and laid close to the ground, where they will decay.

Mr. Estey. You have spoken from a forestry proposition. Looking at it from a water-works angle what effect would different cover have on the color of the water?

Mr. Cline. I am not prepared to answer that question. I presume you are thinking that hardwoods discolor the water.

I have worked in regions like the Appalachians and the Ozarks where the forests are very largely hardwood, and I have never noticed any discolored water in the streams. I believe that water flowing through hardwood forests growing on upland soil, not swamp, would not be discolored. I know when water comes out of a red maple swamp, or any swamp, it will be discolored, but I think that where it is flowing under upland hardwoods the water will be as clear as though the cover were conifers. I may be mistaken, but that is what I should say.

In closing I might say that the President's reference to Mr. Frank E. Winsor's death reminds me of a most pleasant acquaintance with him and other members of the Metropolitan Commission over a number of years, and especially since the Quabbin Reservoir has been under construction. There is one point I tried to make with these gentlemen in connection with their planting, and that was the desirability of close spacing. Instead of planting 6 or 7 ft. apart, which means a slow closing in of the stand, coarse branches, and poor lumber, I suggested that they close the spacing to approximately 5 ft. This means more trees per acre, but there is much more profit in it, as far as the final timber stand is concerned, than with these wider spacings.