GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT

ON A

BELT OF KENTUCKY TIMBERS,

EXTENDING EAST AND WEST ALONG THE SOUTH-CENTRAL PART OF THE STATE,

FROM COLUMBUS TO POUND GAP.

BY LAFAYETTE H. DEFRIESE.

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INTRODUCTORY LETTER.

NEW YORK, February, 1879.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: I herewith submit a report upon a belt of Kentucky timbers, extending from Columbus, on the Mississippi river, to Pound Gap, on the Virginia line.

The data for the report were obtained on a trip made for that purpose during the summer of 1878. The general plan of the report does not differ materially from that of previous reports; but the great extent of country covered by it, and the particular objects in view in this report, rendered necessary considerable differences in detail. Such of these as are important will appear from the body of the report.

Very respectfully,

LAFAYETTE H. DEFRIESE.

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REPORT ON A BELT OF KENTUCKY TIMBERS, EXTENDING IRREGULARLY EAST AND WEST ALONG THE SOUTH-CENTRAL PART OF THE STATE, FROM COLUMBUS TO POUND GAP.

PRELIMINARY REMARKS.

In each of the several previous reports made on Kentucky timbers, attention has been called to a comparatively limited portion of country; and all the conditions of timber growth, the relative numbers of the different kinds of timbers, the changes that these several kinds of timbers undergo under certain circumstances of time or position, have been inquired into somewhat minutely, and in a detailed manner. Such previous reports have been occupied, therefore, each in its own locality, with minute examinations and discussions of tree life, growth and changes, and there has not been much effort to direct attention to the similarities and dissimilarities shown to exist, by comparison of reports, on widely separated localities. In other words, each previous report has been detailed in character and limited in locality. This report is intended to be exactly the reverse. It deals with a very wide extent of country, and in a more or less general way. Its principal objects are to embrace under one view timber growths existing under the most widely different conditions possible within the State, and to call attention to any marked changes that may be found to accompany such differences of condition, and especially to discuss the effects of height above drainage upon such growths. A better opportunity for the latter purpose could not be had than presents itself to one who passes from the swamps and hilly, rolling country of Western Kentucky onto the level and fertile Blue-

grass Region of the central part of the State, and thence across the high mountains, deep valleys, and wild ravines of the eastern portion. Almost every variety of topographical and geological condition to be found in the State is met with on this journey, and the corresponding effects of such changes upon forest growths can be seen and studied.

It should be borne in mind, however, in reading this report, that my observations were confined to a very narrow belt on either side of the line of travel; and that, while I brought to my assistance facts obtained from elaborate and minute study in various parts of the State, nevertheless I may have erred at times from having been necessarily confined to so narrow a strip of country. Conditions may exist at one point which are exceptional rather than general, and which, a few miles distant, would cease to exist altogether. Erroneous reasonings may thus arise, which could not be avoided under the circumstances; though, in preparing data, great care has been taken to avoid material error.

Another source of possible error in such a report as this, to which attention should be called at the outset, arises in dealing with comparative heights above drainage. In a rapid trip over so great an extent of country it is impossible to keep a stationary barometer to correct the fluctuations of the instruments carried; so that, in many instances, heights had to be more or less estimated. Such a source of error was unfortunate; for a difference of level of a few feet will often make a material difference in the growth of timbers, and interfere with comparative work.

GENERAL REMARKS.

In passing from the extreme southwestern to the extreme southeastern part of Kentucky, almost a complete change in forest growth will be noted. This singular change—a great part of which I cannot account for at all at present—begins first to be noticed, along the belt covered by this report, in Madison county, in that cluster of hills of which "Big Hill" is the centre and the most conspicuous. An exception to

this statement should be made in the case of linden or basswood trees, a few of which skirt Muldraugh's Hill farther to the west. (By Muldraugh's Hill, is here meant the entire range of hills bordering the Bluegrass Region on the south.) About the vicinity of Big Hill the first pines (*P. mitis*) make their appearance. Not a single coniferous tree or bush, with the exception of the swamp cypress and a few small cedars in Northwestern Kentucky, is to be seen in the entire western part of the State.

The pines first appear on the dry Waverly shales, extending down to the foot-hills along the knobs about Big Hill, and are also found on the Conglomerate, capping the tops of the highest knobs in this region. Their entire absence in Western Kentucky, and their presence in Eastern Kentucky, cannot be due to difference of geological formation, for both Waverly and Conglomerate are found in the western part of the State. Nor can it be due merely to the height of the hills and mountains in Eastern Kentucky; for pines are often found here on hills much lower than many in Western Kentucky. In another place, and under its proper head, I shall give what I conceive to be the reason of this peculiar phenomenon in the growth and distribution of the pine in Kentucky. At present, I wish merely to call attention to the marked difference between the forest growths of the western and those of the eastern part of the State.

In passing from the west to the east, the first hemlock trees (*Abies Canadensis*) were found by Professor Shaler in a Devonian shale ravine, about five miles north of Irvine, in Estill county. In a previous report on the timbers of the North Cumberland (Bell and Harlan counties), I called attention to the fact that, in that part of the State, hemlock appeared only on coal-measure formations, and was confined almost entirely to the Conglomerate. The finding of hemlock on Devonian shale, in Estill county, shows that in Kentucky, as in other States, that tree is not confined to particular formations. It should be said, however, that very little hemlock was found on this journey elsewhere than on coal-measures.

The magnolias are likewise first met with not far from Irvine, and between that place and Beattyville, while the American laurels (Rhododendron and Kalmia) are not found until the rockier mountains and wilder ravines farther east and south are reached. The same may also be said of the Amelanchiers and some other smaller shrubs. Thus, within comparatively few miles, and without any *apparent* topographical or geological reason for it, the whole character of the forest growth changes; and while the oaks and hickories of the west remain, there are added to them lindens, pines, laurels, and magnolias—stately and beautiful trees of the east alone. I say, without any *apparent* topographical reason, because these timbers are found alike on the mountains and in the valleys of Eastern Kentucky, while in Western Kentucky they do not appear, even on the highest hills. The same geological conditions can be found in the western part of the State as those on which these timbers grow in the east; so that the only point of difference which suggests itself, is in the higher mountains and hills of the east. It may be, therefore, with some of these timbers, that a wild and mountainous country is a necessary condition precedent to their introduction, and that their subsequent spread over the lower hills and valleys is a matter of course; but this is a subject which would require a great deal of preliminary investigation, before an opinion upon it could be safely hazarded.

Nothing is more certain to attract the attention of students of forestry in Kentucky, than the contrast met with in passing from the splendid woodlands of Muldraugh's Hill onto the Cincinnati limestone of the Bluegrass Region, near Danville. Especially is this contrast striking in Garrard county, which, though one of the finest and richest in the State, is nevertheless, with the exception of a few fenced-up groves, a treeless waste, devoid alike of water and forests. Coursing across it here and there can still be traced the dried-up beds of numerous streams, in which, within the memory of citizens living along them, water continuously flowed. Inasmuch as the Cincinnati limestone is an exceedingly waterless formation, or one

the surface of which is not adapted to the holding and flowing of water, I should have been in doubt whether to attribute the dry character of the country to the destruction of the timber or to the formation, had I not been told that water once flowed the year round through the now parched stream-beds. All that can be said is, that the people owe their present dearth to their past thoughtlessness; and the reckless destruction of forests now going on throughout the State portends an even greater calamity before there is a turn for the better. An able investigator of this subject well says: "Since 1835, the forest area of the western hemisphere has decreased at the yearly average rate of 7,600,000 acres, or about 11,000 square miles, and this rate in the United States alone has advanced from 1,600 square miles in 1835 to 7,000 in 1855, and 8,400 in 1876, while the last two years have been scarcely less exhaustive. Statistics for eighty years previous to 1835 show that we have been wasting the supply of moisture to American soil at the average rate of seven per cent. for each quarter of a century during the last one hundred and twenty-five years, and that we are now approaching the limit beyond which any further decrease will materially influence the climate of the entire continent. Many eastern regions, such as Afghanistan, Persia, India, and Asia Minor, once possessed of a fine climate and abundant harvests, are now often scourged by pestilence and famine; and it is altogether probable that their misfortunes began with the disappearance of their native forests. It is quite likely that we shall suffer in climate, fertility, and health before a great while, if we continue to destroy our trees as recklessly as we have done, and it behooves us to be warned in time. * * * For one hundred and fifty years we have been felling the forest; for the next one hundred and fifty we should try to restore what we have taken away."

In previous reports attention has been called to the fact that certain timbers, especially white oaks, do not seem to return again to forests from which they have once been driven by such an agency as fire. It has also been men-

tioned, that the formations best adapted to the growth of chestnut timber are the Conglomerate and Chester sandstones. On soils from these formations chestnut is normally found in the greatest abundance, and growing to the greatest perfection. In passing from Western to Eastern Kentucky, my attention was therefore attracted to the fact that when the Big Clifty (Chester) sandstone first appeared, which was in the neighborhood of Hopkinsville and on Pilot Knob, no chestnut appeared with it. Moreover, the white oak and liriodendron, away from the streams, seemed scrubby and scarce. Otherwise the forest was normal, and I searched in vain for any clue to the absence of these timbers. I finally came to the conclusion that, long ago, the entire country through here, reaching probably as far west as the Cumberland river, had been laid waste by fires, and had been barrens similar to those still remaining in the Purchase, and further east in Barren and other counties.

Mr. Irvine Kennedy, who has lived in this part of Kentucky for sixty-eight years, and who now resides near Elkton, informed me that my conjecture was correct, and that he could remember when all these heavy forests were a uniform growth of young trees, with not an old tree standing, except on streams too large for fires to sweep through their swamps.

I was afterward informed that some chestnut groves exist not far from Elkton, though I did not see a tree. It is possible that they stand in a piece of woods for some reason protected from the ravages of fires. Without special investigation made for that purpose, it is impossible to arrive at anything near the extent of Kentucky forests which represent, not the original growths of the State, but a kind of second growth, sprung haphazard from the burial-place of the primeval forests.

In a previous report on the timbers of the Purchase District (see Report, volume V, this series), attention was called to the remarkable absence of chestnut from that part of Kentucky, although the formation is a mill-stone grit waste, on

which chestnut should be found. A closer examination of the timbers surrounding the present barrens of the Purchase shows that there is very little white oak among them, except along streams and on low grounds. My present opinion is —subject, of course, to correction upon closer study—that the high grounds of almost the entire Purchase, from Tennessee river on the east to the Mississippi on the west, have been swept by fires and denuded of their timbers, and that the only difference between the other forests of this part of Kentucky and the present barrens is one of age. Both are second growths, and in both cases the primitive forests have been swept away by long-continued fires. In this report I give my reasons for believing that in former times the barrens have extended east beyond the Cumberland river, at least as far as Hopkinsville, if not, with local exceptions, to the waters of Big Barren river, leaving the narrow strip between the Tennessee and Cumberland rivers alone unswept by fires. Big Barren river is *probably* the eastern limit, in this locality, of the ancient barrens, part of which are still to be seen along it. The location of the northern limit of these ancient barrens is worthy of special investigation, if the view here advanced be correct, for they have certainly never extended to the Ohio river. Further on in this report I have called attention to certain chestnuts, evidently dropped by passers-by, having sprung up in the Purchase, near Clark river, and died. In this connection, an interesting question presents itself, and that is, whether chestnut and white oak will grow again in a forest once *thoroughly* burnt out, even if planted. If not, it may be that the barrens were never burnt over so long as to kill the roots and seeds of existing timbers, but only long enough to destroy the chestnut, white oak, &c., which would not grow again on the burnt-over grounds. The whole subject is one of the deepest interest, and should be thoroughly investigated.

REMARKS ON SPECIAL LOCALITIES.

There are some peculiarities connected with timber growth in certain localities which are worthy of mention. For in-

stance, speaking broadly and generally, timbers are far better on the north sides of hills than on the south sides. This is doubtless due to the north side of a hill being shadier and damper than the south side, which is exposed directly to the drying heat of the sun. There are some exceptions to the statement that the finest forests grow on the north side of the hill. When the hill is very high, the observation made in the report on the timbers of the North Cumberland, that white oak flourishes best on the south side of the hill, is true. It is also true, even to a greater extent, of pines. If the hill be *low*, the best white oak, as will be noticed further on, like other timbers except pine, grows on the north side; if it be high enough to affect much the temperature of the north side, the white oak is found on the *warm* side; and where white oak is found on the north side of a high hill, it is found right at the base, where it is sheltered, or right on *top*, where the sun reaches it. In the case of the pines, it may be that the method of their distribution, of which I shall speak further on, has something to do with their confinement largely to the southern slopes of hills; but that cannot fully account for the fact, and it must be that the pines of Kentucky are not hardy, and seek the southern sides of mountains for warmth and sunlight.

Again, it would be natural to suppose, inasmuch as there are several belts of distinct timbers on each large hill, each belt composed of those timbers adapted to its height above drainage, that the various species of timbers would shade off gradually in ascending a hill; for instance, that the best white oak would be found at the base of the hill, that that a little higher up would be not quite so good, and that the quality would gradually grow poorer, until the white oak ceased altogether. To my astonishment, this did not seem to be a rule. That is, in descending a hill, the very first trees of a particular species are often as fine as any others found on the hill, unless want of richness of soil prevented. The observation certainly holds good with the beeches, hemlocks, and other timbers with which moisture of soil is the controlling requisite

of growth. They remain of the finest quality till they cease altogether, and their line of growth often forms a sharp and well-defined band around the hill.

As would naturally be expected, the timbers characteristic of a mountain top are not found directly on top of the mountain, but a few feet below the top, on the brow. The reason is, that on the level top there is usually a considerable depth of detritus and decayed vegetable matter, more or less moist, which gives to the timbers somewhat the characteristics of lowland timbers.

SPECIAL TIMBERS.

Reference has already been made to the peculiar, and, in many respects, remarkable distribution of pines in Kentucky. They are not found further west, in the timber belt here spoken of, than the Big Hill region, in Madison and Garrard counties; and the same counties are almost the northern limit of pine growth likewise, though scattering ones may be found on Muldraugh's Hill, still farther north. The pines met with are principally of the *P. mitis* or yellow species, though considerable numbers of *P. rigida* or pitch pine, *P. strobus* or white pine, and *P. taeda* or loblolly pine, are also met with. The question presented by this pine growth is, why is it limited so absolutely and arbitrarily to the southeastern part of the State? Is the reason to be found in the geological formation of that part of the State, or in its topographical nature, or in some problem connected with the original appearance of the pines in the Kentucky forests? As I have already said, the reason cannot be a geological one, for the exact geological counterpart of this section of the State can be found in Western Kentucky, where there are absolutely no pines. The true cause must then be sought in the other two alternatives—topographical nature of the country and method of original appearance and distribution—and I think that these two causes supplemented each other in producing the present peculiarities of pine growth. In order to fully comprehend the matter, let these facts be kept in mind:

1. The pines of Kentucky (hemlock is excepted for the present, and will be spoken of later) require a very dry soil, and for this reason are confined to the rock ledges of the high mountain tops, or to the dry shales of the lower levels. For this reason *pines cannot be distributed by the carrying power of water*, as in that case the seeds would be deposited in low, wet places, where growth would not take place.

2. In a general way, pines gradually increase in numbers from where they are first met with on the north to the southern border of the State, and from where they are first met with in the west to the eastern part of the State. This statement is subject to some modification on account of variations in height of the hills in this part of Kentucky, to be explained presently.

3. Pines are distributed over slopes of hills and mountains facing south and southeast.

A little reflection will show that only one hypothesis will satisfactorily explain all these peculiar facts in relation to the present growth and distribution of the pine; and that is, that the pine forests of Kentucky were introduced at a comparatively late date, and spread, from the vast pine forest and mountain growths of North Carolina, to the south and southeast of this section. Inasmuch as they could not have been distributed by water, for the reason already given, we must look to the wind as the motor power in their distribution. I was informed by all the citizens questioned on the subject that the prevailing winds in Kentucky are *from* the south and west. Of course, it is apparent at once that the pine seeds are carried north from North Carolina by the prevailing southern winds, while the western winds are almost a perfect barrier to confine them to the eastern part of the State. The trees work westward very slowly against the prevailing winds; and when the wind does blow from the east, it is liable to be accompanied by rain, which would destroy its power to carry the seeds to any great distance. If the pine seeds were carried by the winds from the south, of course they would be lodged on the south sides of the hills and mountains, and the pines

would naturally be first found there. I do not say that this is the *reason* why they are found on the south, and not found on the north sides of the mountains, for they would, if conditions were suitable, soon work over from one side to the other. I merely say that, given the conditions here present, the pines would certainly be first found on the south sides of mountains.

It must be said that there are some tolerably strong arguments against the view I have here advanced as to the distribution of the pines, and one of these is, that in the very section of Kentucky where the pines are found, they are by no means uniformly distributed, and oftentimes miles of low hills will intervene without a single pine, and a comparatively solitary high hill will have several on its summit. I can only suggest, in explanation of this, that the high hill-tops are the ones which would most catch the wind-carried seeds, and that, should they be dropped on the low intervening hills, they would probably not grow, unless the formation happened to be one of the dry shales. As I have previously said, my observations go to show that the pines in this part of the State (as also in the Pine Mountains further southwest) grow only on high hill or mountain tops, or else on dry shales, like the Devonian or some of the Waverly shales.

Inasmuch as the hemlock is always found within comparatively few feet, in barometric height, above *local* drainage, and is therefore usually in the hollows and ravines, rather than on the hills, we must look to the water for its distribution. Such seeds as the wind might pick up and lodge on mountain peaks certainly would not grow. To appreciate the peculiar distribution of hemlock, its characteristics must be understood. These I have studied minutely, so far as their growth in Kentucky is concerned, and am convinced—

1. That they do not grow, on the *average*, at a greater height than fifty feet above the local drainage.

2. That, nevertheless they require a *very* dry soil, the more rocky and precipitous, usually, the better. These two conditions can be satisfied only by small mountain streams,

which have a very limited extent of bottom land (hemlock will not grow on bottom land at all), and where the surrounding hills come down to the water edge, forming more or less ravines and precipices. The consequence is, that while the head-waters of the Kentucky river on the one hand, and of the Cumberland on the other, penetrate into the very heart of the hemlock region, and are the mountain streams along which this timber grows to the greatest perfection, yet the Kentucky river does not carry it far northward, nor the Cumberland river far westward. The seeds will be carried downward and deposited by these streams, and will take root and grow, just so long as the above conditions are complied with; but, whenever the streams become large enough to have a belt of bottom lands along them, the possibility of a further spread of the hemlock ceases in Kentucky. The conditions of growth of that timber may be different elsewhere.

It is worth while, in speaking of special timbers, to call attention to a somewhat remarkable forest of beeches, which occupies a belt of country eight or ten miles wide, beginning about three miles from Greensburg, and extending to within about the same distance of Campbellsville, and lying in Green and Taylor counties. The extent of the belt in other directions I could not determine. In this belt, beeches form the forest timbers to the almost entire exclusion of other growths. They not only occupy the valleys, but extend to the tops of the highest hills. The reason is to be found in the formation, which is a reddish, very much decayed St. Louis chert, out of the very top of which the water oozes, and which is therefore always wet. Inasmuch as height above drainage is the principal determinant of beech growth, it is natural that these hills should be covered with such a heavy forest of that timber.

As to the distribution of the magnolias, the so-called American laurels (rhododendron and kalmia), and the linden trees, I confess that I see no reason why they should be confined to the eastern part of Kentucky, unless it be the purely topographical one, that high mountains and deep and ragged

ravines are necessary conditions of their introduction and growth. On the other hand, all these timbers grow and flourish on ground in this part of the State, which has less of those very characteristics than grounds further west, on which they do not grow at all. So far as I can see, the only difference is, that there are high mountains in Southeastern Kentucky, and there are no high mountains in Western Kentucky. The subject of the growth and distribution of these timbers is full of interest, and should be investigated.

I should speak, also, before leaving this head, of the oaks in Kentucky and the West generally. So far as their classification is concerned, they are in a very unsatisfactory condition; and in dealing with them, our botanies are practically worthless. In all of them, the best of which are those of Gray, Wood, and Chapman, the basis of distinction is their leaf or fruit. About the former, a great deal of space is occupied discussing distinctions which do not exist at all; for the leaves of the oaks, with a few marked exceptions given below, shade into one another in such a way that it is impossible to distinguish the trees in that way. It is nearly as bad with the fruit, with the additional inconvenience that it is only for a short portion of the year that such a distinction is available at all. I am convinced that the only characteristic suitable for a basis of classification in forestry, is the bark, and that seems to have been studiously ignored by our best authorities. For my own part, while I desire to be very conservative in speaking on a subject which requires much labor and study, the more attention I devote to the oaks, the more I am inclined to believe that there is no foundation in fact for more than seven oaks in this part of the United States, viz.: white oak, black oak, red oak, Spanish oak, post oak, laurel oak, and chestnut oak. There is exceedingly small basis for a distinction between the red oak and black oak, and I question if they merit the dignity of separate species. All of the many species of our oaks, beyond these six or seven, rest, I believe, upon illusory distinctions, and can be traced through all gradations into one of the seven divisions here given. Of

course, in the following pages, the usual botanical classifications have been made, as a matter of convenience.

There is an oak found near streams, and in rich woods and glens in Kentucky, which cannot be classed, according to the distinctions now in use, as a variety of red oak, nor as a dwarf oak, nor as a *Quercus lyrata.* It resembles *Q. macrocarpa* more than any other oak, perhaps, except that the leaves are not downy or tomentose beneath; but, on the contrary, are a dark, rich, smooth green, and are shining like the leaves of *Q. lyrata.* I have called it *rich red oak*, and have classified it as *macrocarpa.*

There is another oak, called by the people chinquapin oak, and which I have classed as *Q. prinoides*, on account of its very great resemblance to chinquapin oak, but which often grows fifty feet high in the mountains of Kentucky. There is also in the mountains a low, rich green oak, the bark of which is darkish to whitish gray, with long, straight, shallow furrows at the base of the tree, growing more deep and chipped up the stem; branches smooth, gray, with brownish rough spots or dots; acorn broader than long, dorsally compressed, and one fourth buried in a brittle, scaly, flat cup. The leaf lobes are 7, 9, 11 in number, and are awned. The little tree is very rich in fruit. I have called it *Q. ilicifolia*, on account of its great resemblance to that species, though it differs from it in some respects.

TIMBER IN DETAIL.

A mere running sketch of the Purchase country and its timbers will be given here, because a special report on the timbers of this section has been prepared and published, to which the reader is referred for more detailed information. (See Report on Purchase Timbers, volume V, this series.)

In going eastward from Columbus, on the Mississippi, no timbers worthy of special mention are met with for some miles. The old forests have been cut away. About one and one quarter miles out the country is rolling, the soil white-sandy and damp, with large white oak and liriodendron

in low places, as well as black ash, black gum, sweet gum, black and red oak, pawpaw, black sumach, and redbud. Undergrowth is chiefly black oak and red oak. These timbers vary little until Bole's Creek is reached, about three miles from Columbus. On the creek are found sycamore, red elm, liriodendron, white oak, black and honey locust, sweet gum, white walnut, small black walnut, and considerable sugar maple and black ash.

Five miles out from Columbus, toward Mayfield, the forests grow heavier and more valuable, white oak forming a considerable percentage of the timbers (as much as fifty per cent. in low places), liriodendron about twelve per cent., the remainder being composed of black and pig hickory, red oak, black oak, some scarlet oak, white and red elm, sweet and black gum, and sycamore. The country is rolling, with long, damp, white-sandy levels.

About five and three quarter miles out the first swamp laurel oak, the first white maple, and the first winged elm of any size are found. On Elsey Branch, a mile further on, shag hickory and pin oak first appear—the latter very large and fine. The other timbers remain as above noted, with occasionally a fine black ash.

Eight and one half miles from Columbus one prickly ash occurs. The timbers otherwise remain without change until North Fork of Obion river is reached, eleven miles out. There the first swamp chestnut oak appears. Spanish oak also begins to grow very prominent in these forests, and to form more than one half of the upland oaks. The first post oak seen appears between North Fork of Obion river and Milburn.

Four miles beyond Milburn, toward Mayfield, the Purchase pebbles come to the surface, and a thin, dry soil, covered with post oak, scrubby black oak, &c., is the result. These pebbles are the waste of the decayed mill-stone grit, and are found in every part of the Purchase at a greater or less depth below the surface. Upon it white oak is not found; but while, as a formation, it is very dry, it brings the streams

to the surface, and along them in this locality grow the first red or water birch met with. About seven miles from Milburn, on these surface streams, pin oak is found in the greatest abundance, while post oak and black-jack crown the low, gravelly hills. An occasional spotted birch is found along the foot-hills, and considerable willow along the branches.

About eight miles from Milburn, and midway between there and Mayfield, the present "barrens" of the Purchase are entered. For a discussion of them, see the report on the Purchase timbers previously alluded to. While some of the views and the limits there expressed have been modified by later study, that is not true of the *cause* of the original barrens there given. The boundary of the present barrens, between Mayfield and Cadiz, seems to be, in this locality, Mayfield Creek; but this is not true further south, between Mayfield and Murray. I have already given reasons for believing that all the upland of the Purchase has, in former times, consisted of barrens.

On Mayfield Creek splendid cypress trees are found, associated with liriodendron, red birch, white and red elm, sweet gum, sycamore, black ash, pin oak, white oak, black gum, black hickory, &c., while in the upland forests beyond, toward Cadiz, post oak, scarlet oak, black oak, and black-jack are the principal timbers. On Panther Creek the timbers common to Mayfield Creek, with the exception of cypress, are again found. There is a marked absence also of sweet gum, for which I could assign no cause. On the hills through here grow white oak (at bases), red oak, black oak, and Spanish oak (about midway), and scarlet oak, post oak, scrub shag hickory, and black-jack (on top). The hickory here spoken of is a mountain variety of *Carya sulcata*. [The distribution of the timbers, as affected by height above drainage, will be illustrated by tables and discussed further on in this report.]

Before reaching the West Fork of Clark river, I found two chestnut bushes, about six inches in diameter, which had evidently sprung up from chestnuts dropped by passers-by. They had grown up to this size, and both had died, without

any apparent cause, except that the formation, in its *present condition*, is not adapted to chestnut growth. This matter has been previously discussed.

The timbers on West Fork of Clark river have been spoken of especially in a previous report, and do not need mention here. After passing the river the barrens continue, without interruption, except on small streams, until Wadesboro is reached and passed. The shrub spirea is found near Wadesboro. On nearing East Fork of Clark river, about one mile beyond Wadesboro, considerable good timber is found, consisting of white oak, liriodendron, white ash, black and pig hickory, Spanish, scarlet, black, and post oak, dogwood, persimmon, pawpaw, black sumach, spotted birch, sassafras, &c. On Clark river the usual swamp timbers appear in vast forests, and of the finest proportions. Sweet gum, black gum, shag and white hickory, white oak and liriodendron are especially fine.

After crossing Clark river, white oak is tolerably abundant, often extending to the hill-tops. This would seem to indicate that a *part* of the strip of country between West Fork of Clark river and Tennessee river, as well as the strip previously mentioned, between the Tennessee and Cumberland rivers, was never swept by fires to the same extent as those parts of the Purchase west of this fork of Clark river. This inference is still further strengthened by the existence of considerable chestnut all through here. It may be that the fires from the west did not penetrate across West Fork of Clark river, while those from the east found a western barrier in the Cumberland river. A fact to be mentioned presently, however, throws some doubt upon this, and leads me to believe that, at times, the fires swept across both of these streams.

About one mile from the Tennessee river we strike the *Protean* or the *Silicious group* of rocks, without any marked change in the timbers. In the Tennessee river bottom are found splendid groves of cypress, from three to seven and one half feet in diameter, nearly always standing in marshy places, in a few inches of water, with their knees reaching

up into the air. The bark on the point of these knees is always very thin. In the Tennessee bottom, in addition to the Clark river timbers, are hackberry and box-elder.

After crossing Tennessee river, there is considerable chestnut in spots, and white oak abounds on low grounds, where it does not seem that there would be much protection in case of continuous sweeping fires. Inasmuch as this white oak and chestnut are found all through between the Tennessee and Cumberland rivers, it seems very probable that the Cumberland river was a fire barrier on the east. It should be said, however, that the white oak between the rivers on upland soil is very unhealthy, and appears to be rapidly dying out, a very large proportion of the trees being already dead. The same is true of some white oaks that appear in protected spots after crossing Cumberland river. If it be true that occasional fires have crossed over and gotten between the rivers, not enough to kill out the white oak, but enough to affect the soil in such a way that white oak will not flourish on it, this decay becomes one of exceeding great interest and importance. For, in that case, the burning off of Black Mountains, now taking place regularly, will soon drive from the forests one of the finest bodies of white oak timber in the world, whether the burning be carried to sufficient extent to injure the other timbers or not.

In Trigg county, between the rivers, the first iron-wood (hop hornbeam) and the first chestnut oak are met with. A change of level, of comparatively few feet, here, is sufficient to completely change the character of the timber. Along the branches, the white oak, white hickory, shag hickory, and red oak are good, and there is considerable elm and some liriodendron, beside the usual small growth. Red birch, sycamore, laurel oak, and white oak appear in plenty on Gilbert's creek, about one and one half miles from Cumberland river.

On Cumberland river grow the most beautiful cotton trees I ever saw, reaching a diameter of four feet and a height of eighty. Sycamore, black ash, sweet gum, swamp red oak (the *macrocarpa* of Wood), swamp chestnut oak, and splendid

hickories abound, with the other swamp timbers previously noted. No chestnut is to be seen after crossing Cumberland river, and the usual upland and lowland timbers are met with in succession, without any change worthy of note, for some miles. Little River flows, at the point crossed here, over a bed of St. Louis limestone, and has scarcely any bottom or swamp soil proper, and, consequently, no swamp timbers.

After leaving Little River, the country is high, dry, and only slightly rolling, for three or four miles. The timbers are poor and valueless, with the exception of some black cherries and one hackberry found on this high level.

About six and one half miles from Cadiz, toward Hopkinsville, in a slight depression, pin oak, white hickory, black and sweet gum, sycamore, some black ash and honey locust, are to be noted. Not a white oak is to be found. The high, dry, nearly level stretch spoken of above lasts, with no surface water, until Hopkinsville is reached. There is nothing worthy of note in the timbers, except that upland and swamp laurel oak are plenty.

After passing Hopkinsville, we begin to leave the St. Louis limestone, and approach the Chester sandstone, which already caps the highest hills. Some of the timbers normally found upon it, though, are absent. The introduction of red oak, forming the larger part of the forest growth, is a marked feature in passing onto the calcareous limestone and lower Chester from the St. Louis limestone. Scarlet oaks crown the hill tops, and post oaks are found in depressions, or largely on the hill-sides *below* the Chester. The latter feature is local, however, as on a high hill, about five miles from Hopkinsville, post oaks extend up onto the Chester. The blackjack, however, is clustered around the hills just at the base of the Chester, and this I noticed to be generally true. Sugar maple, bartram oak, swamp chestnut oak, white elm, and black ash are found in considerable quantities along the streams.

For six or eight miles beyond Hopkinsville, toward Fairview, the timbers change little in kind or quality from those

just noted, except that some red haw and winged elm are found. There is no white oak, no sweet gum, no chestnut (that I could find), and no liriodendron. On Pilot Rock, northeast of Hopkinsville, which is a lofty bluff of Big Clifty sandstone, cedar and liriodendron are both met with; but this is very local, and even here no chestnut is to be seen, so far as I could gather.

Between Fairview and Elkton the timbers, as a whole, are not valuable; but in places black ash, white elm, pig and shag hickory, and such timbers, are exceedingly fine. Especially is this true on West Fork of Red river, about one and one half miles from Fairview. On this stream are also found splendid white oak, swamp chestnut oak, red and pin oak, white and shag hickory, black and blue ash, sweet gum, liriodendron, white elm, sycamore, box-elder, sugar maple, white maple, and redbud. All of these timbers are very fine. It is a peculiar, though an easily-explained fact, that in a large part of the country through here the timbers are better on the hill-tops than on the lower grounds. The reason is, that the hills are capped with Chester sandstone, the detritus of which forms a damp soil, favorable for large trees, while the upper St. Louis limestone here is not adapted to timber growth.

Toward Elkton, scattering bartram oaks and cedars are found, in addition to the usual red oak, shag hickory, pig hickory, white hickory, winged elm, small black ash, scrub white oak (in spots), Spanish oak, black oak, post oak, black gum, &c. Yellow wood is also found near Elkton, with some honey locust, redbud, and red (slippery) elm. Of course the swamp timbers have never been affected by fire; and on streams fine white oak, liriodendron, white and sugar maples, sweet gum, laurel oaks, &c., flourish. The upland and low-land timbers alternate, with no changes worthy of note, until Russellville is reached—and there our party took the train and went by rail to Glasgow Junction.

Between Glasgow Junction and Mammoth Cave the topography is very different from that spoken of in the previous pages. There is no well-defined succession of hills and hol-

lows, the result of erosion, through the latter of which the streams of the country flow. The formation is a cavernous Saint Louis limestone, the roofs of whose caverns have given way in many places and let the surface of the ground fall in, forming regular sink-holes, more or less circular in form, often of the dimensions of wide and deep hollows, but with no outlets. There are no surface streams, and into these sink-holes the surface water flows, and the detritus washes and accumulates. It is natural to expect in such places the most splendid timbers, and such are often found there.

Again, forest fires have evidently not denuded certain parts of the country in the neighborhood of Mammoth Cave. What is known as Doyle's Valley, for instance, has been, for some reason, largely protected from the ravages of fire, even if the entire district has not been. From the growth of chestnut, I am inclined to think that it has never been continuously burned over.

On leaving Glasgow Junction, toward Mammoth Cave, plenty of white oak is found in the sinks; post oak, black oak, scarlet oak, and red oak are found on the higher grounds, and as soon as Chester sandstone, which caps the so-called hills, is reached, chestnut is found in great abundance. This is the first chestnut worthy of note found, and all that has been found, so far, if a few bushes on the silicious limestone, near Tennessee river, be excepted; though doubtless all this Chester sandstone, from Hopkinsville to Glasgow Junction, would have been covered with it, but for the fires that long ago swept over this richly timbered country, year after year, and drove its choicest trees from the forests.

On the hill sides facing Doyle's Valley the trees are magnificent, and white oak, liriodendron, white hickory, massive chestnut, scarlet oak, red oak, black oak, Spanish oak, chestnut, ashes, redbud, &c., abound. The chestnut, however, is limited to the sandstone, and stops abruptly when the limestone is reached in descending the hill.

On nearing Mammoth Cave, and all along the banks and cliffs of Green river, hornbeam (*Carpinus Americana*, often called iron-wood, but not the true iron-wood) and hop horn-

beam (true iron-wood) abound. On the long, high level above the cave the principal timbers are red, black, and Spanish oak. They are worthless except for fire-wood.

In the immediate vicinity of Mammoth Cave, and crowning the hill-side facing Green river, above and below it, the timbers are red oak, liriodendron, chestnut (on sandstone or its detritus), white hickory, white oak, black walnut, blue ash, an occasional sugar and rock maple, winged elm, &c. At the base of the hill, on Green river, are beeches, sycamores, spice-wood (the first met with), white hickory, liriodendron, and white oak. Black sumach, woodland huckleberry, buckeye, dogwood, &c., are among the small growths.

About two miles from Mammoth Cave, toward Cave City, the hill-tops are poor, and are covered with Spanish oak, scarlet oak, black-jack, and an occasional mountain oak. In the sink-holes and on their steep sides grow splendid chestnut, pig and white hickory, liriodendron, some white oak, post oak, and black locust. The chestnut is found only on the sandstone. These upland and lowland timbers alternate, without any changes worthy of note, except occasional swamp chestnut oaks, Bartram oaks, laurel oaks, and black hickory, until we begin to pass into the present eastern barrens, about twelve miles from Cave City, and within about eighteen miles of Greensburg. White oak and chestnut cease to exist, except the former on streams, &c., and a repetition of the barren timbers of the Purchase occurs. There seems to be a neck of country about Mammoth Cave which has, for some reason, more or less escaped the ravages of fires.

Nothing else of interest occurs until we begin to pass from the cavernous St. Louis limestone onto the Keokuk limestone, sixteen or eighteen miles from Cave City. The change of formation first attracts attention by the circular sinks beginning to fade away into valleys, and the steep cave-hills into the more gently-rolling ones, due to erosion. The normal hill and valley topography gradually succeeds again the wonderful cavernous district, of which Mammoth Cave is the most widely known, if not the most interesting and instructive part.

The Keokuk is an exceedingly fertile formation, and its timbers are nearly always, on the limestone, of the finest. Its soils are rich in marls, it furnishes a good supply of surface water, and has all the requisites for the production of splendid forests. Timbers, therefore, grow better and more valuable at once on passing onto the Keokuk; but white oak, chestnut, and most of the liriodendron, have been driven from the forests in this locality by fire. With these exceptions, the hill-side facing Little Barren river on the west furnishes a good sample of the timbers that grow on the Keokuk limestone. They are black cherry, black locust, swamp chestnut oak, black walnut, some liriodendron, white and shag hickory, sycamore, mulberry, blue ash, red elm, white maple, redbud, water beech, hackberry, and cedar. On the same formation, immediately after crossing Little Barren river, plenty of chestnut and white oak are found, with scarlet oak, black oak, pig hickory, and sugar maple, in addition to the timbers just mentioned above; and all through the hills white oak, chestnut, and liriodendron become exceedingly fine and valuable. This points to the probability that Little Barren river was the eastern barrier to the ancient fires.

On nearing Green river, about five and one half miles from Greensburg, the forests are magnificent. They consist of large liriodendron, white oak, shag hickory, white hickory, black walnut, beeches, swamp (rich) red oak, hackberry, honey locust, red elm, box-elder, blue ash, sugar maple, water beech, and swamp chestnut oak. In the swamp, in addition to these, are black locust, big buckeye, and black ash.

After crossing Green river, we ascend again onto a somewhat sharply-rolling country, whose bed rock is very much decayed St. Louis chert, and whose timbers, for several miles, are nearly altogether beeches. This peculiar beech growth, occupying alike the highest hills and the lowest grounds, has already been spoken of.

About five and one half miles from Greensburg, toward Campbellsville, the beeches begin to give way to black oak, red oak, liriodendron, chestnut, pig and black hickory, swamp

chestnut oak, white oak, blue ash, &c.; and within about three miles of Campbellsville white oak forms as much as fifty per cent. of the splendid forests. Scattered through the woods are also found white walnut, tree of Paradise, fine black walnut, black cherry, iron-wood, shrub buckeye, big buckeye, red-bud, sassafras, dogwood, red oak, Spanish oak, scarlet oak, chestnut, red haw, black sumach, and pith elder. The entire absence of sweet gum, even from the swamps, all through the country, from the Cumberland river eastward, will have been noticed. I could find no satisfactory reason for it.

A long, dry shale level, covered principally with black, Spanish, and scarlet oak and black hickory, begins within about nine miles of Mansville (Buena Vista). Occasionally the shale is cut across by small streams, and in the depressions white oak, laurel oak, water beech, winged elm, spotted birch, and some chestnut are found. In some of these depressions, where the shale is always moist, the forests are very heavy, and white oak, chestnut, liriodendron, pig and white hickory, black and Spanish oak, &c., abound. About three miles from Mansville, post oak and sweet gum are met with again.

At Mansville, on Robinson's Creek, we pass onto Devonian shale, and the timbers become nearly worthless, except on streams where the usual lowland timbers are found.

About three miles beyond Mansville, toward Stanford, there is a small belt of country, less than half mile in breadth, on which thirty per cent. of the undergrowth is white oak. I have seen only two or three other spots in the State where any considerable proportion of the bushes consists of that timber. The tops of the hills in this locality are covered with post oak, scrub black oak, huckleberry, &c.; and the first mountain chestnut oak seen east of the Cumberland river is here found. Pith elder and black sumach inhabit the fence-rows, with occasionally a shrub buckeye, some bushes of winged elm, &c. The hills, in a wholly Devonian shale formation, are always low, and their timber growth is comparatively worthless, such as scarlet oak, post oak, Spanish oak, scrub

black oak, and scrub hickory. On low grounds considerable white oak, pig hickory, and winged elm are found, but they are not valuable.

About five and one half miles from Mansville, we pass from the Devonian shale onto the underlying Corniferous limestone, of which there is a layer of only three to five feet in thickness in this locality. Underlying this again is the so-called Cumberland sandstone, a bluish, silicious, almost semi-limestone formation. The only immediate change of timber noticed was the introduction of a few swamp chestnut oaks, and their presence cannot be attributed merely to change of formation. Some white and sugar maples appear on low grounds, with sweet and black gum, white oak, red oak, and iron-wood.

On the Cumberland sandstone liriodendron again becomes a conspicuous timber, and the forests become much better in every way. On a large hill, about seven miles from Mansville, the woods are exceedingly rich. The principal timbers are blue ash, Ohio buckeye, black walnut, white and shag hickory, liriodendron, and white oak. Big buckeye forms from forty to seventy-five per cent. of the timbers in this rich forest. On the eastern face of this chain of hills, not far above its base, and about ten miles from Mansville, we pass onto the Cincinnati limestone. The timbers do not vary in kind from those given above, and there are no changes for several miles, except that occasionally a hackberry or an aspen is seen.

Taken as a whole, the standing forests are poor and valueless all along South Rolling Fork. The formation alternates between Cumberland sandstone and Cincinnati limestone—first up onto the former, then down onto the latter, and so on. All through the valleys the timbers have been cut away, and on the hills they are worthless.

At about six miles south of Hustonville (twenty miles from Mansville), there is the largest forest of bartram oak I know of in Kentucky. The valuable timbers are all cut away, on low and high grounds alike. The standing forests are worthless, and are likely to remain so, unless a thrifty cultivation and protection soon succeed the long-continued destruction.

At about two miles south of Hustonville the Cumberland sandstone dwindles away to a shaly bed about ten feet in thickness, overlaid by heavy deposits of Corniferous; and in starting through "Nigh Gap," it gives out altogether, and the overlying Corniferous rests directly upon the underlying Cincinnati limestone. "Nigh Gap" is the passage-way over Muldraugh's Hill, starting from Rolling Fork. The base of the hill here is Devonian shale, which is succeeded by Keokuk limestone at a height of seventy-five barometric feet. The transition presents a marvelous change in the timbers, and brings into strong contrast the difference between these two geological formations, in their effects upon forest growths. On the shale the timbers are mountain chestnut oak, scrub white oak, sour-wood, red oak, a few beeches (right on the river), some rock maple, &c. On the Keokuk, immediately adjoining, and on a higher level, grow splendid forests of white oak, black hickory, chestnut, black locust, liriodendron, white and shag hickory, sugar maple, redbud, spicewood, mulberry, blue ash, black ash, black cherry, American linden or basswood (the first met with), black walnut, red haw, and the usual small growth. The exceeding variety and richness of these Keokuk timbers is worthy of note. As to the questions pertaining to distribution, as affected by height above drainage, they become of the first importance from this point eastward, and will be discussed and illustrated under a separate head further on in this report.

After crossing Muldraugh's Hill, we enter the counties (north part of Lincoln and Garrard) the forests of which have been almost completely cut away. There are only scattering patches of fenced-in groves, consisting mostly of black and blue ash, white oak, black walnut, pig and shag hickory, and hackberry, until Muldraugh's Hill is reached again, near Big Hill, in the southern part of Madison county. The geological changes are numerous. Stanford rests on Cincinnati limestone, and this continues to be the formation in depressions for some distance. On the higher grounds Cincinnati (?) sandstone appears. Between Paint Lick and Irvine, and

about twenty-nine miles from the latter place, we pass from Cincinnati up through about ten feet of Corniferous onto Devonian shale. Hackberry is found scattered all through the country.

About twenty-seven miles from Irvine the formation is still Devonian shale; but its detritus forms a long, whitish level, on which, in choice local spots, considerable white oak is found. Timbers are chiefly poor and valueless.

We strike the Corniferous again near Silver Creek, about two miles west of what is locally known as Johnson's Shop; but we pass onto Devonian shale again on Silver Creek. Pawpaw bushes, black sumach, and scrub buckeye are found in the greatest abundance all through here, together with some laurel oak and post oak. The valuable timbers have all been cut out.

Near Big Hill, while Devonian shale is still the lowland formation, Waverly (Keokuk) shales are the foot-hill formation. The tops of the high hills, such as Big Hill and Buzzard's Basin, are capped with Conglomerate; so that we have a complete geological section, from Devonian shale to Conglomerate, on one of these hills. Here the first pines (*pinus mitis*) are met with on the journey eastward. They crown Big Hill and other high points, and are found on the dry, thin shales of the foot-hills.

After leaving Big Hill post-office, toward Irvine, on Red Lick Fork, red birch, holly (the first noted), sweet gum, white oak, Spanish oak, red elm, spotted birch, service berry (*Amelanchier*), laurel oak, black ash, willow, red oak, cedar, shag hickory, sugar maple, buckeye, pine, box-elder, redbud, black gum, pawpaw, and sour-wood are met with. A large part of the valley timbers is still cut away. Some American linden is found on the high knobs between Big Hill and Irvine, associated with fine black walnut, white oak, white hickory, and liriodendron, about the heads of the numerous little branches that flow from the hill-sides. The timbers remain without essential change to Estill Springs.

After passing Irvine, and turning up the Kentucky river toward Beattyville, the formation is successively Devonian (on lower spots) and Waverly (chiefly cortigalli). The forests for some miles are not very valuable. A low, dark green, exceedingly fertile mountain oak (*Quercus ilicifolia?*) appears in great abundance on the hill-sides, and about five miles from Irvine hemlock is first seen. Fine pig hickory, white oak, Spanish oak, red oak, blue ash, green ash (only one), sugar maple, buckeye, liriodendron, white hickory, and red elm are scattered all along the river and mountain sides. The timbers remain pretty much the same for three or four miles, when the first magnolias (cucumber trees) are met with. Associated with them are Ohio buckeye, black ash, redbud, winged elm, liriodendron, white maple, water beech, green dogwood, amelanchier, rhododendron, and kalmia (the first of these laurels found), red elm, spotted birch, red oak, mulberry, white oak, walnut, cedar, red sumach, and pawpaw. The formation is Keokuk.

All of the hill-sides near Irvine are covered with sp endid forests of black and blue ash, pig, shag, and white hickory, liriodendron, sugar maple, white oak, bartram oak, sycamore (on streams), box-elder, red elm, some American linden, magnolias (*cucumber* and *Frazeri*), red birch, mulberry, sweet gum, big buckeye, and catalpa.

About fourteen miles from Irvine, toward Beattyville, the river valley contracts and becomes very narrow, the hills close in on all sides, and we pass through a deep ravine, the escape from which is over what is widely known, locally, as the "Winding Stairs." In ascending the Winding Stairs, the following timbers are found: linden, black and blue ash, rich red oak, chestnut, white oak, liriodendron, white maple, white and black walnut, white hickory, pig hickory, magnolias (umbrella and cucumber), black birch, black gum, water beech, dogwood, mountain chestnut oak, spicewood, willows (near a spring), rhododendron, kalmia, azalea (*nudiflora* and *viscosa?*), Amelanchier (two varieties), pines (*mitis* and *rigida*), black oak, scarlet oak, black sumach, sassafras, and dog-

wood. The chestnuts begin as soon as Chester sandstone is reached, in ascending the hill. The timbers here given are nothing more than a fair average, and all of them may be found on any high hill in this part of the State.

After reaching the top of the Winding Stairs, there stretches out a long, irregularly-level expanse of country, on which the timbers are not worth special mention. From this level the road descends to Lower Stufflebean Creek, about two and one half miles from Beattyville. The formation is Sub-conglomerate shale, varying into Conglomerate sandstone. The timbers are not noteworthy, except that holly and swamp alder appear in considerable quantities.

For several miles beyond Beattyville, toward Jackson, no great changes in the forests occur, and the timbers are such as are usually met with on the lowlands. We follow the Kentucky river tolerably closely for a considerable distance. About three and one half miles from Beattyville, along the river bank, grow perfect thickets of pawpaws, which often reach a height of fifty feet! With them, and along the foot-hills, grow red and white elm, sycamore, black and blue ash, linden, big buckeye, water and common beech, liriodendron, hemlock, swamp alder, pith elder, red oak, iron-wood, amelanchier, sweet gum, golden alexander, red and black haw, and hawthorn. On the higher hills are post oak, black oak, red oak, scarlet oak, mountain oak, black locust, and the usual hill timbers. About five miles from Beattyville the forests of white oak are as fine, along the rich hill-sides, as I ever saw. Hickories are splendid also, and walnut, liriodendron, chestnut (on sandstone formations), and linden are unsurpassed along all the ravines whose waters head in the rich woods below the brows of the high hills. The tops of the hills are crowned with black oak, scarlet oak, mountain chestnut oak, rock maple, scrub hickories, and pines.

The splendid timbers given above continue, with only local breaks, all along Lower and Upper Twin Creeks, and the hills through which they flow. The latter stream empties into Middle Fork of Kentucky river, within about twelve or thir-

teen miles of Jackson, Breathitt county: and at its mouth the road leaves the river and turns up it, follows it to its head, crosses the divide at its head waters, and descends onto West Fork of Cane Creek, down which it follows toward North Fork of Kentucky river. The timbers all through these high, abrupt, and inaccessible hills, and deep, rich, ravine-like hollows, are scarcely surpassed in the State. A considerable amount of fine old forest walnut, black birch, and cherry still stand in these fastnesses, and gigantic liriodendrons, white oaks, ashes, lindens, locusts, chestnuts, elms, buckeyes, magnolias, and maples have, so far, bid defiance to the axes that have laid these timbers waste in other parts of the State. Civilization has not yet penetrated into these forest wilds, and the grandeur of the trees and the silence of the woods make a striking impression upon one.

The tall, dark, rich-green oak spoken of heretofore, and which I have called *rich red oak*, flourishes all through these woods. It is probably the *macrocarpa* of the botanies. A few hackberries, considerable gray birch, some white pine, &c., are met with.

High up on Upper Twin Creek, about seven miles from Jackson, on a hill-side facing north and east, at a barometric height of thirty-five feet above the small stream below, a rich belt of black walnut trees encircles the hill. There are not a great many trees in the belt, but some of them are exceedingly fine. Beds of coal are found along Upper Twin Creek, and the formation is coal-measure sandstone. All through the woods there is found, in great abundance, a hickory which I have called *microcarpa*, because it is evidently a variety of the "white hickory" of former reports on Kentucky timbers. It is a tall, clean-trunked, fine-bodied tree, branching high; bark comparatively thin, nearly smooth right at base, where the shallow interspaces of the bark are nearly straight, or only slightly chipped, but considerably more chipped higher up the trunk; leaves linear, acute at base, lance-tipped, serrate and smooth, except slightly downy at base of veins.

From Jackson to the mouth of Troublesome Creek, seven miles out toward Hazard, we pass right along North Fork of Kentucky river, with the usual lowland timbers along the river, and no changes of moment on the hills. Our route now lay up Troublesome Creek to Lost Creek; up Lost Creek to its head waters, across the divide onto Lot's Creek, and thence to Hazard. The hill timbers along this course are very similar to those already given on Twin Creek, and the forests are everywhere of the finest. The question of distribution, as affected by height above drainage, which is the most important one that presents itself in this part of the State, will be, as I have previously said, illustrated and discussed separately.

A list of the timbers noted in the Troublesome Creek region, includes white, black, and pig hickory, white oak, holly, black and blue ash, white ash, black walnut, liriodendron, chestnut, black gum, black and gray birch, winged elm, white, rock, black and mountain maple, redbud, mulberry, red oak, black oak, mountain chestnut oak, scarlet oak, beeches, black cherry, hawthorn, red haw, big buckeye, black locust, linden, water beech, silver poplar, cucumber and umbrella trees, swamp chestnut oak, sycamore, bartram oak, scrub red oak, magnolia (*Frazeri*), pines, cedar, hemlock, elm (*racemosa*), American laurels (rhododendron and kalmia), spicewood, papaw, pith elder, willows, persimmon, dogwood (green and low cornel), black sumach, and swamp alder. The *scrub red oak* is probably the *ilicifolia* of the botanies. The great variety, and the richness in valuable timbers, of these forests, I think, can scarcely be surpassed. The formation is coal-measure sandstone.

The timbers above given are found, with local variations and alternations, until North Fork of Kentucky river is reached again at Hazard. The usual swamp timbers are there found, and, in addition to them, hazelnut, aspen, and Solomon's seal.

After passing Hazard, the road follows North Fork of Kentucky river about six and one half miles, to the mouth of

Carr's Fork. It then turns up that stream, follows it for about ten miles, crosses over the divide onto Rockhouse Creek, and strikes the Kentucky river again at Whitesburg, thirty-five miles from Hazard. The upland and lowland timbers between these two places are precisely the same, with the addition of wintergreen and white willow (*Salix candida*), as those given in the Troublesome Creek region. The old forest walnut is scarce; but it is exceedingly large, and of good quality, on the heads of most of the streams, far up under the brows of the high hills. White linden and ironwood are found. The former has not been met with previously, but it abounds on the mountains to the southwest.

In about ten miles of Whitesburg quite a marked change in the distribution of the hill timbers occurs. The formation remains coal-measure sandstone; but the surface soils of the hills are a thin, whitish shale detritus, very poor, and there are no damp, dark, rich hill-sides, covered with splendid lowland timbers nearly to the top. The swamp timbers are narrowly confined to the margins of the streams and to the bottoms. In other words, the line of comparative moisture, if such line be imagined, has been removed down the hills; so that, to find a belt of given moisture, one would have to look much nearer the bases of the hills. A corresponding effect is, of course, produced upon the timbers.

In passing over the divide between the head waters of Kolley's Branch and Sandy Lick, within about seven miles of Whitesburg, the road circles around the head of a branch which flows from a deep ravine to the left (northeast) of the road. Just above the head waters of this branch, on the steep hill-side, grow some of the finest liriodendron and black walnut trees I have seen in Kentucky. One of the former reaches the enormous size of eighty inches in diameter, with fifty feet of clear, straight trunk. The walnuts are thirty-eight to forty inches, with fifty to sixty-five feet of beautiful body. White oak, white and pig hickory, buckeye, and other timbers, are proportionately good and valuable. A few "burn-

ing bushes" (*Euonymus Americana*) are also found. The formation is coal measures.

At Whitesburg the North Fork of Kentucky river is reached again, and for some distance beyond the road follows the river pretty closely. The usual lowland timbers, of which lists have been given, are met with. A great deal of sweet gum is found in localities, especially about five miles from Whitesburg. The hills near the river are largely covered with poor sandstone shale, and the timbers are not very good. At a distance from the river, however, the hills are richer, and the forests are very valuable. Considerable white walnut and black birch are found all through the woods. Otherwise, the timbers remain comparatively unchanged, until the head waters of North Fork of Kentucky river are reached, at the base of the mountain below Pound Gap.

On the mountain sides near Pound Gap and along the dark, rich ravines, stately and beautiful walnut, linden (American and white), black birch, black cherry, white oak, liriodendron, hickories, and most of the valuable forest timbers of the State, flourish in the greatest abundance. The ancient forests stand unharmed by the ax, and are likely so to remain for some years to come.

About three quarters of a mile from Pound Gap, the road crosses the Pine Mountain fault, and we pass at once from the coal measures to Devonian shale. The shale is only a narrow strip, however, and we are soon on the overlying Keokuk, and, inasmuch as that is one of the richest timber-producing formations in the State, growing alike the timbers of the limestones and those of the sandstones, the splendor of the forests is only slightly interrupted. When I speak of the Keokuk being one of the richest timber-producing formations known, I have reference to the Keokuk limestones of the East, for the Waverly shales are among the poorest of all formations—as dry, thin, and unproductive as the Devonian shales.

The observer will notice, all through this part of Pine Mountain, that there are two belts of pine trees. The mountain

pine (*P. pungens*) and the pitch pine (*P. rigida*) are found on the dry, sandy bluffs and tops of the mountains; the long-leafed pine (*P. palustris*) and the yellow pine extend further down on the mountain slopes.

At Pound Gap we pass across from Kentucky into Virginia, and at the base of the mountain, on the Virginia side, flows Pound Creek. We follow this stream to Indian Creek, thence turn up Indian Creek to its head waters and across to Gladesville. As soon as we pass Pine Mountain into Virginia, the hill-sides are covered with chinquapin (*Castanea pumila*), not one of which has, so far as I could discover, crossed the mountain northward. The chinquapins do not extend up nearly to the top of Pine Mountain, and evidently the climate is too cold for them, and this mountain is their northern boundary. They are found in the greatest abundance all through the woods of Virginia, and southward.

The magnolias begin to die out after crossing Pine Mountain, though a few are found along shady ravines and on rich hill-sides in Virginia. The coal measures reappear again at a short distance from Pound Gap, on the Virginia side, and thence we pass onto the Conglomerate, which lasts nearly to Clinch river. There a fault of ten thousand feet, running along the line of Clinch river, brings up abruptly the Knox limestone, and between there and Abingdon, Virginia, a succession of faults causes an almost constant alternation of the Cincinnati and Knox limestones. The forest timbers are not, upon the whole, so good as are those on the north side of Pine Mountain, in Kentucky; but they are everywhere valuable, and there is no marked difference in kind, other than those noticed.

TIMBER DISTRIBUTION AS AFFECTED BY HEIGHT ABOVE DRAINAGE.

Although the data for this report have been prepared with special reference to a discussion of the effects of height above drainage upon timber growth, and, with that object in view, the following tables have been arranged, nevertheless it is necessary to point out some of the dangers of generalizing

from such data, and especially some of those disturbing elements which render investigation in this particular direction liable to error. The first, and probably the most important, of these is sudden and abrupt changes in the nature and relative hardness of different parts of the same formation. In fact, to this cause is due, almost altogether in *hills*, and very largely in *mountains*, height above drainage itself; but it is in a narrower sense that it becomes a disturbing element in discussing timber growth. The sudden cliffs and benches on hills and mountains are caused by difference in hardness of two successive strata; and a cliff of exceedingly hard rock, or hard, dry soil, even when near the base of a hill, will often be permanently drier than a bench or hill-top barometrically much higher above drainage. The hardness of such a cliff prevents the formation of detritus and the retention of water For this reason a softer formation or bench, easily worn away, and capable of forming a surface detritus which will retain moisture, is, so far as effect upon timber growth is concerned, nearer to water than a hard cliff hundreds of feet below it.

Another disturbing element is sudden change in geological formation. One of the dry shales, like the Devonian and some of the Waverly shales, will cause as much change in timber growth as would be produced by the greatest height above drainage attainable in our mountains. Of course the change might be different in character, but in amount it would be as great. Changes of this nature, though, can usually be guarded against in gathering data.

The natural difference in shade, moisture and coldness, between the northern and the southern faces of hills, also produces its effect upon the timber growth. All of these disturbing elements have been taken into consideration, and accounted for, as far as possible, in preparing the following tables. The liability to slight error, however, should be kept in view.

In the tables, "N. F.," "S. F.," &c., under the barometric height at the head, mean, respectively, "North Face," "South Face," &c., of the hill.

TABLE No. 1.

Barometric height.	Location.	Formation.	Timbers.
1350 feet.	Foot-hill in Trigg county, about one mile from Tennessee river.	Silicious Limestone.	White oak (fifty per cent. of timbers), red oak, black oak, black and pig hickory, iron-wood, black gum, dogwood, and Spanish oak.
1390 feet.	Same on hill-side.	Same.	Black oak (sixty per cent. of timbers), Spanish oak, pig hickory, black hickory, and scrub oak.
1400 feet.	Same.	Same.	Same, with mountain chestnut oak.
1410 feet.	Same.	Same.	Same, with post oak and some chestnut.
1460 feet.	Bench of hill.	Same.	Mountain chestnut oak (forty per cent. of timbers), black oak, scarlet oak, post oak, and chestnut (only one).
1485 feet.	Hill-top.	Same.	Black-jack, mountain chestnut oak, and scrub black oak.

TABLE No. 2.

Barometric height.	Location.	Formation.	Timbers.
1290 feet. (E. F.)	Foot-hill four miles from Tennessee river.	Silicious Limestone.	Sweet gum, white elm, white oak, rich red oak, pig hickory, and white hickory.
1375 feet.	Hill-side.	Same.	White oak, rich red oak, black hickory, and pig hickory. Sweet gum and elm have given out.
1430 feet.	Same.	Same.	White oak, pig, shag, and white hickory end. Post oak, black oak, and Spanish oak begin.
1475 feet.	Hill-top.	Same.	Black-jack, scrub Spanish oak, post oak, and scarlet oak.

TABLE No. 3.

Barometric height.	Location.	Formation.	Timbers.
1375 feet. (W. F.)	Foot-hill 3½ miles from Cumberland river.	Saint Louis Limestone.	Liriodendron, white oak, red oak (one only), sweet gum, sugar maple, and red maple.
1450 feet.	Hill-side.	Same.	Liriodendron, black oak, pig and black hickory, and red maple. Sweet gum, white oak, and sugar maple have disappeared.
1495 feet.	Bench of hill.	Same.	Scarlet oak, black oak, post oak, and black-jack.
1538 feet.	Hill-top.	Same.	Post oak and black-jack.

TABLE No. 4.

Barometric height.	Location.	Formation.	Timbers.
1315 feet.	Base of small hill of representative timbers, 5½ miles from Hopkinsville.	Calcareous Limestone.	Bartram oak, swamp laurel oak, pig hickory, post oak, and red haw.
1325 feet.	Hill-side.	Same.	Post oak, pig hickory, black oak, scarlet oak, black-jack, and upland laurel oak.
1350 feet.	Same.	Beginning of Chester Sandstone.	Black oak, scarlet oak, Spanish oak, pig hickory, and black hickory.
1390 feet.	Hill-top.	Chester Sandstone.	Scarlet oak, post oak, black oak, and Spanish oak, predominating in order given.

TABLE No. 5.

Barometric height.	Location.	Formation.	Timbers.
1452 ft. (S. W. F.)	Foot-hill two miles from Elkton.	St. Louis Limestone.	White oak, red oak, pig and shag hickory, white and winged elm, bartram oak, yellow wood, and red oak.
1520 feet.	Hill-side.	Same.	Post oak, blue ash, redbud, yellow wood, and hickories.
1540 feet.	Hill-side.	Same.	Same, except hickories end, and black-jack begins.
1560 feet.	Hill-side.	Top of St. Louis Limestone.	Hickories, post oak, and black-jack on Sandstone. (Note—Re-appearance of hickories on Sandstone.)
1625 feet.	Hill-top.	Chester Sandstone.	White oak (one), black oak, hickory, and black-jack.

TABLE No. 6.

920 feet.	Foot of average hill, ten and three fourths miles from Greensburg.	Upper Keokuk and Lower St. Louis Limestones.	Splendid white oak, liriodendron, pig hickory, and white hickory.
970 feet.	Hill-side.	St. Louis Limestone.	Same, except hickories and liriodendron end, and scarlet oak and black oak begin.
1050 feet.	Hill-side.	Damp, rotten St. Louis Chert.	White oak, chestnut, black oak, red oak, and scarlet oak.
1070 feet.	Hill-top.	Same.	Same, with Spanish oak.

TABLE No. 7.

Barometric height.	Location.	Formation.	Timbers.
1120 feet. (S. F.)	Knob about 9 miles from Mansville—base.	Cincinnati Limestone.	Splendid liriodendron, white oak, rich red oak, blue ash, black walnut, white and shag hickory, sweet gum, and buckeye.
1138 feet.	Hill-side.	Cumberland Sandstone begins.	Same, except sweet gum ends.
1240 feet.	Hill-side.	Devonian Shale begins.	White oak, black oak, red oak, mountain chestnut oak, pig hickory, mountain maple, and spicewood—all on top of Cumberland Sandstone.
1285 feet.	Hill-side.	Devonian Shale.	Scarlet oak (very large percentage), post oak, black-jack, huckleberry, and dogwood.
1380 feet.	Hill-side.	Top of Shale bluff.	Mountain chestnut oak, scattering scrub black oak, scarlet oak, and huckleberry.
1450 feet.	Hill-top.	Steep bluff, Keokuk Limestone.	Scrub post oak, mountain chestnut oak, winged elm, redbud, spicewood, and azalea.

TABLE No. 8.

1575 ft. (N. W. F.)	Base of Muldraugh's Hill, on Rolling Fork.	Devonian Shale, with Corniferous, right in creek.	Mountain chestnut oak, beech, red oak, sour-wood, scrub white oak, and mountain maple.
1640 feet.	Hill-side.	Beginning of Keokuk Limestone.	Magnificent white oak, chestnut, liriodendron, black oak, black hickory, white hickory, ash, black locust, &c. (Note.—Great change in timbers in passing onto Keokuk.)
1675 feet.	Hill-side.	Keokuk Limestone.	Splendid liriodendron, chestnut, white and shag hickory, redbud, sugar maple, spicewood, and mulberry.
1700 feet.	Hill-side.	Keokuk Limestone.	Same as last, and black and blue ash, linden, black cherry, black walnut, hawthorn, red oak, and amelanchier.
1735 feet.	Hill-side.	Thin Waverly or upper Keokuk Shale.	Mountain chestnut oak, black oak, red oak, pig hickory, and iron-wood.
1810 feet.	Hill-top.	. . . . .	Mountain chestnut oak, scrub black hickory, blue ash (one), small red oak, and azalea. (Note.—The breaking of our mercurial barometer prevented the preparation of further data until Irvine was reached.)

TABLE No. 9.

Barometric height.	Location.	Formation.	Timbers.
1290 feet. (N. F.)	Base of Estill Springs Knob.	Devonian Shale.	White oak, pin oak, black gum, and honey locust. No small growth.
1350 feet.	Hill-side.	Same, with detritus of Cortigalli Sandstone.	White oak, liriodendron, red oak, water beech, sour-wood, and pine (*mitis*).
1385 feet.	Bench.	Top of Devonian Shale.	On the Shale bench only pine, dwarf red oak, and post oak.
1420 feet.'	Saddle of bench.	Cortigalli Sandstone.	White oak, Spanish oak, scarlet oak, white maple, huckleberry, and sour-wood.
1465 feet.	Hill-side.	Same.	Mountain chestnut oak, scarlet oak, white maple, huckelberry, and black sumach.
1580 feet.	Same.	Same, with heavy detritus.	Very heavy undergrowth of hickory, black oak, redbud, and dogwood. Old trees are white oak and black oak.
1685 feet.	Same.	Cortigalli bluff.	Mountain chestnut oak, mountain maple, redbud, sour-wood, and dogwood.
1720 feet.	Same.	Cortigalli.	Mountain chestnut oak, shrub white hickory, winged elm, dogwood, &c.
1785 feet.	Hill-top.	Same.	Mountain oak, scrub hickory, scarlet oak, redbud, scrub elm, huckleberry, and pine (*mitis*). Pines and white sumach almost exclusively occupy the south face of the Knob.

TABLE No. 10.

Barometric height.	Location.	Formation.	Timbers.
1300 feet.	Base of "Winding Stairs," 14 miles from Irvine.	Keokuk Limestone.	Swamp chestnut oak, white oak, white and shag hickory, liriodendron, black ash, rich red oak, sycamore, box-elder, red elm, buckeye, sugar maple, American linden, magnolias (cucumber and Frazeri), mulberry, sweet gum, red birch, and catalpa.
1480 feet.	Hill-side—base of bluff.	Base of St. Louis Limestone.	Up to this bluff, last timbers flourish. Fine belt of linden at this height.
1535 feet.	Bench of hill.	St. Louis Limestone.	All foot-hill timbers are found on this bench, as it is the *spring level*, and the ground is very moist Spicewood and willow are also found.
1575 feet.	Bench of hill.	Base of Chester Sandstone.	Splendid chestnut, white oak, liriodendron, white and pig hickory, umbrella tree, black and blue ash, water beech, dogwood, &c. (Note.—Appearance of chestnut on Sandstone.)
1700 feet.	Bench of hill.	Base of Conglomerate Sandstone.	Chestnut, liriodendron, black beech, white hickory, linden, black gum, water beech, mountain chestnut oak, and dogwood.
1750 feet.	Hill-side.	Conglomerate Sandstone.	Chestnut, mountain maple, mountain chestnut oak, black gum, water beech, dogwood, rhododendron, and azalea.
1800 feet.	Hill-side.	Same.	Thicket of Kalmia (latifolia), rhododendron (max.), with chestnut oak, mountain maple, water beech, sour-wood, huckleberry, amelanchier, and azalea.
1820 feet.	Hill side.	Same.	Pine begins. Other timbers same as last.
1900 feet.	Hill-top.	Same.	Pine, scarlet oak, scrub black oak, dogwood, sour-wood, black sumach, sassafras, and huckleberry.

TABLE No. 11.

Barometric height.	Location.	Formation.	Timbers.
1460 feet.	Base of characteristic low hill, six miles from Beattyville.	Conglomerate Sandstone, with underlying Shale.	Splendid white oak, liriodendron, black hickory, black ash, rich red oak, water beech, redbud, red maple, and dogwood.
1490 feet.	Hill-side.	Conglomerate Sandstone.	Belt of white hickory. Other timbers unchanged, except black ash and rich red oak have given out.
1520 feet.	Hill-side.	Same.	Spanish oak, black oak, black hickory, scrub white hickory, and scattering white oaks.
1545 feet.	Hill-top.	Same.	Spanish oak, scarlet oak, sour-wood, and dogwood.

TABLE No. 12.

1405 feet. (N. F.)	Base of hill, fifteen miles from Jackson.	Coal-measure Sandstone.	White oak, beech, chestnut, white maple, dogwood, black oak, red oak, and amelanchier.
1470 feet.	Bench of hill.	Same.	Splendid white oak, beech, water beech, hickory, green cornel, and black gum.
1510 feet.	Hill-side.	Same.	White oak ends. Mountain chestnut oak, water beech, mountain maple, black gum, dogwood, amelanchier, and sassafras.
1605 feet.	Level hill-top.	Same.	White oak, red oak, water beech (what a misnomer!), sour-wood, dogwood, and amelanchier. (Note.—Reappearance of white oak on detritus of low, level hill-top.)

TABLE No. 13.

Barometric height.	Location.	Formation.	Timbers.
1600 feet.	Base of "Town Hill," one and three fourths mile from Jackson.	Coal-measures.	Liriodendron, white oak, white and shag hickory, linden, umbrella tree, water beech, red maple, redbud, beech, dogwood, sour-wood, and amelanchier.
1640 feet.	Hill-side.	Same.	Beeches end. Other timbers same.
1690 feet.	Hill-side.	Same.	Spanish oak, red oak, black oak, black hickory, pig hickory, and one or two white oaks.
1750 feet.	Hill-side.	Same.	Red oak, black oak, chestnut, mountain chestnut oak, black locust, black gum, scarlet oak, and pine (*rigida*).
1835 feet.	Hill-top.	Same.	Black oak, red oak, chestnut, mountain chestnut oak, mountain maple, sour-wood, dogwood, &c.

TABLE No. 14.

1530 ft. (N. W. F.)	Foot-hill on Troublesome Creek, twenty-one miles from Hazard.	Coal-measure Sandstone.	Sycamore, beech, linden, sugar maple, white elm, gray birch, big buckeye, papaw, liriodendron, rich red oak, amelanchier, golden Alexander, spicewood, magnolia (*Fraseri*), and dogwood.
1620 feet.	Dark, rich hill-side.	Same.	Nearly all beeches; some large liriodendron, blue ash, black gum, sugar maple, and small cornel.
1690 feet.	Same.	Same.	White oak, beeches, black gum, cornel bushes, and golden Alexander.
1740 feet.	Bench of hill.	Same.	White oak, white hickory, black gum, sugar maple, and beeches, the latter forming 80 per cent. of timbers.
1780 feet.	Hill-side.	Same.	Beeches (50 per cent.), chestnut, white oak, black gum, sour-wood, dogwood, huckleberry, and golden Alexander.
1840 feet.	Hill-side.	Same.	Chestnut, black birch, rock maple, beech, kalmia, sour-wood, and dogwood.
1875 feet.	Hill-side.	Same.	Chestnut, red oak, black oak, thin-bark hickory, mountain maple, mountain chestnut oak, sour-wood, and amalanchier.
1920 feet.	Rocky bluff.	Same.	Mountain chestnut oak, dwarf chestnut, rock maple, kalmia, amelanchier, and sour-wood.
1975 feet.	Hill-top.	Same.	Gray birch, mountain maple, and sour-wood.

TABLE No. 15.

Barometric height.	Location.	Formation.	Timbers.
1975 ft. (S. E. F.)	Opposite face of preceding hill—hill-top.	Coal-measure Sandstone.	Timbers last given.
1925 feet.	Hill-side.	Same.	Splendid pig hickory, black oak, black locust, red oak, mountain chestnut oak, mountain maple, and dogwood.
1900 feet.	Hill-side.	Same.	Liriodendron begins. Black walnut, linden, red mulberry, red oak, black oak, and gray birch.
1860 feet.	Hill-side.	Same.	Beeches begin. Mountain chestnut oak ends. In addition to beeches, sugar trees, liriodendron, and linden are found.
1775 feet.	Hill-side.	Same.	Splendid liriodendron, white oak, big buckeye, sugar trees, red oak, and gray birch.
1680 feet.	Hill-side.	Same.	Umbrella and beeches (the latter forming 90 per cent. of timbers).
1524 feet.	Foot-hill.	Same.	Same as foot-hill timbers on opposite side of hill.

TABLE No. 16.

1560 feet. (N. F.)	Foot-hill on Lost Creek, fourteen miles from Hazard.	Coal-measure Sandstone.	Hemlock, chestnut, red maple, white oak, water beech, beech, linden, black gum, gray birch, alder, spicewood, dogwood, sour-wood, and magnolia.
1605 feet.	Hill-side.	Same.	White oak, magnolia, water beech, white maple, black gum, gray birch, spicewood, and dogwood.
1655 feet.	Hill-side.	Same.	Linden, white oak, chestnut, gray birch, water beech, rock maple, red oak, amelanchier, sour-wood, and dogwood.
1705 feet.	Hill-side.	Same.	Splendid chestnut belt, pig hickory, black oak, black hickory, a few white oaks, gray birch, mountain chestnut oak, sour-wood, dogwood, and golden Alexander.
1760 feet.	Hill-side.	Same.	Chestnut, red oak, black gum, gray birch, black locust, mountain maple, mountain chestnut oak, and huckleberry.
1825 feet.	Bend of hill.	Same.	White oak (small amount), chestnut, black oak, mountain chestnut oak, beech, sour-wood, dogwood, sassafras, and amelanchier.
1925 feet.	Hill-top.	Same.	Red oak, black gum, thin-bark hickory, chestnut, and mountain chestnut oak.

TABLE No. 17.

Barometric height.	Location.	Formation.	Timbers.
1880 feet.	Base of hill, starting over from head waters of Lost to those of Lot's Creek, six miles from Hazard.	Coal-measures.	Splendid liriodendron, white oak, chestnut, beeches, black and blue ash, rich red oak, sugar maple, black birch, white and pig hickory, white maple, magnolia (umbrella, cucumber, and auriculata), hemlock, and dogwood.
2040 feet.	Top of divide—low gap.	Same.	Chestnut, liriodendron, white oak, white hickory, black and gray birch, black oak, black hickory, dogwood, and sour-wood.
2120 feet.	Hill-bench.	Same.	Red oak, black oak, black gum, mountain chestnut oak, pine (*rigida*), and kalmia.
2180 feet.	Hill-side.	Same.	Black-jack, scrub oak, and pine (*rigida*).
2225 feet.	Top of Sandstone bluff.	Same.	Pine (*mitis*), scrub black oak, and scrub red oak (*ilicifolia*).
2265 feet.	Hill-top.	Same.	Pine, scrub chestnut, and mountain chestnut oak.

TABLE No. 18.

Barometric height.	Location.	Formation.	TIMBERS.
1700 feet. (N. F.)	Base of rich hill, with three veins of coal, five miles from Hazard.	Coal-measures.	White oak, liriodendron, beeches (50 per cent. of timbers), linden, black ash, box-elder, swamp chestnut oak, white ash, white and black hickory, magnolia, white walnut, red oak, buckeye, water beech, papaw, and spicewood.
1825 feet.	Hill-side.	Same.	Splendid blue ash, white oak, liriodendron, shag hickory, gray birch, water beech, sugar maple, black gum, hazelnut, golden Alexander, and dogwood.
2020 feet.	Hill-side.	Same.	Liriodendron, chestnut, black oak, hickories, &c. Not much change from last timbers.
2220 feet.	Hill-side.	Same.	Magnificent forest of liriodendron, linden, black and blue ash, black hickory, black walnut (not large), sugar maple, birch, swamp chestnut oak, rich red oak, redbud, spicewood, papaw, and dogwood.
2300 feet.	Base of bluff.	Same.	Liriodendron, chestnut, linden, blue ash, rich red oak, black locust, dogwood.
2375 feet.	Hill-side.	Same.	Mountain chestnut oak, black oak, scrub white hickory, mountain maple, Amelanchier, dogwood, sour-wood, and huckleberry.
2425 feet.	Hill-side.	Same.	Pine (*rigida*), huckleberry, and Kalmia.
2500 feet.	Hill-top.	Same.	Pine (*rigida*), red oak, mountain maple, huckleberry, and kalmia.

TABLE No. 19.

Barometric height.	Location.	Formation.	TIMBERS.
1920 ft. (S. S. W. F.)	Base of divide between Breeding's Creek and Rockhouse Creek, thirteen miles from Whitesburg.	Coal-measures.	Beeches, white oak, liriodendron, white and black walnut, big buckeye, rich red oak, linden, water beech, magnolia, winged and red elm, black ash, white hickory, willows, dogwood, and sour-wood.
1980 feet.	Hill-side.	Coal-measures.	Beeches, gray birch, liriodendron, black gum, linden, buckeye, white walnut, magnolia, and dogwood.
2050 feet.	Same, near head of branch under brow of hill.	Coal-measures.	Magnificent liriodendron, blue ash, white hickory, shag hickory, chestnut, sugar maple, beeches, mulberry, rich red oak, buckeye, water beech, dogwood, and papaw.
2180 feet.	Hill-side.	Coal-measures.	Belt of white oak, with black oak, chestnut, hickory, magnolia, dogwood, amelanchier, sour-wood, and sassafras.
2250 feet.	Hill-side.	Coal-measures.	Chestnut, black locust, iron-wood, rock maple, black gum, amelanchier, sour-wood, and dogwood.
2290 feet.	Broken Sandstone bluff.	Coal-measures.	Mountain chestnut oak, chestnut, kalmia, dogwood, and sour-wood.
2340 feet.	Top of bluff.	Coal-measures.	Mostly pines (*rigida and mitis*), since last level. Here, chestnut, scrub white hickory, black oak, rock maple, scrub post oak, black sumach, amelanchier, sour-wood, and dogwood.
2355 feet.	Hill-side.	Same—shaly Sandstone.	Thicket of post oaks, with scrub white hickory, mountain ash, black locust, and mountain chestnut oak.
2400 feet.	Base of bluff.	Massive Sandstone.	Only mountain chestnut oak trees, with small growth same as at 2340 level.
2500 feet.	Hill-top.	Coal-measures.	Chestnut, mountain chestnut oak, black locust, scrub red and black oak, scrub hickory, dogwood, and sassafras.

TABLE No. 20.

Barometric height.	Location.	Formation.	TIMBERS.
2120 feet.	Base of divide, between Kolley's Branch and Sandy Lick, seven miles from Whitesburg.	Coal-measures.	Splendid white oak, liriodendron, white hickory, beeches, black gum, sugar maple, big buckeye, linden, black ash, mulberry, rich red oak, gray birch, magnolia (cucumber), and papaw.
2250 feet.	Hill-side.	Same.	Chestnut, red maple, rock maple, beeches, sour-wood, dogwood, and sassafras. (I was unable to go higher on this hill. The top would be about 2400 feet.)

TABLE No. 21.

2230 feet.	Base of Pine Mountain, starting through Pound Gap.	Coal-measures.	White oak, liriodendron, linden (American and Canadian), chestnut, rich red oak, hemlock, beeches, magnolias, black and blue ash, gray and black birch, red maple, black gum, buckeye, dogwood, and sour-wood.
2475 feet.	Mountain-side, one mile from Pound Gap.	Line of Pine Mountain fault. Devonian Shale.	Mountain chestnut oak, chestnut, beech, gray birch, scrub oak, red oak, magnolia, mountain maple, white walnut, shag hickory, liriodendron, white oak, black gum, linden, and wintergreen. (NOTE.—We pass almost immediately from Devonian Shale onto Keokuk, and there is little perceptible change in the timbers.)
2560 feet.	Mountain-side.	Keokuk Limestone.	Magnificent liriodendron, chestnut, linden, ashes, buckeye, rich red oak, white hickory, black walnut; some white oak, sugar trees, black locust, black birch, magnolia, mountain chestnut oak, water beech, and papaw.
2700 feet.	Mountain-side.	Saint Louis Limestone.	Linden, white hickory, liriodendron, pig hickory, red oak, buckeye, black locust, gray birch, and mountain chestnut oak. (NOTE.—Absence of chestnut.)
2800 feet.	Mountain-side.	Chester Sandstone.	Chestnut, white walnut, linden, black oak, sugar trees, shellbark hickory, and mountain chestnut oak.
2870 feet.	Bluff.	Same.	Mountain chestnut oak, mountain maple, magnolia, gray and spotted birch, black locust, scrub oak, scrub chestnut, rhododendron and kalmia, dogwood, and sour-wood.

2925 feet.	Mountain-side.	Very micaceous Sandstone. Conglomerate (?)	Chestnut, mountain chestnut oak, black and blue ash (not large), black locust, linden, mountain maple, magnolia, and white walnut.
3100 feet.	Pound Gap—top of divide.	Conglomerate Sandstone.	Chestnut, red oak, black locust, white walnut, mountain chestnut oak, pith elder, white and black sumach, sassafras, dogwood, and sour-wood.
3260 feet.	Peak to right of gap, going south.	Conglomerate.	Small shell-bark hickory, chestnut, mountain chestnut oak, scrub oak, spotted birch, dwarf black hickory, mountain hazelnut, huckleberry, and sassafras.
3410 feet.	Top of peak.	Same.	Shell-bark hickory, mountain chestnut oak, gray birch, linden (small), black locust, white walnut, black oak, scrub oak, scrub white oak (only one), chestnut, spotted birch, sassafras, and sour-wood. (NOTE.—On the opposite (southeast) face of the mountain there is a great deal of pine, but no other material difference in the timbers.)

From the foregoing tables, taken from different parts of the forests throughout the entire length of the State, and, therefore, as general as it is possible to obtain them, much information can be obtained as to the effect of height above drainage on Kentucky timbers. For instance, let us take white oak and go through the various tables. The following is the result:

Timbers.	Height of hill in feet.	Height to which white oak grows	Proportion of height to which white oak grows to entire height of hill.	Formation.
White oak . .	135	40	30—	Silicious Limestone.
White oak . .	185	130	70+	Silicious Limestone.
White oak . .	163	75	46+	St. Louis Limestone.
White oak . .	173	68	35+	St. Louis Limestone.
White oak . .	150	150	100	Keokuk Limestone.
White oak . .	600	275	46+	Keokuk Limestone.
White oak . .	330	130	39+	Cincinnati Limestone.
White oak . .	235	100	43—	Devonian Shale and Candigalli.
White oak . .	435	230	53—	Candigalli.
White oak . .	85	60	71—	Conglomerate Sandstone.
White oak . .	135	135	100	Coal-measures.
White oak . .	235	90	38+	Coal-measures.
White oak . .	445	250	56+	Coal-measures.
White oak . .	401	251	63—	Coal-measures.
White oak . .	365	265	73—	Coal-measures.
White oak . .	385	150	40+	Coal-measures.
White oak . .	800	520	65	Coal-measures.
White oak . .	580	260	45—	Coal-measures.
White oak . .	1030	336	32+	Coal-measures.

From this table can readily be deduced the average height of all the hills in Kentucky selected for these experiments, the average height above drainage to which white oak grows, and the relation that the latter height bears to the entire height of the hill. The following table shows these deductions:

Timbers.	Average height of hill.	Average height on hill to which white oak grows.	Proportion of latter to former.
White oak	308.8	184.7	60 nearly.

In other words, throughout the forests of Kentucky the white oak extends, on a general average, over sixty per cent. of the

hills. A slight examination will also show that on Keokuk limestone white oak extends to seventy-three per cent. of the total height of the hills; on Conglomerate sandstone, to seventy-one per cent.; on coal-measures, to fifty-seven per cent.; on silicious limestone, to fifty per cent.; and on St. Louis limestone, to forty per cent. This indicates that Keokuk, leaving out the Keokuk shales, is the richest of the formations in white oak growth.

In the same way it may be shown, from the general tables, that liriodendron extends to an average of forty-five per cent. of the total heights of hills, or not quite half way. The reader can easily make deductions for all other timbers. It will be noticed that there is no general and definite relation existing between the height of hills and the height to which any particular timber will grow. Everything depends upon the nature of the hill, and upon whether the formation is adapted to retaining moisture. On a damp hill, though very high, a timber will be found, growing entirely to the top, which would not extend more than a few feet up another and drier hill. It is exceedingly interesting, though, to know the *average* height above drainage to which the principal forest trees extend; and that can be deduced from the tables given.

SUMMARY.

A brief review of the foregoing pages will show—

First. That changes in geological formation will produce immediate, and often exceedingly marked, effects upon the character of the timbers. Such changes are often noticed, in *shallow-rooted* timbers, before a change of formation is reached, owing to the effect of detritus from the neighboring formation. They may likewise be noticed in very *deep-rooted* timbers, for the opposite reason, that their roots extend down beneath the surface formation, and penetrate the underlying one, when that is not visible.

Second. That height above drainage always produces a marked effect upon timbers, whatever the formation; but that such effect is less in the case of a Keokuk limestone formation than in any other found in Kentucky.

Third. That there is no regular proportion between the total heights of hills and the heights to which particular timbers grow. Everything depends upon the nature of the formation.

Fourth. That of the marked difference in character between the forests of Eastern and those of Western Kentucky, only the distribution of the pines can be satisfactorily accounted for without further and special study in that direction.

LIST OF TIMBERS.

The following is a list of timbers met with and spoken of in this Report:

ORDER CUPULIFERÆ—MASTWORTS.

1. *Genus Quercus—oak.*
   - White oak, Quercus alba (L.)
   - Swamp white oak, Q. bicolor (Willd.)
   - Bartram oak, Q. heterophylla (Mx.)
   - Red oak, Q. rubra (L.)
   - Spanish oak, Q. falcata (L.)
   - Scarlet oak, Q. coccinea (Wang.)
   - Post oak, Q. obtusiloba (Mx.)
   - Rich red oak, Q. macrocarpa (Mx.)
   - Black oak, Q. tinctoria (Bart.)
   - Pin oak, Q. palustris (Mx.)
   - Laurel oak, Q. imbricaria (Mx.)
   - Swamp laurel oak, Q. laurifolia (Mx.)
   - Chestnut oak, Q. castanea (Muhl.)
   - Swamp chestnut oak, Q. prinus (Willd.)
   - Chinquapin oak, Q. prinoides (Willd.)
   - Black-jack, Q. nigra (L.)
   - Scrub oak, Q. ilicifolia (Willd.)
2. *Genus Castanea—chestnut.*
   - Common Chestnut, Castanea vesca (L.)
   - Chinquapin, Castanea pumila (Mx.)
3. *Genus Fagus—beech.*
   - Common beech, Fagus sylvatica (L.)
   - Red variety, Fagus ferruginea (Ait.)

4. *Genus Corylus—hazelnut.*
   Common hazelnut, Corylus Americana (Walt.)
5. *Genus Ostrya—hop hornbeam.*
   Common ironwood, Ostrya Virginica (Willd.)
   Var. hornbeam, Carpinus Americana (L.)
   (NOTE.—I prefer giving the latter as a mere variety of the former, rather than as a distinct *genus carpinus.*)

ORDER JUGLANDACEÆ.

1. *Genus Carya—hickory.*
   Black hickory, Carya tomentosa (Nutt.)
   White hickory, Carya microcarpa (Nutt.)
   Shag hickory, Carya alba (Nutt.)
   Shellbark hickory, Carya sulcata (Nutt.)
   Pig hickory, Carya glabra (Torr.)
2. *Genus Juglans—walnut.*
   Black walnut, Juglans nigra (L.)
   White walnut, Juglans cinerea (L.)

ORDER BETULACEÆ.

1. *Genus Betula—birch.*
   Black birch, Betula lenta (L.)
   Red birch, Betula nigra (Ait.)
   Yellow birch, Betula excelsa (Ait.)
   Spotted birch, Betula pumila (L.)
2. *Genus Alnus—alder.*
   Swamp alder, Alnus serrulata (Willd.)

ORDER ACERACEÆ.

1. *Genus Acer—maple.*
   White maple, Acer dasycarpum (Ehr.)
   Black maple, Acer nigrum (Mx.)
   Red maple, Acer rubrum (L.)
   Same, Var. tridens.
   Sugar maple, Acer saccharinum (L.)
   Mountain maple, Acer spicatum (Lam.)
2. *Genus Negundo.*
   Box-elder, Negundo aceroides (Moench)

ORDER CONIFERÆ.

1. *Genus Pinus—pine.*
   - Yellow pine, Pinus [illegible]tis (Mx.)
   - Pitch pine, Pinus r[illegible] (Miller.)
   - Loblolly pine, Pinus [illegible]
   - White pine, Pinus s[illegible]
   - Mountain pine, Pinus p[illegible]
2. *Genus Abies.*
   - Hemlock, Abies can[illegible]
3. *Genus Taxodium.*
   - Bald cypress, Ta[illegible]ychum (Rich.)
4. *Genus Juniperus.*
   - Common cedar, Juniperus Virginiana.

ORDER ULMACEÆ.

1. *Genus Ulmus—elm.*
   - Red elm, Ulmus fulva (L.)
   - Winged elm, Ulmus alata (Mx.)
   - Cork elm, Ulmus racemosa (Thomas.)
   - White elm, Ulmus Americana (L.)
2. *Genus Celtis.*
   - Hackberry, Celtis occidentalis (L.)

ORDER ROSACEÆ.

1. *Genus Cerasus—cherry.*
   - Black cherry, Cerasus serotina (D. C.)
2. *Genus Prinus—plum.*
   - Common plum, Prinus Americana (Marsh.)
3. *Genus Cratægus—thorn.*
   - Black thorn, Cratægus tomentosa (L.)
   - Yellow thorn, Cratægus punctata (Jacq.)
   - Hawthorn, Cratægus oxycantha (L.)
4. *Genus Amelanchier.*
   - Service berry, Amelanchier canadensis (T. & G.)
   - Same, shrub, Var. oblongifolia (T. & G.)
5. *Genus Spiræ.*
   - Ninebark, Spiræ opulifolia (L.)
   - Mountain spiræ, Spiræ corymbosa (Raf.)

ORDER OLEACEÆ.

1. *Genus Fraxinus—ash.*

Black ash, Fraxinus sambucifolia (Lam.)
Blue ash, Fraxinus quadrangulata (Mx.)
White ash, Fraxinus Americana (L.)
Green ash, Fraxinus viridis (Mx.)

ORDER MAGNOLIACEÆ.

1. *Genus Magnolia.*

Big laurel, Magnolia grandiflora (L.)
Cucumber tree, Magnolia acuminata (L.)
Umbrella tree, Magnolia umbrella (Lam.)
Big-leafed magnolia, Magnolia macrophylla (Mx.)
Ear-shaped magnolia, Magnolia Fraseri (Walt.)

2. *Genus Liriodendron.*

Tulip tree (yellow poplar), Liriodendron tulipfera (L.)

ORDER TILIACEÆ.

1. *Genus Tilia—linden tree.*

American basswood, Tilia Americana (L.)
Canadian or white basswood, Tilia heterophylla.
Canadian or white basswood, Var. alba (Vent.)

ORDER ERICACEÆ.

1. *Genus Kalmia.*

Spoon-wood, Kalmia latifolia (L.)

2. *Genus Gaultheria.*

Wintergreen, Gaultheria procumbens (L.)

3. *Genus Vaccinium.*

Blueberry, Vaccinium corymbosum (L.)

4. *Genus Oxydendrum.*

Sorrel tree, Oxydendrum arboreum (D. C.)

5. *Genus Azalea.*

White azalea, Azalea viscosa (L.)
Pinxter-bloom, Azalea nudiflora (L.)
Tree azalea, Azalea arborescens (Ph.)

6. *Genus Rhododendron.*
   Large rhododendron, Rhododendron maximum (L.)
7. *Genus Clethra.*
   Sweet pepper, Clethra alnifolia (L.)

ORDER SALICACEÆ.

1. *Genus Populus.*
   Cotton tree, Populus Angulata (Ait.)
   Aspen, Populus tremuloides (Mx.)
   Balm of Gilead, Populus candicans (Ait.)
   Silver-leafed poplar, Populus alba (L.)

ORDER LEGUMINOSÆ.

1. *Genus Gymnocladus.*
   Coffee tree, Gymnocladus canadensis (Lam.)
2. *Genus Gleditschia.*
   Honey locust, Gleditschia triacanthus (L.)
3. *Genus Robinia.*
   Black locust, Robinia pseudacacia (L.)
4. *Genus Cercis.*
   Redbud, Cercis canadensis (L.)
5. *Genus Cladastris.*
   Yellow wood, Cladastris tinctoria (Raf.)

ORDER CORNACEÆ.

1. *Genus Nyssa.*
   Black gum, Nyssa multiflora (Wang.)
   Swamp black gum, Nyssa uniflora (Wang.)
2. *Genus Cornus.*
   Common dogwood, Cornus florida (L.)
   Yellow dogwood, Cornus sericea (L.)
   Green cornel, Cornus alternifolia (L.)

ORDER SAPINDACEÆ.

1. *Genus Æsculus.*
   Big buckeye, Æsculus flava (Ait.)
   Small buckeye, Æsculus pavia (L.)

ORDER HAMAMELACEÆ.

1. *Genus Liquidamber.*

Sweet gum, Liquidamber styraciflua (L.)

1. *Genus Hamamelis.*

Witch hazel, Hamamelis Virginiana (L.)

ORDER ANACARDIACEÆ.

1. *Genus Rhus—sumach.*

Smooth sumach, Rhus glabra (L.)
Large sumach, Rhus typhina (L.)
Mountain sumach, Rhus copallina (L.)
Poison oak (sumach), Rhus toxicodendron (L.)

ORDER AQUIFOLIACEÆ.

1. *Genus Ilex.*

Holly, Ilex opaca (L).

ORDER CAPRIFOLIACEÆ.

1. *Genus Sambucus.*

Pith elder, Sambucus canadensis (L.)

2. *Genus Liburnum.*

Black haw, Liburnum prunifolium (L.)

ORDER ARTOCARPACEÆ.

1. *Genus Morus.*

Red mulberry, Morus rubra (L.)

ORDER PLATANACEÆ.

1. *Genus Platanus.*

Sycamore, Platanus occidentalis (L.)

ORDER RUTACEÆ.

1. *Genus Xanthoxylum.*

Prickly ash, Xanthoxylum Americanum (Miller.)

2. *Genus Ailanthus.*

Tree of heaven, Ailanthus glandulosa (Desf.)

ORDER BIGNONIACEÆ.

1. *Genus Catalpa.*

Catalpa, Catalpa bignonioides (Walt.)

ORDER LAURACEÆ.

1. *Genus Benzoin.*
   Spicewood, Benzoin odoriferum (Nees.)
2. *Genus Sassafras.*
   Common sassafras, Sassafras officinale (Nees.)

ORDER ANONACEÆ.

1. *Genus Asimina.*
   Papaw, Asimina triloba (Dunal.)
   Same, Asimina parviflora(?) (Dunal.)

ORDER CALYCANTHACEÆ.

1. *Genus Calycanthus.*
   Sweet shrub, Calycanthus floridus (L.)

ORDER EBENACEÆ.

1. *Genus Diospyros.*
   Persimmon, Diospyros Virginiana (L.)

ORDER CELASTRACEÆ.

1. *Genus Enonymus.*
   Burning bush, Enonymus Americanus (L.)

ORDER UMBELLIFERÆ.

1. *Genus Thaspium.*
   Golden Alexander, Thaspium cordatum (Nutt.)

ORDER CAMELLIACEÆ.

1. *Genus Stuartia.*
   Stuartia, Stuartia Virginica (Cav.)