Forests and Floods.

F. M. Andrews.

The relation which forests bear in many ways to the flow of rivers is a question of the utmost importance to the whole country. When one observes what has been and still is being done in most parts of the United States toward forest destruction it seems strange that the people, as a whole have been so slow in waking up to the seriousness of the situation. Only within very recent years is the public beginning to realize that the forests are vanishing rapidly and that they are confronted by a serious problem. They have destroyed the vast forests of this country apparently with no thought or regard for the consequences. Now they are beginning to reap the reward of their shortsightedness in a score or more ways. Chief among the results caused by the continued removal of the forests is the frequent recurrence of floods which become more and more destructive. There have been and perhaps still are some people who believe that the forests are inexhaustible. How such belief can exist at the present, in view of such evident disappearance of forests everywhere is very surprising. A less commendable attitude than this apparent ignorance is the position some assume that there will be timber enough in the country during their lifetime and that therefore they need not concern themselves as to the future. A great service, however, for the preservation of our forests and their proper management has been performed by the admirable work of the Forestry Department of the United States Government. Excellent work also has been rendered by the various forestry schools of the different institutions and by farsighted individuals the country over who have seen the impending dangers and have endeavored by means of education and by timely counsel and advice to avert the dire consequences resulting from the wholesale destruction of the forests.

Within recent years special and important studies have been made in order to ascertain to what extent the flow of various streams is dependent

on forests[1] and surface conditions in general.[2] Hall and Maxwell in their study gathered together the data for a number of rivers from records which had been kept for sixteen to thirty-four years. The following data, taken from their table on page 4 of Hall and Maxwell's papers, will furnish proof that floods are on the increase.

The Potomac River was measured at Harper's Ferry, Va. It drains a basin of 9,363 square miles. In the first period of record (1890–1898) of nine years there were nineteen floods lasting thirty-three days. There were 1,351 days of low water.

In the second period of record (1899-1907) of nine years there were twenty-six floods lasting fifty-seven days. The increase of rainfall in the second period was only .13 of an inch per year. Days of low water 1,693.

The Monongahela River was measured at Lock 4, Pennsylvania. It drains a basin of 5,430 square miles.

In the first period (1886-1896) of eleven years there were thirty floods lasting fifty-five days. There were 912 days of low water.

In the second period (1897-1907) of eleven years there were fifty-two floods lasting one hundred days. There were 979 days of low water. The rainfall decreased only .08 of an inch per year.

The Cumberland River was measured at Burnside, Ky. It drains a basin of 3,739 square miles.

In the first period (1890-1898) of nine years there were thirty-two floods lasting eight-nine days. There were 1,261 days of low water.

In the second period (1899-1907) of nine years there were forty-three floods lasting 102 days. There were 1,576 days of low water. The rainfall decreased .54 of an inch per year.

The Wateree River was measured at Camden, S. C. It drains a basin of 5,135 square miles.

In the first period (1892-1899) of eight years there were forty-six floods lasting 147 days. There were 1,164 days of low water.

In the second period (1900-1907) of eight years there were seventy floods lasting 187 days. There were 508 days of low water. The rainfall increased .25 of an inch per year.

The Savannah River was measured at Augusta, Ga. It drains a basin of 7,300 square miles.

---

[1] Toumey, James W. The Relation of Forests to Stream Flow. Yearbook of the Departments of Agriculture, 1903, pp. 279-288.

[2] Hall, Wm. L. and Maxwell, Hu. Forest Service Circular 176, 1910.

In the first period (1890-1898) of nine years there were forty-seven floods lasting 116 days. There were 566 days of low water.

In the second period (1899-1907) of nine years there were fifty-eight floods lasting 170 days. There were 292 days of low water. The rainfall decreased .17 of an inch per year.

The Ohio River was measured at Wheeling, W. Va. It drains a basin of 23,820 square miles.

In the first period (1882-1894) of thirteen years there were forty-six floods lasting 143 days. There were 1,333 days of low water.

In the second period (1895-1907) of thirteen years there were fifty-nine floods lasting 188 days. There were 1,609 days of low water. The rainfall decreased .14 of an inch annually.

The data here cited for the above mentioned rivers is also true for many other streams, but these will serve as good examples of what has been and is taking place wherever deforestation has occurred. In such rivers as the Ohio, Cumberland, and Wateree, changes are most conspicuous, and it is in these that most of the forest has been removed, while least change appear in those streams where most of the forests remain.[3]

This state of affairs is what we should expect, but the data given for the rivers referred to proves this by direct observation and leaves the matter no longer a question of guesses or opinion.

From what has just been said it is certain that as deforestation progresses floods will, with equal amounts of precipitation, become more frequent and increase in severity. To be sure, there are other factors that enter somewhat into any consideration of the cause of floods. Among these may be mentioned rainfall, season of the year and temperature, character of the soil, presence of lakes which might impound a good part of the "run-off" temporarily and afterwards gradually supply it to the streams, and thus while at first preventing flood afterwards lessen the lengthy periods of low water. Also the question of whether the land is nearly level or very hilly and steep is important. A heavy precipitation might do no damage whatsoever in the former case, whereas in the latter among steep and deforested land the destruction might be appalling.

But after we have considered all these points and many others that might be mentioned, the fact remains that the chief cause of the frequent

---

[3] Hall, Wm. and Maxwell, Hu. Forest Service Circular 176, p. 3.

and destructive floods in this state and elsewhere is the wholesale destruction of the forests.

Another proof of the efficiency in controlling the "run-off" has been furnished by Toumey.[4] He made a study of a number of small areas with reference to precipitation and run-off in the San Bernardino Mountains, California. He found in every case that the forest had a very decided effect in regulating the run-off of the water and in the regulation of stream flow. In this way the forests of southern Indiana especially have been of great value. Within the last quarter of a century by far the greater part of the Indiana forests have been removed, so that now but few areas of the primeval forests remain. That rain therefore, which falls, has in most cases, nothing on the steep soil to check it and disastrous floods are the result.

In the forest the heavy rain is first checked by the large trees and their foliage. From these the water next falls to the smaller trees and bushes, then to the thick carpet of leaves. The lower part of this bed of leaves is in partial decay and here again much of the water percolating through is temporarily arrested. From here the water is further arrested by the generally deep humus soil. In this way even most long-continued and heavy rains are effectually checked and a disastrous flood cannot well occur in a region possessing such a covering of the land. In addition most of the water which is checked in this way instead of rushing off as on barren land, gradually runs or seeps away, thus regulating the flows of streams and maintaining the nearly even and continued flow of springs.

There have been later floods in the Ohio River than the one of 1907, and the same applies to the streams of Indiana, due to deforestation which has taken place wherever timber was available.

A recent and severe penalty due mostly to reckless deforestation was given the state of Indiana and the whole Ohio valley in the disastrous flood of the Ohio River and its tributaries in the spring of the present year. This equaled or surpassed in some places the record of any previous flood and was especially remarkable for the suddenness of its appearance. The precipitation over much of Indiana and the Ohio valley in general was enormous and much above the average. For example Reynolds[5] states

---

[4] Toumey, James W. The Relation of Forests to Stream Flow. Yearbook of the Department of Agriculture, 1903.

[5] Reynolds, Robert U. R. The Ohio Floods: Their Cause and The Remedy. American Forestry, May, 1913, p. 288.

that from March 23 up to the morning of the 27th, Bangorville, Ohio, had a total of 9.50 inches (the normal rainfall for the whole month of March at that place is 3.93 inches); Marion, Ohio, 10.60 inches (normal for the month 3.51 inches); Bellefontaine, Ohio, 11.16 inches (monthly normal, 3.79 inches).

In the state of Indiana, in places, at least, the precipitation was even greater than in those just mentioned for Ohio. For example at Bloomington, Indiana, on March 25th, 6.56 inches[6] of rain fell, and for the month of March 13.3 inches. The normal rainfall for Bloomington for March is about 3.91 inches. The 6.56 inches of rainfall on March 25th, which was probably equaled or excelled in other states, occurred to a greater or less extent over at least half of the state of Indiana. This immense volume of water from an area in Indiana of about 18,175 square miles rushed away from the deforested hills unimpeded. As a result almost every stream in the state was immediately flooded far beyond its banks and every movable object washed away. It is probable that with such huge and sudden precipitations as occurred in March of 1913 the floods would not have been entirely prevented if the region affected had been covered by a dense forest. It would have prevented, however, most of this great flood and at the same time have prevented all or nearly all of the destructive results. If the flood during the spring of 1913 had occurred in winter, when the ground was frozen hard and covered with a deep snow, the results would have been appalling beyond description. Under such conditions in the deforested area the snow would soon have been melted and have added to the volume of water. The frozen soil could not have absorbed any of the water; little forest remains to have checked the flow in any way, so that the crest of the flood would have been higher and the extent of its destruction would have been much greater than it was. Yet this is exactly what Indiana and other states may expect sooner or later. Another great flood like that of 1913 might occur says Reynolds[7] "within the next decade, especially if, as asserted, we are now passing through a cycle of wet years." Under present conditions, however, with the greater part of the forests gone, and their destruction going rapidly on, we can easily see that heavy and sudden precipitations of equal intensity to those just referred to will cause greater floods and bring greater havoc than before. Floods are frequently fol-

[6] Government Station Report for Bloomington, Ind., March 25, 1913.

[7] Reynolds, Robert U. R. The Ohio Floods: Their Cause and The Remedy. American Forestry, May, 1913, p. 288.

lowed by serious drouths, such as the one of this year, frequently finishing the destruction of much that the flood may have left. In southern and southeastern Indiana Culbertson[8] states that "less than 10 per cent. of the original forest areas are still left intact," and the original forests that do remain have in most instances "not more than 30 per cent. of their former number of trees." Other parts of the state that were forested are about in the same condition. Culbertson[9] also draws attention to "the gradual lowering of the ground water level in all portions of the State" and the results of such a disastrous state of affairs. Culbertson[10] also points out for the southern part of Indiana which he studied that many "streams that thirty years ago furnished abundant power for mills during ten months of the twelve now are even without flowing water for almost half the time." The same state of affairs exists in most of the other deforested parts of Indiana. It is not at all difficult for one to recall springs and streams that ran vigorously the entire year but which now are either inactive or else run only during the wet season.

Erosion is generally one of the most conspicuous and damaging results of a flood in a deforested region. In foreign countries which have been deforested for a long time, as for example China, great damage has been done. The same thing I have seen in Italy, a part of whose once forested surface is badly cut up by the rush of unchecked floods. But in this country, especially in the southern part of Indiana, erosion is very evident and bottom lands that were not eroded have been damaged or rendered useless by debris and stones carried down from deforested hills.

A statement from a United States bureau[11] shows some of the results of erosion. "According to the latest determinations (beginning with the classic measurements of the Mississippi by Humphreys and Abbott) the rivers of the mainland United States are annually pouring into the seas fully 1,000,000,000 tons of sediment. This sediment is carried partly in solution but chiefly in suspension, in the 35,000,000,000,000 cubic feet or more of river water drained from the United States and is additional to the coarser detritus pushed or rolled along the sides of the swifter streams. The volume of material thus lost to the land is increasing with settlement and cultivation; it is almost wholly washed from the surface and is the

[8] Culbertson, Glenn. Deforestation and Its Effects Among the Hills of Southern Indiana. Ninth Annual Report of the State Board of Forestry, 1909, p. 63.

[9] I. C., p. 65.

[10] I. C., p. 74.

[11] Yearbook of the Department of Agriculture, 1907, p. 82.

very richest soil material, the cream of the soil. The value of the material is not easily fixed, but at a moderate appraisal the annual loss would exceed all the land taxes of the country. Besides impoverishing the soil, the sediment pollutes the water, reducing their value for domestic and manufacturing purposes and endangering the lives of those compelled to use them, and causing streams to scour their channels and build bars; and through scouring and building it compels the lower rivers to shift and overflow, thereby reducing the value of fertile bottom lands. However estimated the loss is enormous, and the chain of evils resulting from the annual erosion of this billion tons of soil is long and complex and leads directly back to the farm."

How easily and rapidly water may transport objects with the increasing swiftness of the current is seen from the following experiment given by Page[12]: "It has been found by experiment that a current moving at the rate of three inches per second, will take up and carry *fine clay;* moving six inches per second, will carry *fine sand;* eight inches per second, *coarse sand,* the size of linseed; twelve inches, gravel; twenty-four inches, pebbles; three feet, angular stones of the size of a hen's egg."

"It will be readily seen from the above," says Le Conte[13], "that the *carrying-power increases much more rapidly than the velocity.* For instance, a current of twelve inches per second carries gravel, while a current of three feet per second, only three times greater in velocity, carries stones many hundreds of times as large as grains of gravel." "A current" running three feet per second, or about two miles per hour, will move fragments of stone the size of a hen's egg, or of about three ounces' weight." Then from the law established we say[14] "a current of ten miles an hour will carry fragments of one and a half ton, and a torrent of twenty miles an hour will carry fragments of 100 tons' weight. We can thus easily understand the destructive effects of mountain-torrents when swollen by floods."

Hall and Maxwell[15] state that "when the slope exceeds 10 per cent., cultivation does not long go on before erosion sets in, and erosion if unchecked will remove the soil and gully the surface until all fertility has

---

[12] Page's Geology, p. 28. Quoted by Joseph Le Conte in his Elements of Geology, Fourth Edition, pp. 18-19.

[13] Le Conte, l. c., p. 19.

[14] Le Conte, l. c., p. 20.

[15] Hall, Wm. L. and Maxwell, Hu. Surface Conditions and Stream Flow.—Forest Service Circular 176, p. 10.

gone and all productive power is lost." And further Culbertson[16] says that in southeastern Indiana "contrary to what might have been supposed, a larger per cent. of the steep hill slopes has been cleared than the land of the more level regions." In such a case as this just the reverse method of clearing the forests as to location should have been followed for reasons above stated.

One of the ways in which large amounts of forest trees are destroyed is for railroad ties, and enormous numbers of them are required. Brisbie[17] states that "to build 71,000 miles of railway required 184,600,000 ties. Ties have to be replaced every seven years. As every one knows, railroad ties are cut from young timber, the trees being from eight to twenty inches in diameter, and this demand strikes at the very source of our timber supply." "The number of cross-ties in use on the railroads of the United States is estimated to be about 620,000,000; the number used annually for repairs and for extensions of track is estimated to be from 90,000,000 to 110,000,000, requiring, we may say, the entire product of 200,000 acres of woodland annually."[18] So rapid has been the consumption of timber for ties and the exhaustion of the supply so apparent that some years ago the Pennsylvania Railroad Company began to plant trees from which later on to get its ties. For railroads to do this is a rather late plan. Notwithstanding some views to the contrary, iron ties ought to be used and probably will be used in the future. About the year 1888 the fences of the United States were valued at "$2,000,000,000," "and it" cost then "$100,000,000 annually to keep them in repair."[19] These and other causes aside from lumbering show the waste of timber which years ago could have been practically prevented by the use of other and better materials. In most instances if the timber removed from the land and wasted were now available it would exceed in value that of the land.

In 1909 there were 48,112[20] saw mills being operated in the United States. Of these in 1910 there were 1,044[21] in Indiana. These mills vary much as to capacity, but the daily output of all is enormous. Timber is today being cut into lumber that a quarter of a century ago in Indiana would in many cases have been rejected as fuel. In addition we have in

---

[16] Culbertson, Glenn. l. c., p. 63.

[17] Brisbie, James S. Trees and Trees-Planting. 1888, p. 9.

[18] Fifth Annual Report of the State Board of Forestry, 1905, p. 209.

[19] Brisbie, James S., l. c., p. 9.

[20] Elliott, Simon B. The Important Timber Trees of the United States, 1912, p. 10.

[21] American Forestry, 1913.

Indiana as elsewhere the veneer-mills, that are able, however, to cover up a multitude of sins.

Following deforestation comes, sooner or later in this country, the proverbial forest fire which completes the destruction by killing the small trees and destroying the possibility of the future forest. It is not necessary to discuss the results of such fires further than to state that locomotives generally cause most of such conflagrations, and consequently steps are being taken to have the trains in some places, as in parts of Canada, run by electricity. Spark arresters are a failure. In 1909 it was estimated that in Indiana the annual loss from forest fires was $175,000,[22] and this seems to be a very conservative estimate. For the prevention of fires in Indiana some laws have been enacted and in every possible way those in charge have endeavored to lessen the danger. Efforts to pass more favorable laws for forestry have been attempted in Indiana, such as exemption from taxation, but this "failed because it could not be done constitutionally."[23] It would be well if the cutting away of the forests could be controlled by law. For instance it is a serious mistake to allow anyone to buy a stretch of forest, especially in hilly districts, then to move in a sawmill and cut out all the available timber without regard to reforestation or results, and then finally to sell the land for what it will bring or to allow the soil to wash away. In some foreign countries the removal of forests is controlled. In France, for example, even years ago an owner was not allowed to remove forests on his land without "four months" notice in advance. The forest service may forbid this clearing in case the maintenance of the forest is deemed necessary upon any of the following grounds:

"1. To maintain the soil upon mountains or slopes.

"2. To defend the soil against erosion and flooding by rivers, streams and torrents.

"3. To insure the existence of springs and water courses.

"4. To protect the dunes and seashore against erosion of the sea and the encroachment of moving sands.

"5. For purposes of military defense.

"6. For the public health."[24]

---

[22] Tenth Annual Report of the State Board of Forestry, 1910.

[23] Fifth Annual Report of the State Board of Forestry, 1905.

[24] Pinchot, Gifford. Publications of the American Economic Association, 1891, Vol. 6, pp. 214 and 215.

Germany and Switzerland also maintain a wise control over their forests. Similar protection of the forests of this country should be enacted. One very noticeable thing in this state and country is the extreme waste of the forest resources. This is seen from the time the tree is cut in the woods until what remains of it is issued in the finished product.

This is not the case in some foreign countries, and should serve as a useful lesson to the state. Great service has been rendered to the state already by those who have worked to have the present Indiana forestry laws enacted and by those who by instruction or advice have endeavored to further the cause of forestry in Indiana.

Notwithstanding the presence of other factors which may help to produce or prevent floods, the fact remains as has been sufficiently outlined in this paper by various examples, that deforestation is by far the greatest cause of floods. The examples have shown that where forests are present floods are practically absent, and as the forests are removed the floods become more numerous and destructive.

Probably the most thorough study thus far of any single stream in this respect is that made by M. O. Leighton[25] for the Tennessee River. The same state of affairs exists in Indiana, and every effort should be put forth to remedy the danger. The one great element of success will lie in the proper education of the public to the disastrous results of reckless deforestation and the benefits of forest preservation. As Elliott well says: "Probably our forests are in no worse condition today than those of Germany and France two hundred years ago, when those nations began reforestation. Success crowned their efforts and should ours, if we put forth the same endeavors."[26]

[25] Leighton, M. O. Floods in the United States. Cited from Hall and Maxwell, l. c., pp. 5–6.
[26] Elliott, Simon B., l. c. p. 13.