THE FUTURE OF THE CHESTNUT TREE IN NORTH AMERICA

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NOW-A-DAYS one often hears the question, "What is going to become of our chestnut trees?" In fact, whenever the subject of trees is broached in the course of a conversation, this inquiry is bound to come out—not, as I believe, that the interrogator hopes to receive a satisfactory answer, but more in the way of a general query.

As I do not claim to be gifted with second sight, I do not mean to imply by the title of this paper that I can foretell the future of this tree—rather, in the same philosophical spirit of the interrogator, on the basis of certain facts relating to the past and present history of the species, I shall make an inquiry into its probable future.

It is natural that the condition of this tree should arouse concern, valuable as it is to us in a great variety of ways. For one thing, we are always in need of woods which, like the chestnut, are comparatively resistant to decay when in contact with the soil; and this is one of the main reasons why a large proportion of the railroad ties and telegraph poles in the eastern United States are of chestnut. However, as far as the finer, technical uses are concerned, such as interior finish of houses, furniture, etc., it is a decidedly second-class material because of its warping and checking tendencies; yet it is often used for these purposes, where the element of cheapness is the chief consideration. By the uninitiated, chestnut used in interior house finish may easily be mistaken for the more expensive ash. One of the chief sources of tannic acid, important in leather manufacture, is our chestnut tree. And every small boy, not to mention his elders, knows the value of the nuts, which are sweeter than those of its near relative, the European chestnut.

In addition to these valuable properties, when it grows in the open, the tree develops a massive, round head, with short, powerful trunk, and low-sweeping limbs, which make it a most beautiful ornamental tree (Fig. 2).

The natural range of the chestnut (*Castanea dentata*), is from southern Maine[1] to the valley of the Winooski River in northern Vermont, to southern Ontario, and along the shores of Lake Ontario[2] to southeastern

[1] Knight, Ora W., "Some Noteworthy Plants of the Penobscot Valley," *Rhodora*, 8: 65–66, 1906.

[2] Sargent, C. S., "Silva of North America," 9: 14, 1896.

Michigan,[3] southward in the eastern part of its range to Delaware, and in the west to southeastern Indiana[2] and extreme southern Illinois,[4] while it extends along the southern Appalachians to north central Georgia,[5] central Alabama[6] and Mississippi, and central Tennessee. This distribution is most easily remembered if we observe that it takes the general form of an ellipse, which is about twice as long as broad, with the southern end in central Mississippi, Alabama and Georgia, the northern end in Maine, New Hampshire and Vermont, while the greatest cross diameter of the ellipse extends from southeastern Michigan to Delaware (Fig. 1).

Although this is the area which now includes all chestnut growing naturally or "wild" in the United States, it does not necessarily represent the territory it has always occupied in the past. For geological evidence, as well as our own observational powers, show us that in both plant and animal worlds the confines of a species are constantly varying —now expanding, now contracting. This condition is evidently due to a great variety of factors, but at the very groundwork of them all lie the fundamental principles of the struggle for existence and the survival of the fittest. In modern times the modifying action of man on this perpetual contraction or expansion of a species has been by no means slight, and with the ever-increasing facilities of commerce, his influence is becoming more and more marked. To cite an example from the plant world, some of the most obnoxious weeds that grow about us to-day, and are the bane of the farmer, are intruders from foreign countries, their seeds having been brought in with various imported materials. Having thus arrived here, many of them find congenial soil and make their home among us, thereby considerably widening the range of distribution of their particular species. On the other hand, by the unwitting introduction of various fungous or insect parasites, man may be instrumental in the contraction or even the extinction of some of our plant or animal species.

Such examples as the bison, or the North American Indian, demonstrate how rapidly the distribution of a species or race may change, even within the memory of man.

Geological data, as furnished us in the form of fossils, are often illuminating as to the former distribution of our plant and animal species. For example, the giant big-tree and redwood, of California, quite prob-

[3] Otis, C. H., and Burns, G. P., "Michigan Trees, a Handbook of the Native and Most Important Introduced Species," p. 95, Ann Arbor, 1913.

[4] Gleason, H. A., "Additional Notes on Southern Illinois Plants," *Torreya*, 4: 168, 1904.

[5] Harper, R. M., "Flora of Middle Georgia," *Bull. Torrey Bot. Club*, 27: 333, 1900. "Botanical Explorations in Georgia During the Summer of 1901," *ibid.*, 30: 294: 1903.

[6] Mohr, Charles, "Plant Life of Alabama," Contributions from the U. S. Nat. Herbarium, 6: 60, 1901.

ably had formerly a much wider range than their present contracted limits, for fossils of conifers belonging to the same genus have been found even as far north as Greenland. And it is reasonable to assume that, if conditions remain the same, such species will continue to weaken and die out, although in this case also man's treatment can considerably modify the result.

Unfortunately, in the case of the American chestnut, there is no fossil evidence of its former distribution. Mr. F. H. Knowlton, of the United States Geological Survey, writes us: "So far as I know, the American chestnut has not been found fossil anywhere in this country, but the parent form, that of *Castanea sativa* (the European chestnut)

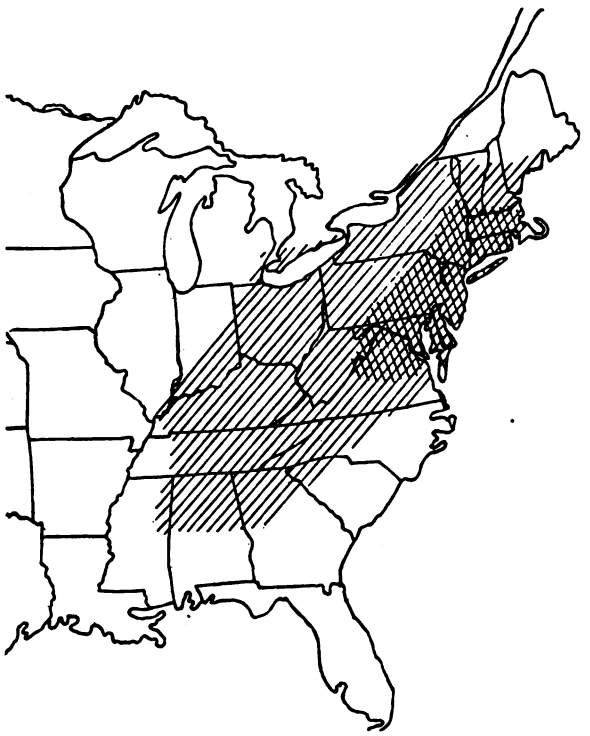

FIG. 1. SHOWING THE NATURAL RANGE OF THE AMERICAN CHESTNUT. The cross hatching shows in a general way the extent of territory covered by the chestnut bark disease.

has been found at a number of localities in England and Italy, in deposits of inter-glacial or pleistocene age." As far as the genus is concerned, *Castanea* once had a much wider range in North America than at present, for, according to Sargent,[7] "Before the middle tertiary period *Castanea* existed in northern Greenland, and in Alaska, where traces of the leaves and fruit of *Castanea Ungeri* Heer have been distinguished;

[7] Sargent, C. S., *loc. cit.*, p. 10.

and impressions of one and perhaps two species found in the miocene rocks of Oregon, and in those of the upper miocene of the Colorado parks, show that *Castanea,* which already existed in Europe in the cretaceous period, once inhabited western North America, whence it has now disappeared."

Coming now to the condition of the chestnut tree to-day, let us first figure up its liabilities, *i. e.,* those diseases and injuries from which it is prone to suffer, and then set down on the other side of the balance sheet its assets, *i. e.,* those inherent qualities which accrue to its advantage in the struggle for existence.

It is a significant fact that both the European and the American chestnuts have been attacked in recent years by serious diseases which have attracted a great deal of attention here and abroad. In Europe the disease known as the *Male dell' Inchiostro* and various other troubles have very seriously affected the European chestnut.

In the United States, the well-known bark disease, discovered in 1904 near New York City, has already caused enormous damage to the chestnuts in southern New England, New York, New Jersey, Pennsylvania, Delaware and Maryland, and it also occurs in Virginia and West Virginia[8] (Fig. 1). It is unnecessary here to describe this trouble in detail, as excellent accounts of it have already been published and are easily available.[9] It is sufficient to state that it is caused by a fungus which grows in the living bark of the tree, gaining an entrance through wounds or openings of any sort in the bark. As the fungus grows, it kills the bark, and by gradually increasing the radius of its operations, eventually reaches around the trunk or branch which it entered, in this way girdling it.

When this disease was first discovered, and its disastrous nature realized, one of the first questions that arose was that of the source of the causal fungus. Where did this fungus come from? Was it a native fungus, or was it brought into this country from abroad? It was easily seen that the answer to this question was of fundamental importance, for if the fungus was a native species, then its sudden attack was evidently due to unusual environmental factors of some sort, and with the recurrence of the normal conditions the virulence of the attack would cease. On the other hand, if the fungus were an imported parasite, there would be no telling where its depredations would end.

Those who held to the first theory, *i. e.,* that the fungus was a native

[8] The disease has also been recently reported in a nursery in North Carolina. See Metcalf, Haven, "The Chestnut Bark Disease," *Jour. of Heredity,* 5: 8–18, 1914.

[9] Metcalf, Haven and Collins, J. Franklin, "The Control of the Chestnut Bark Disease," U. S. Dept. of Agr., Farmer's Bull., 467: 1–24, 1911.

Clinton, G. P., "Chestnut Bark Disease," Rept. of Conn. Agr. Expt. Sta., 1912, 359–453; pls. 21–28, 1913.

form, believed that it had hitherto escaped the notice of botanists, occurring in an inconspicuous way as a weak parasite or saprophyte, but that conditions unfavorable to the chestnut, such as extremely cold winters and severe droughts, continued coppicing, etc., had rendered the tree susceptible to attack. As to the suddenness of the outbreak, this was to be accounted for by the very unusual climatic conditions which prevailed about the time of its appearance. Moreover, serious troubles of the chestnut had been before noted in this country, but had never been really explained.

On the other hand, those who believed the fungus to be an introduced species pointed to its apparent spread from the region around New York City as a center, our greatest port of entry, to the suddenness of the attack, to the fact that the fungus had never been observed here before, and lastly, to the partial immunity of certain varieties of the Japanese chestnut, which were first raised extensively on Long Island, the implication here being that the fungus might be a Japanese species to which, in their native home, the Japanese chestnuts had in the course of a long period of time become partially immune.

The last point was significant, but not conclusive, since the fungus had never been found in Japan, nor was it possible at the time to locate it in any foreign country.

In the course of time investigations brought out the fact that the fungus was closely related to a species already known in Europe and America, and by some was considered a variety of this, while others regarded it as a distinct species. Without going into details, it is sufficient to note the main fact emerging from them, namely, that the fungus was a new form, at least one not before known in Europe or America.

For a long time efforts to locate the fungus in the orient were without avail, but recently Mr. Frank N. Meyer, of the United States Department of Agriculture, has sent to Washington specimens from a blighted chestnut in China, which have been found to contain the identical fungus which has caused the trouble here. Moreover, from the nature of the locality in which it was collected, the fungus appeared to be indigenous. It should also be noted that the Chinese trees gave the appearance of being much more resistant to the disease than the American.[10]

Unless, indeed, we construct a theory of independent origin of species identically the same, due to essentially similar conditions of environment, we are justified, then, in believing that this parasite was brought into this country, and, judging from the past, may continue its steady

[10] Shear, C. L., and Stevens, N. E., "The Chestnut Blight Parasite (*Endothia parasitica*) from China," *Science*, N. S., 38: 295–297, 1913.

Metcalf, Haven, "The Chestnut Bark Disease," *Jour. of Heredity*, 5: 8, 1914.

advance in the area in which the chestnut naturally occurs. However, we shall consider this point again later.

In common with other forest trees, the chestnut is subject to the attack of several species of fungi which bring about a decay of the heart wood. Normally, the tree is protected from such invaders by its incasement of bark, but when this is injured in any way, a vulnerable spot is opened up through which fungi can enter. Notably is this the case in trees injured by forest fires, for here the living bark as well as the sapwood underneath may be entirely killed in spots, causing the so-called fire-scars, and furnishing an easy ingress for fungi. Once inside, in the heartwood, the fungus may work up and down in the interior of the trunk, softening the wood by its decaying action, or "dozing" it, as the lumbermen say. If the tree, thus deprived of the firmness of its solid cylinder of heartwood, its chief mechanical support, does not fall a prey to the next violent windstorm, it is in any case weakened, and the way lies open for attack upon its last stronghold, the sapwood and living bark.

Another widespread trouble of the chestnut, which I have found of common occurrence in New England forests, but apparently more destructive in the southern Appalachian mountains, is caused by the attack of the two-lined chestnut borer, *Agrilus bilineatus*. Next to the fungus which causes the bark disease, this insect is perhaps its most serious enemy. It is said to have a preference for trees enfeebled in some way, through such causes as drought, unfavorable soil conditions, etc., yet it is possible that where it breeds in great numbers it may be forced to attack vigorous individuals. In any case I have seen many examples of trees, which to all appearances had been in a perfectly sound condition, being rapidly killed by the attacks of this tiny grub. On opening up the inner bark, the long, sinuous channels of the larvæ were disclosed, now and then with a sharp turn in a lateral direction, the combined effects of several of these galleries resulting in a practical girdling of the tree. Many other insects attack the chestnut, but they are of secondary importance.

Let us next consider the practise of "coppicing." As is the case with many other of our forest trees, the chestnut habitually sends up sprouts from the stumps of felled trees, sometimes more than one hundred of these developing from a single parent stump. These "coppice" shoots grow rapidly, having the well-developed roots of the parent tree at their disposal for the absorption of nourishment from the soil, and enter into fierce competition with one another for light and space. Although in the natural course of events the weaker ones succumb and die out in the struggle, the woodsman may assist nature in this process of elimination by cutting out the weaker shoots early, in order to give the more vigorous ones a better chance In either case, eventually four or five, or rarely

more, vigorous trunks remain, which on reaching a suitable size are cut down and used for railroad ties, telegraph poles, or lumber, as desired; and from their stumps new coppice shoots arise, to repeat the whole history of their forebears. In some regions this coppicing has gone on for four or five generations of sprouts.

The question now before us is, "Does this continued coppicing weaken the vitality of the chestnut tree and thus make it more susceptible to disease?" The general opinion seems to be in the affirmative. Zon,[11] speaking of the chestnut in southern Maryland says:

> It must not be forgotten, however, that a chestnut stump can not go on coppicing forever. With each new generation of sprouts, the stump becomes more and more weakened, and hence gradually loses its capacity to produce healthy and vigorous sprouts. Although it is impossible to state with certainty how many generations of chestnut can be raised from the same stock without impairing the vitality of the sprouts, the effects of repeated and bad coppicing manifest themselves in the increasing number of dying chestnuts all over Maryland. The immediate cause of their death can nearly always be traced to attacks of either insects or fungi, yet the prime reason is their decreased vitality, which makes them easy prey to their natural enemies.

As stated by Dr. Clinton:[12]

> It is certainly a curious coincidence that the blight makes its first appearance and causes its greatest damage in the regions where the chestnut has suffered most from repeated cutting over.

Dr. Clinton quotes Nellis, of the U. S. Forest Service, who, in an unpublished working plan on "Utilization of Blight-killed Chestnut," writes:

> It is expected that this study will show that the present range of the chestnut bark disease is in a region of entirely second growth chestnut, which has been culled of its most valuable timber, where only rough products are now being produced.

Without entering into the discussion as to the relation of the bark disease to coppiced areas, I will merely state that coppiced chestnut is in general apt to be affected with disease of some sort. Especially frequent are heart-rotting fungi which may enter by way of the decaying parent stump, and the unsound condition of the trunk they cause is communicated to succeeding generations. It is also conceivable that the root system of the sprouts, inasmuch as it is partly that of the parent tree, may be weaker on this account. For, although we have no evidence to prove that the parent root system becomes inherently weaker with age, yet it is reasonable to expect that the soil about it would become more and more exhausted of its nourishment, to say nothing of possible external injuries to which it might be subjected in the course of a long period of time.

As already intimated, forest fires are extremely disastrous to the

[11] Zon, R., "Chestnut in Southern Maryland," Bureau of Forestry, U. S. Dept. of Agric. Bull., 53: 29, 1904.

[12] Clinton, G. P., *loc. cit.*, p. 402.

chestnut, not only by reason of their direct effect where they kill the tree outright, but also by exposing its interior to the attacks of fungi and insects. In addition, such fires impoverish the soil by burning out the humus, thus materially lessening its fertility. Reproduction also receives a setback because seedlings, young sprouts, or nuts lying on the ground ready for germination, are easily killed. Forest fires have been abundant throughout the range of the chestnut tree, and it is reasonably certain that they have been much more frequent since the white man has settled these parts of North America. In the southern Appalachians, the deadly work of fire, followed by insects and fungi, is to be seen on every hand. In this connection the following citations give us some conception of the general condition of the chestnut in the southern Appalachians.

Dr. Mohr,[13] speaking of the chestnut in Alabama, says:

> The chestnut, usually one of the most frequent trees of these forests, is at present rarely found in perfection. The older trees mostly show signs of decay, and the seedlings, as well as the coppice growth proceeding from the stumps, are more or less stunted. It is asserted by the old settlers that this tree is dying out all over the mountainous regions, where at the beginning of the second half of the century it was still abundant and in perfection.

W. W. Ashe,[14] says:

> For many years the chestnut on the lower mountains in the southeastern portion of the state has been dying out, a few trees at a time. . . . Some of these are killed by the two-lined chestnut borer, but while this decline is in part due to the ravages of the borer, it seems to be due more to excessive burning and to the consequent destruction of humus and impoverishment of the soil.

W. P. Corsa,[15] states:

> From causes not well understood, there is a marked decline in the vigor of the chestnut throughout the broad area of territory in the southern states where the white man found this tree among the most thrifty of the original forests. Down to the first quarter of the present century there seems to have been no mention of a trouble in the chestnuts of that section. Within the memory of residents of the Gulf States the chestnut flourished in all their higher lands. In point of time the trouble seems to have begun in the most southern limit of chestnut growth, and there the destruction has been most complete. It has pushed its encroachments throughout Mississippi, Alabama, Georgia and South Carolina, and is now reported in the strongholds of chestnut growth in North Carolina, Tennessee and Virginia.

Buttrick,[16] in a study of the conditions in North Carolina, says:

[13] Mohr, Charles, *loc. cit.*, p. 61.

[14] Ashe, W. W., "Chestnut in Tennessee," State Geol. Survey of Tennessee, published in cooperation with the Forest Service, U. S. Dept. of Agr. Bull., 10-B, p. 11, 1912.

[15] Corsa, W. P., "Nut Culture in the United States," Unnumbered Bull. of Div. of Pomology, U. S. Dept. of Agric., 1896, p. 78.

[16] Quoted by permission, from the manuscript of a report on the chestnut in North Carolina, prepared by P. L. Buttrick, under the joint direction of the

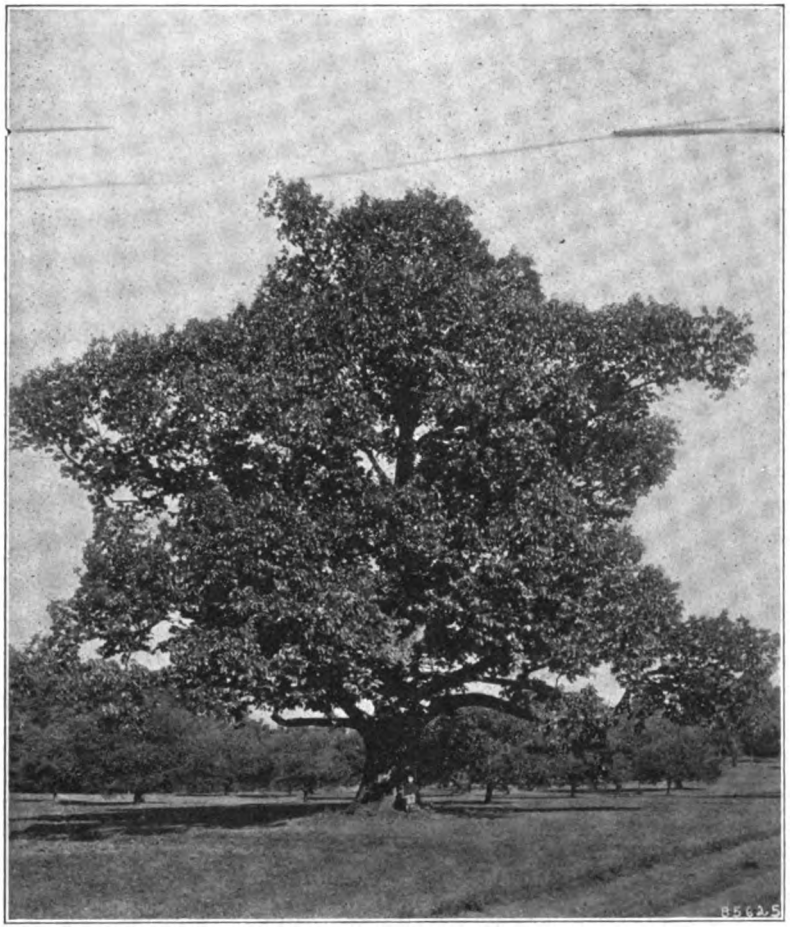

FIG. 2. AMERICAN CHESTNUT, CENTRAL MARYLAND. Photograph supplied by the United States Forest Service.

It is well known that chestnut was much more abundant and important throughout the Piedmont region and at places in the mountains themselves than is the case to-day.

Records show that during the first half of the past century, chestnut formed an important part of the growth forest throughout the western Piedmont section, although probably never as important a one as in the mountains. It was also apparently found much farther east than at present and may have at one time reached the Coastal Plain.

About seventy-five years ago it began to die throughout the eastern portion of the plateau and by the sixties it was dying throughout Guilford county and to the west. In the early eighties it began to die throughout Iredell, and the counties north and south of there. Since then the "death wave," as we may call it, has traveled west and overflowed the Brushy and South Mountains; has reached half way up the slopes of the Blue Ridge, and is still rising in the

Laboratory of Forest Pathology, U. S. Dept. of Agric., and the North Carolina Geological and Economic Survey; and soon to be published by the latter.

northern and has actually crossed it in its southern section. West of the ridge in most of the regions where chestnut is wanting, its disappearance has been quite recent and, indeed, it is still disappearing.

This strange phenomenon is not confined to North Carolina, but is to be seen to a greater or less extent on the outer portions of the range of the chestnut, throughout the southern half of its range. Reports show that chestnut has largely died out or was formerly much more abundant in portions of Virginia, South Carolina, Georgia, Alabama, Mississippi and Tennessee, and that the recession is still going on.

This apparently mysterious decline in vigor of the chestnut in the south is evidently not due to any one factor, but probably to a variety of causes. Probably frequent forest fires are to blame for the beginning of most of the trouble, and these, as we have seen, are followed by the attacks of fungi and insects. The cutting over and clearing up of large areas may also result in soil conditions which are not as favorable as formerly. Climatic changes may also have something to do with the case.

If we summarize briefly the troubles of the chestnut described in the preceding pages, we find that in the northern half of its range it is a prey to the bark disease; throughout its whole area it is attacked by the two-lined chestnut borer, as well as by other insects, and also by fungi which destroy the heartwood. The common practise of coppicing can only be regarded as harmful when carried on for several generations. Forest fires have been frequent, resulting in injuries of many sorts. In the southern states still other factors are evidently at work.

Let us now turn to the other side of the balance sheet, *i. e.*, to the assets of the chestnut, those traits in its life and habits which are of advantage to it in the struggle for existence and the perpetuation of the species.

Of first importance is its rapid and vigorous growth. Among the numerous advantages to be derived from this is the power to close over any chance wounds with new tissue with greater ease than would be the case in a more slowly growing species. And we have already seen how wounds may open the door to disease and decay.

An inherent power for rapid growth also enables the tree to develop roots quickly in times of need, and also, in competition with other species in the forest, to lift its crown above them in order to secure better light. Moreover, in this connection we should recall that the chestnut is fairly "tolerant," *i. e.*, not easily killed out or injured by the shade of older, larger trees.

As regards its soil requirements, we find that, unlike such trees as the tulip or basswood, it is not at all fastidious. Its principal needs seem to be an adequate amount of moisture in the soil, for it appears to be quite sensitive to drought, and also a soil which is fairly deep and loose. As to the chemical nature of the soil it is not particular, except that it rarely grows in a limestone region. Neither need the soil be a fertile one, for chestnut trees grow and thrive on sterile soils, provided they be porous

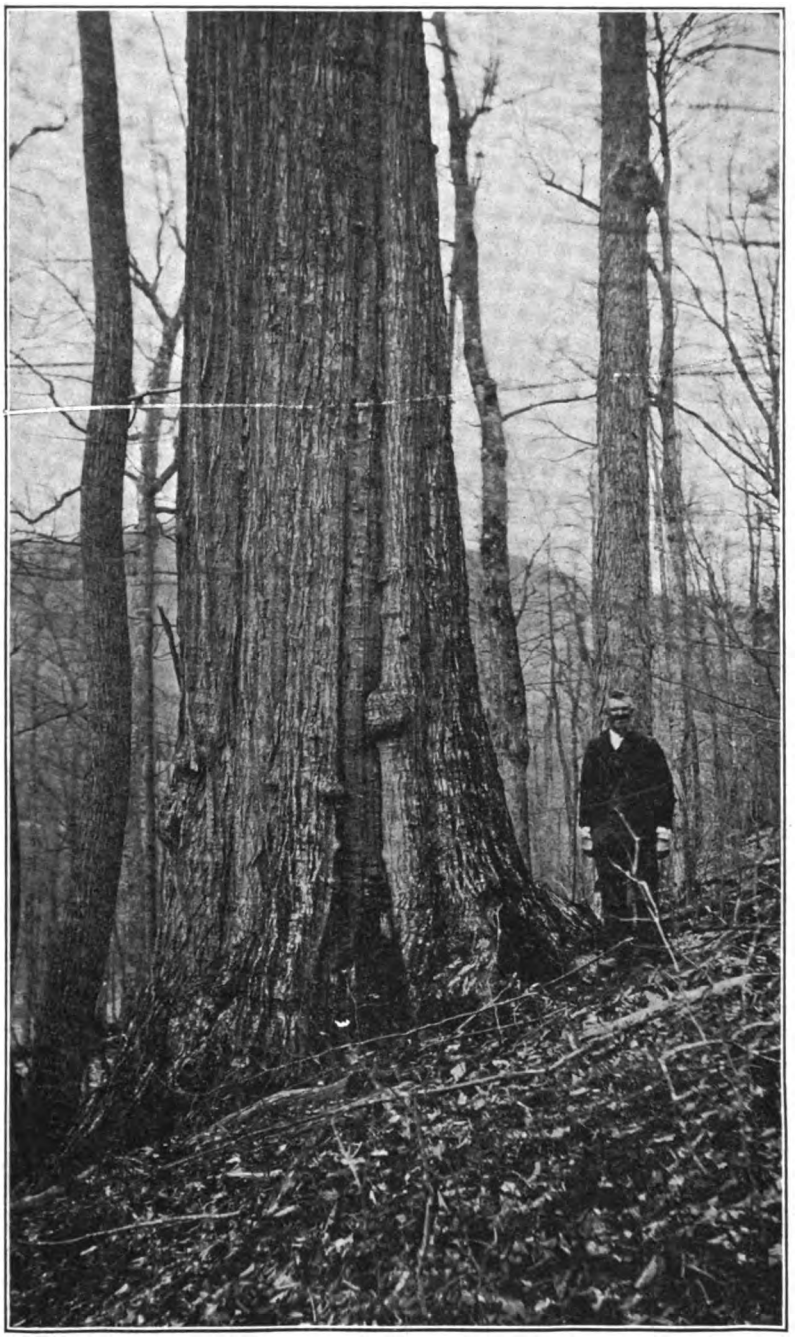

FIG. 3. AMERICAN CHESTNUT, MITCHELL COUNTY, NORTH CAROLINA. Photograph supplied by the United States Forest Service.

and have a sufficient underground supply of moisture. In the matter of soil requirements, therefore, it is easily suited, and it is hardly necessary to add that this is a distinct asset on the side of the perpetuation of the species.

Just as is the case with other organisms in both plant and animal kingdoms, all our tree species possess an average age limit. Some of the individuals of the species live longer, and others die out before the limit is attained, but to every species one might assign an average length of life. This age limit differs, of course, with different species: for example, some of the oaks are notably longer lived than such species as the aspen or the gray birch. Some of the causes of these differences in longevity are obscure, and this is not the place for their discussion. What we wish to point out is that trees as well as animals, vary in their age limits.

Now, a tree, on reaching maturity, begins to reproduce, that is it forms seeds, which, if they find conditions suitable for them, develop into individuals like their parent. I have here in my yard a silver maple, the seed of which I planted in 1904. Two years ago, in 1912, when it was eight years old, and about ten feet high, it bore a few blossoms and seeds. Last year more seeds were produced than the year before, and this year it is loaded with blossoms. Although still a small tree, not yet ten years old, it is arriving at maturity, and is able to reproduce itself. It should continue to do this until the end of its life. Of course under modern city conditions, where, among other disturbing elements, the ubiquitous lawn mower can always be counted on to do its deadly work, it is a question how many, if any, of its descendants will survive. But, nevertheless, here or anywhere, the *chances* of reproducing its kind depend ultimately on the number of seeds it bears, and this number, again, depends directly on the length of its life.

It is clear then that with two species with differing age limits, other things being equal, the species which is longer lived would have the better chance to perpetuate its kind.

When we consider the genus *Castanea,* we find it especially favored in this respect, for it has long been noted for its longevity. The following extract from Sargent's[17] "Silva of North America" is of interest in this connection:

> The Tortworth chestnut tree on the estate of the Earl of Ducie, in Gloucestershire, which is still in a healthy condition, was remarkable for its great size in the reign of Stephen, who ascended the English throne in 1135, and is probably considerably more than a thousand years old. In 1776, the short trunk of this remarkable tree measured fifty feet in circumference at five feet from the ground.

Further on, writing of trees on Mt. Ætna, in Sicily, Sargent says:

[17] Sargent, C. S., *loc. cit.,* 9: 8, 1896.

FIG. 4. CHESTNUT TREE, NEAR THE TRAIL TO BUCK SPRING LODGE, PISGAH FOREST, NORTH CAROLINA. This tree measured eighteen feet in circumference. Photograph supplied by the United States Forest Service.

The trunks of two of these Sicilian trees measured sixty-four and seventy feet in circumference: and at the end of the last century the low trunk of . . . the largest of the trees had a circumference of nearly two hundred feet at the surface of the ground. . . . Trees with trunks from twenty to thirty feet in circumference and believed to be at least a thousand years old, are not uncommon in southern Europe, where the chestnut is the largest, and with the exception perhaps of the olive, the longest lived inhabitant of the forest.

The above quotations apply of course to the European chestnut. In North America large trees of the native species are also not rare (Figs. 3 and 4). Although definite data as to their ages are wanting, they show enough for our purpose, namely, that the American chestnut shares in the family characteristic of extreme longevity enjoyed by its European relative.

I have already spoken of the sprouting capacity of the chestnut, and for various reasons have stated that when coppicing is too long continued it can only result harmfully. On the other hand, the sprout-producing ability *per se* should be reckoned as a distinct advantage to the species. We know that when the lumberman fells such trees as the pine or hemlock he sounds the death knell of that individual. On the contrary, in the case of the chestnut, as we have seen, this is just the operation which leads the way to an increase in the number of individuals, for where one tree existed before, now four or five ultimately develop, sprouting from the stump. This kind of "vegetative" reproduction which, eventually, of course, results in increased seed production, is naturally an important factor in prolonging the life of the species. Zon[18] says of the chestnut in southern Maryland:

> Were it not for its sprouting capacity and its frequent occurrences on slopes difficult to till, chestnut in Maryland would be a species of the past, as white oak and several other species are fast becoming.

There is, possibly, another point which may be in favor of the chestnut tree, although it applies only to the southern representatives of the species. As far as we can judge from reports and surveys, the progress of the chestnut bark disease into the southern states has been slow: at least, it has apparently spread into this territory with no such rapidity as has been remarked in the northern states.

Under the circumstances, it is entirely reasonable to assume that some condition exists in the south unfavorable to the development of the blight fungus. Various explanations have been offered, but none of them is more than a hypothesis, since, as far as I know, no accurate scientific investigation of the case has been made.

Perhaps the most plausible theory is to the effect that the southern chestnut may contain a larger amount of tannin than the northern tree and that this higher content of tannin may be inimical to a vigorous development of the fungus. Whether it is actually a fact, however, that a southern tree contains more tannin than a northern tree of equal age, has not been determined. We know that the tannic acid manufacturers use only southern chestnut for their material, and yet this may be simply because larger trees exist in the south, and we know that the older, larger trees contain more tannin. The actual comparative tannin content of northern and southern trees would form an interesting subject for future investigation. Dr. Clinton,[19] acting on the supposition that some such relation as this might exist, has carried on some interesting experiments with the chestnut blight fungus in culture media containing various percentages of tannic acid. He has found, among other

[18] Zon, *loc. cit.*, p. 13.

[19] Clinton, G. P., *loc. cit.*, pp. 404–407, and pp. 430–434.

things, that while the fungus grew vigorously up to a certain percentage of tannic acid, its development was very sensibly retarded if the percentage was slightly increased beyond this point. If the southern tree actually contains a large amount of tannin we should have here a fundamental barrier to the advance of the chestnut blight fungus, and thus a decided advantage in favor of the southern representatives of the species. However, as I have already intimated, the whole matter is theoretical, since there is entirely insufficient evidence to substantiate it.

If we summarize, then, the points which the American chestnut has to its credit on the asset side of the balance sheet, we find that it exhibits a rapid and vigorous growth, it is fairly tolerant, at least in youth, it is not over particular as regards soil requirements, it enjoys longevity as an inherent characteristic, it reproduces itself by sprouting from the stump, and finally, as regards the trees in the southern section of its range, their supposedly larger content of tannin may prove to be a protective power against the annihilating advances of the bark disease.

This list is impressive—in fact, one could hardly conceive how the species could be more favored, and, indeed, these are undoubtedly the main reasons why it has been so firmly established and abundant throughout its range.

When we review the troubles by which it is assailed on every hand, it is remarkable how many of them are due primarily to man's activities: as, for example, the introduction of the bark disease, continued forest fires, repeated coppicing, change of soil conditions from cutting over large areas, etc. And although through the efforts of a few some of the evils may be checked or diminished, from the complex nature of the case, the deadly work will inevitably continue. One can not avoid the conviction, therefore, that, if the present conditions persist, the virtual extinction of the American chestnut is only a question of time. In the south it is dying out where it once flourished, and in the north its general condition is such that it may soon cease to be classed as an important timber tree. How long it will survive it is of course impossible to predict with any degree of exactness. But at the present rate of decline its future life may possibly be measured in hundreds of years, but not in thousands.

The most hopeful indications for chestnut in North America in the future lie along the line of breeding experiments. Since the blight is our worst enemy, work on the development of varieties immune to this is of the highest value. It has long been known that certain Japanese forms are somewhat resistant to the blight, and the disease is comparatively inconspicuous on the Chinese chestnut, on which it has recently been found.[20] Fortunately work on hybridization of chestnut species had been started long before the blight was discovered in this country. Among

[20] Metcalf, Haven, *loc. cit.*

the investigators in this field, Van Fleet,[21] of the United States Department of Agriculture, crossed Asiatic and European forms with the American chestnuts, the latter consisting of *Castanea dentata,* the forest tree, and *C. pumila,* a shrubby species growing in the southern states. The last species appears, by-the-way, to be somewhat resistant to the blight. Van Fleet says:

> The results of these undertakings have been successful, in the main. The appearance in 1907 among our plantings of the terribly destructive new bark disease organism, *Endothia parasitica,* put a summary termination to the experiments with *C. americana* (*dentata*) and its derivatives, but selection work has since continued with self and chance-pollinated individuals of the chinquapin and Asiatic types. . . . The Asiatic chestnuts, and the chinquapin-Asiatic hybrids, are plainly highly resistant. Few have shown any appearance of infection and when noticeable the injury is quite local in character. Second generation seedlings of chinquapin-crenata crosses show no disease at all although always exposed to infection.

The nuts produced by these chinquapin-Asiatic hybrids are of decidedly superior quality, so that, if they continue free from disease, they will solve the problem from the standpoint of the chestnut orchardist. It is doubtful, however, whether they will ever attain the size of forest trees. But it is quite possible that an immune variety for timber purposes may be produced by crossing a form like the Chinese chestnut, *C. mollissima,* with our native forest tree.

Work of this kind is extremely valuable and, although slow in yielding results, may eventually prove to be the only means of continuing the existence in our land of a greatly esteemed tree.

[21] Van Fleet, Walter, "Chestnut Breeding Experience," *Jour. of Heredity,* 5: 19–25, 1914.