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### THE GRAND RIVER, ONTARIO PENINSULA.

Effect of Deforestation and Swamp Drainage.

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(Read before the General Section, 14th December, 1905.)

The peninsula of South-Western Ontario is remarkable for the great bodies of fresh water surrounding it. Taking as north-easterly limit the shortest line between Georgian Bay and Lake Ontario the area of the peninsula is 16,500 sq. miles. The area of the abutting bodies of water, Lake Huron, Lake Erie, and part of Lake Ontario, is 33,900 sq. miles, while adjoining Lake Huron on the West and North-West are Lake Michigan, 25,000 sq. miles, and Lake Superior, 32,000 sq. miles.

In topography the Peninsula presents what may be called a table land, comprising parts of the counties of Grey, Wellington, and Dufferin (see map, Plate 1,) from which the surface slopes in every direction, abruptly to the North, where the fall is over 1,100 feet in a little more than twenty miles, more gradually towards the West and still more so towards the South-West and South, to the almost level rim of surrounding water, the difference in level between Georgian Bay and the inlet of the Niagara River, i.e., between Lake Huron and Lake Erie, being only about nine feet. In general the surface is rolling. A broad, flat area extends for the greater part from the outlet of Lake Huron along the southerly limit of the peninsula almost to Lake Ontario. A peculiar feature is the Niagara escarpment, an abrupt rise of 200

to 300 feet defining the difference in level between Lake Erie and Lake Ontario, and extending along the south shore of Lake Ontario a distance of from five to ten miles to Hamilton, where it is near the head of Burlington Bay. Thence it stretches to the North and is well defined for a long distance. To the East of what has been called the table land a broad ridge forms the watershed between Georgian Bay and Lake Ontario, sloping down to the level of Lake Simcoe, which is 140 feet above Georgian Bay and 475 feet above Lake Ontario.

Westerly winds are largely preponderant. Graphic evidence of this is afforded on the exposed islands of Georgian Bay, where the wind has almost a clear sweep for 500 miles, by the scrub pine with their well marked slant and their branches mostly on one side of the trunk. The origin of most of the precipitation is herewith indicated. A large part, especially in the south-easterly part of the Peninsula is, however, also due to east winds over Lake Ontario.

Originally the Peninsula was covered with an almost continuous heavy forest of pine and hardwood, interspersed with swamps. In 1901 the woodland area had been reduced to 14.9% of the whole, and since then it has become still less. A large decrease of woodland was noted from 1897 to 1901. There are a few comparatively small forest reserves in Ontario, but none in the Peninsula.

What climatic change has been caused by deforestation is not definitely known. Variations in temperature seem to have become much greater and more abrupt, and transition between the seasons of the year also more abrupt. The forest cover kept the ground moist after rainfall and retarded melting of the snow. Precipitation records have been kept at various points on the lakes for over sixty years. In Toronto the records date from 1840, for which year the record is 29.57 in. rainfall as against 30.4 in. in 1904. The average total precipitation, dividing snowfall by 10 to reduce to water, for sixty years is 33.0 in., with minimum 24.37 in. in 1874, and maximum 48.49 in. in 1878. For the past ten years the average is 31.1 in. There is to be said that rainfall and snowfall observations are at best only approximate. There is a personal equation of the observer, and results have been found to vary materially with the height of the instrument above the ground, other conditions being alike. In the interior of the Peninsula records have been only recent, for about the last twenty-five years, but fairly well distributed. From a table compiled for the years 1883 to 1888 it appears that the greatest precipitation is near the height of the north-west slope, over 40 in., other areas showing mostly 35 to 40 in., and 30 to 35 in. In passing it may

be said that this is very favorably above the minimum of 20 in. accepted as necessary for agricultural or pastoral purposes.

It is clear that precipitation in the Peninsula is not materially affected by deforestation, but is due more to the permanent conditions already outlined. The run-off is, however, very directly affected. The forest cover not only checks evaporation and snow melting but renders the surface permeable so that the water finds its way more readily into the ground to appear elsewhere in the form of springs, and by drawing up and exhaling moisture beneficially affects the atmosphere. Large swamps are natural reservoirs, like great sponges, and are extremely valuable in giving regularity to flow of springs.

The drainage area of the Grand River, as shown in shaded outline on the map, comprises nearly the whole of the counties of Wellington, Waterloo, and Brant, and parts of Dufferin, Halton, Oxford, Wentworth, Norfolk, and Haldimand, a total of 2,600 sq. miles, approximately one-sixth the area, and essentially the central part, of the Peninsula. In its original condition, about up to the year 1800, this whole area was densely wooded or covered with swamp. Some little clearing had been done before that date. From 1800 settlement extended as far as Waterloo County, which by 1820 was mostly taken up. From about 1850 on, settlement extended farther up, but the headwaters of the river in the townships of East and West Luther, Amaranth, Melancthon, and Proton remained practically intact until 1870. The township of Luther, now East and West Luther, as recently as 1871 is described as nearly wholly consisting of impenetrable swamp. The adjoining townships were largely swamp and partly hardwood forest. In the following years drainage of these townships, aided by special provincial legislation and provision of funds, became rapid, as did also the general clearing off of forests.

Up to about the year 1860 the flow of the river was fairly regular, with a good body of water throughout the summer and no great floods as a rule in the spring, except locally where the water might be held back by the formation of ice gorges. The spring freshets were in April or beginning of May, and only exceptionally as early as March. A record kept in Galt beginning with 1858 gives the spring freshets at that point as in March for the four years 1858, 1856, 1860, and 1861 (these years from other records appear to have been very low in snowfall) after which until 1877 they were almost all in April. After 1877 the floods were mostly in March and twice at the end of February.

The minimum summer flow seems to have decreased more particularly since about 1875, coincident with the drainage and

clearing of the head townships. From fairly definite evidence at points in Waterloo Township the decrease in the past fifteen years appears to be fully 40% of the minimum in 1890. At Galt (total drainage 1,325 sq miles), and farther down the river the decrease appears not to have been so much. The Speed River empties into the Grand above Galt and the Nith at Paris. (Total drainage 2,020 sq. miles.) The drainage areas of these tributaries have not changed so much in recent years.

The proportion of woodland in the drainage area in 1901 was, by townships, as follows:—

Melancthon.. . . . .	16.2	North East Hope.. . . . .	10.4
Arthur.. . . . .	6.8	Wilmott.. . . . .	10.2
West Luther.. . . . .	7.2	Waterloo.. . . . .	9.8
East Luther.. . . . .	5.3	Puslinch.. . . . .	6.9
Amaranth.. . . . .	1.9	Blandford.. . . . .	12.4
Burford.. . . . .	11.9	Blenheim.. . . . .	8.5
East Garafraxa.. . . . .	6.8	North Dumfries.. . . . .	12. .
Maryborough.. . . . .	14.3	South Dumfries.. . . . .	5.4
Peel.. . . . .	14.8	Beverly.. . . . .	11.8
Pilkington.. . . . .	6.5	West Garafraxa.. . . . .	1.4
Nichol.. . . . .	15.1	Burford.. . . . .	11.9
Eramosa.. . . . .	10.7	Oakland.. . . . .	17.3
Erin.. . . . .	5.8	Brantford.. . . . .	2.7
Mornington.. . . . .	10.8	Onondago.. . . . .	9.
Wellesley.. . . . .	15.4	Townsend.. . . . .	12.8
Woolwich.. . . . .	13.7	Tuscarora.. . . . .	not given
Guelph.. . . . .	7.6	Oneida.. . . . .	11.1
Nassagaweya.. . . . .	21.1	Cayuga.. . . . .	4.4

For the whole of the drainage area the percentage of woodland is 9.85.

The main source area of the Grand River may be considered as extending to Elora, above Pilkington Township, with a surface of about 425 sq. miles. The snowfall throughout this section is very great. At Fergus one snowfall year is recorded as 135 in., and a number of years are over 100 in. Formerly the forests and swamps retained the snow and let it off gradually. The country from the north of Melancthon to almost the south line of Luther Townships, an extensive plain, is now of hard surface, largely, though not mostly, in grazing land which can be traversed across country independently of roads in almost any direction. A few warm days in February or March start the run-off with a rush, and it takes but a short time for the accumulation of snow to disappear.

For comparison it will be of interest to note the forestation in some of the oldest and most thickly populated countries of Europe. A recent tabulation, 1902, gives the following percentage of forest to total area:—

Germany.....	26%
France.....	18%
Belgium.....	17%
Hungary.....	28%
Austria.....	32%
Spain.....	17%
Italy.....	14%

Could the forestation of the Grand River basin be increased to 20% or more there would be no question of great benefit in regulation of flow. The Provincial Forestry Reports class a large part of land as waste. The total in the Grand River drainage area from the 1901 report is 12.3%, the percentage being larger in the upper townships. Waste lands are given as including swamp and marsh. These are by no means waste when their river regulation value is considered, and for this purpose a large increase of swamp and marsh area would be welcome. There are also large areas of cleared non-arable land, and these present special opportunities for reforestation. In the United States reforestation in various parts of the country, has become well established. In Massachusetts, the Boston Metropolitan Water Board alone reforests about 200 acres per annum.

When it is considered that the valley of the Grand River is already well populated, will in a short time have three large cities, Berlin, Galt, and Brantford on the river, and is and will continue to be, one of the foremost manufacturing districts in the Dominion, forethought and provision in the way of establishing conditions to benefit the climate and regulate excesses of the river must be held to be well worth while.

The available water power of the river and its improvement by regulation of flow is a feature of great importance. The total fall from Dundalk, with elevation 1,710 ft., to the mouth of the river is nearly 1,140 ft. Elevations are successively as follows:—

Grand Valley.....	1,510 ft.
Elora.....	1,250 ft.
Breslau.....	961 ft.
Galt.....	847 ft.
Paris.....	803 ft.
Brantford.....	641 ft.
Lake Erie.....	572.3 ft.

In many places there is a very considerable fall in a short distance. In Elora there is a single drop of over 40 feet, where the river enters a limestone gorge. The water power is made use of at a number of places along the river. Its value is greatly impaired by the extreme low water continuing for about two months in the year.

The flow regulation of the river by means of large storage basins is for the present hardly practicable from an economical view point, and will not here be further considered.

The cross-section (Plate II) taken three miles above Breslau, Waterloo Township, is a typical one for a large part of the river. The low water discharge at this point, as measured in September this year, is 82 cubic ft. per second. The spring flood discharge is approximately 10,500 cubic ft. per second, and has been considerably more. The maximum continues for a short time only, a few days at most. A heavy rain raises the water level very quickly, and has in recent years given a rise of as much as 4 ft. over night. At Brantford the spring flood in 1900 was 16 ft. above low water level. At Galt the minimum flow appears to be about 60% more than at the section given, this being due to the Speed River. Former spring high water and summer low water are shown approximately on the section. The photograph, Figure 1, taken near the section (Plate II) shows recent high and low water levels, high water being about a foot above the bare place on the tree at the edge of the bank where ice has cut away the bark. Figure 2, near the same place, shows a small elm 8½ in. in diameter immediately above the ice-scarred part of the trunk. High water rises about 6 ft. on this tree. Its age would be about 30 years, indicating the probable period of ice floe encroachment on the ground at its base.

In conclusion it is to be stated that definite observations in the drainage basin are few. Precipitation records have been kept since 1881 only at Guelph at the Ontario Agricultural College, and these are much the most reliable; and at Brantford, Galt, Conestogo, Elora, and Fergus, for periods of from five to ten years. There are no data on run-off, except roughly general ones.



FIG. 1



FIG. 2

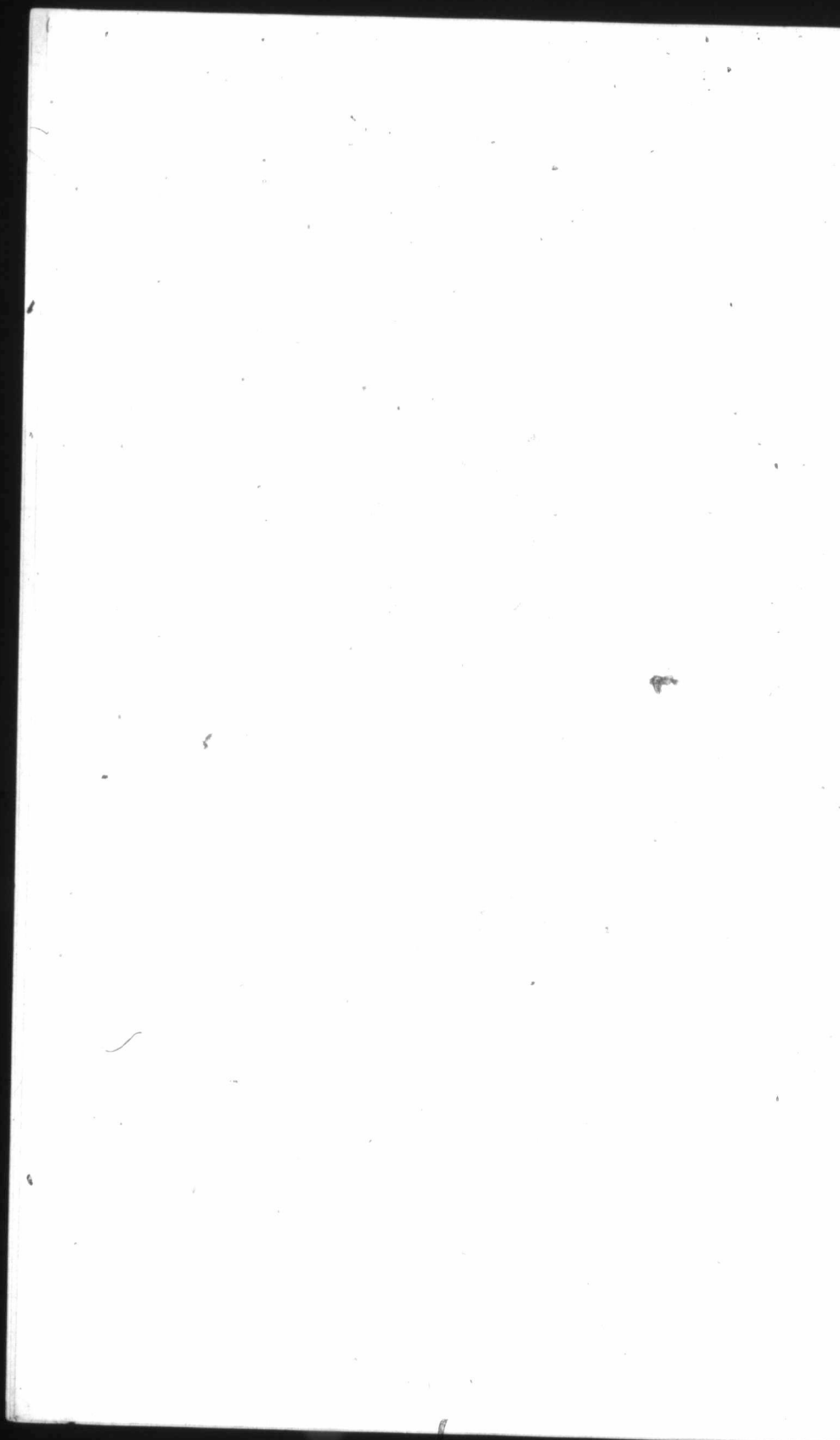
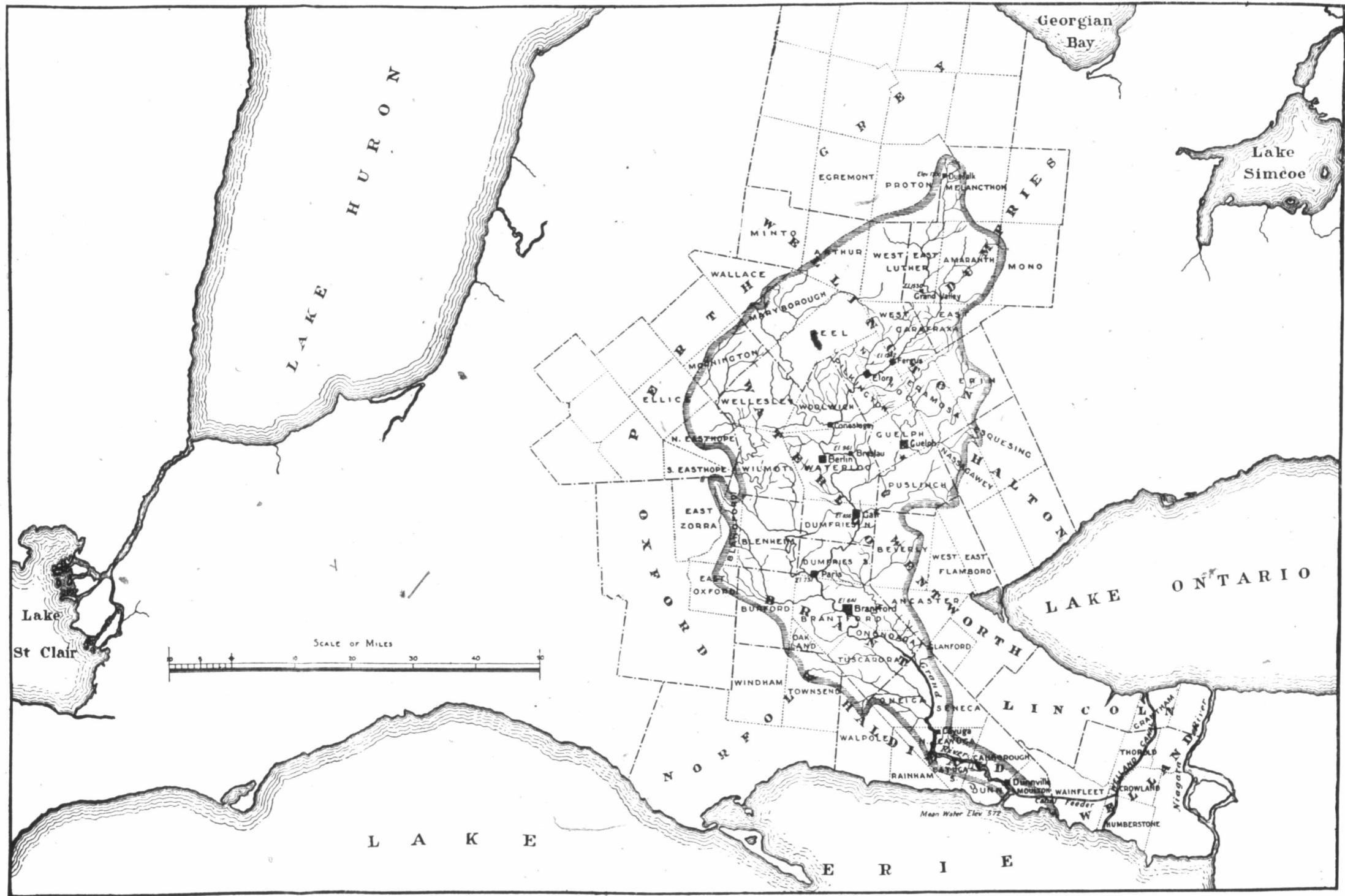




PLATE I.



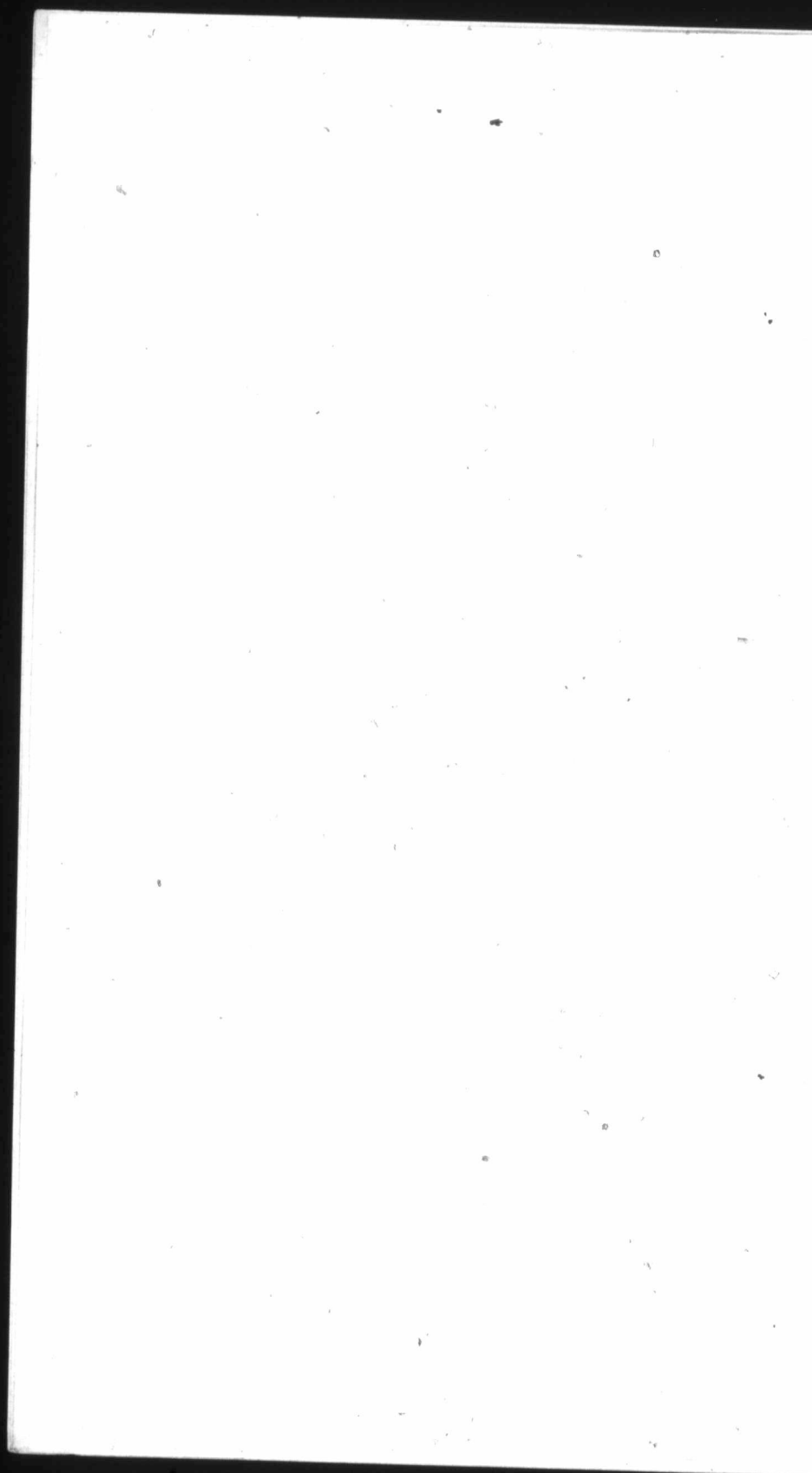
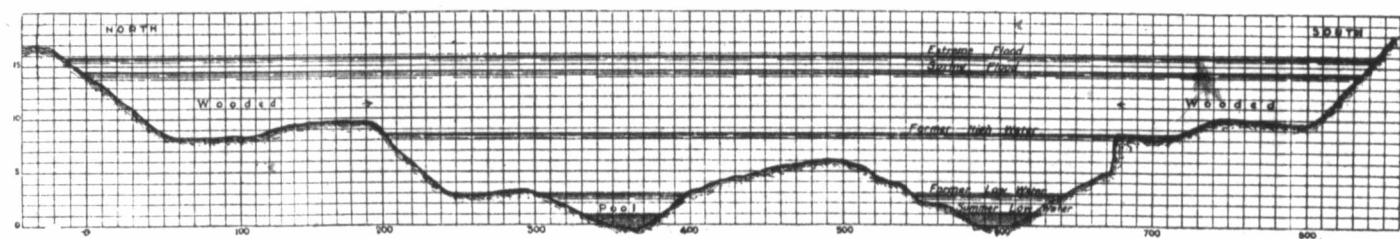


PLATE II.



Cross-section of the Grand River above Breslau.