THE GLACIAL POT HOLE AREA, DURHAM COUNTY, ONTARIO

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Protection forests, where absolute forest land is located at the headwaters of several prominent streams, are taken for granted.

It is contended that marginal and sub-marginal agricultural lands, when located at the headwaters of rivers or creeks flowing through more valuable agricultural lands, should be considered in a similar manner and a protection forest established. The area under discussion comes under this classification and combines several other very valuable features.

This is the first time, to the writer's knowledge, that it has been established that such a large area of a glacial moraine had no surface drainage to the adjacent streams, and yet, owing to the nature and depth of the sand and gravel formation, it contained the ground water reservoir which fed springs in those streams and kept the flow fairly uniform all year. This reservoir has been seriously depleted during the past one hundred years. It is contended that proper ground cover will reduce evaporation of Fall and Winter precipitation and make more water available for ground water storage.

Groups of pot holes, such as the ones under discussion, are a very interesting geological formation and at the same time are of inestimable value to the surrounding agricultural lands.

THE PRESENCE of depressions in the sand and gravel interlobate moraine, which was formed by glacial action across the county of Durham about 15 miles north of Lake Ontario, has been known to many people since the country was first opened up for settlement. The exact location and true significance of groups of these depressions, however, is just now beginning to be realized. During a conservation study of the northern part of the Wilmot Creek Drainage Unit which was made in 1939-40 a certain number of data were collected which indicated that a portion of the glacial moraine was acting in the capacity of a ground water reservoir of unusually large dimensions. With this point in mind, it was decided that a rough survey should be made to determine the boundaries of areas that could be classed as depressions or pot holes and to show them on a plan in relation to the drainage units which are fed, in part, by the reservoir created by those pot holes.

A set of aerial photographs, which would show ground conditions from Burketon through Pontypool to Rice Lake and from the northern limits of drainage into Lake Ontario to the southern limits of drainage towards the north which forms part of the Trent River Drainage System, was obtained and studied with the aid of stereoscopic glasses.

In the field it was found that the depressions in the glacial moraine had been formed in various ways. Some were like bowls, the rims of which were high and sharply defined. Absolutely no water could get out of these by surface drainage. A second formation was similar to the tributaries of a stream with all ravines leading the water to a hole with such high sides that again there was no chance of water getting out to any of the rivers going south to Lake Ontario or north to the Trent River. A third formation, similar to the last mentioned, had the ravines leading to one of the main river systems but at some point a mound of sand and gravel obstructed surface drainage. On the Dominion Government contour map these ravines were shown as being definitely a part of that river but on the ground the mound was found to be less than the twenty-five foot contour interval and a hand level had to be used to get the true story of what happened to spring flood

waters. These mounds may be high enough to hold all the water which comes from higher elevations or they may allow a certain amount of overflow in years of excessive precipitation or when heavy rainfall comes just at the time of the melting of a large accumulation of snow. The water held by these natural dams, and the pot holes, does not join the spring floods but is held for a period of several days or weeks or until the frost is drawn out of the ground. The water in some pot holes disappears very quickly, others drain more gradually, and those at Pontypool retain a quantity of water all summer and fall. These points were checked on three occasions in the spring of 1940. In the spring of 1941 there was so little frost in the ground that the majority of the holes absorbed the water as fast as the snow melted.

By interviews with many residents of the locality it was learned that the ponds at Pontypool had a much higher water level in the early days. Also, certain holes which collect spring flood water and hold it for very short periods at the present time, used to be ponds all summer, similar to the ponds at Pontypool. Residents located at the source of the rivers flowing both ways from the glacial moraine gave accounts of fishing in brooks which are dry now, except during the spring floods. These brooks were fed by springs located at elevations higher than the present springs and they flowed all year.

The information obtained in this way led to more careful observations of the springs on all sides of the glacial moraine. Their approximate elevations were charted and it was interesting to note that the majority of them made their appearance at 875 to 1,000 feet above sea level. Also that those springs which flowed with a more or less regular volume all year were those adjacent to areas where pot holes were known to be located. Springs which were irregular and were not strong enough to flow continuously were found to be adjacent to a sharp divide where all surface water was drained quickly from the slopes in the spring flood and after thunderstorms. The ravines in which the irregular springs were located had a much longer stretch of dry creek beds not only at the headwaters but even down into the agricultural areas of lower elevation.

In the report on the drainage unit of the Wilmot Creek¹ it was noted that there was a certain amount of similarity in the elevations of the ponds at Pontypool, the water table tapped by drilled wells on the high lands, and the elevation of springs on the south slope of the moraine, as shown below:

Approximate elevation of Pontypool ponds	1050 feet
Wells on the high lands	925-1025 feet
Approximate elevation of the main springs feeding streams adjacent to the pot hole area	875-1000 feet

It may be of interest to note that Lake Ontario is 245 feet above sea level and the highest part of the moraine is approximately 1250 feet.

It is impossible, with the present information, to make any statements in regard to the exact structure of the interlobate moraine, but, to visualize its water holding capacity, it might be advisable to discuss the possibilities. There was, apparently, a large quantity of sand and gravel pushed up between the two lobes of the glacier. This varied from zero to 250 feet or more in depth.

¹ Wilmot Creek Drainage Unit. This report can be obtained free of charge by applying to the Dept. of Lands & Forests, Reforestation, Toronto.

The information about springs and wells would indicate that there is an impervious formation in the vicinity of the thousand foot elevation. It is quite possible that this is an uneven formation of glacial till containing underground drainage systems of different sizes and pot holes of varying depths. This might account for the drilled wells tapping water tables between 925 feet and 1025 feet. In the same way it might account for the appearance of springs at 875 feet to 1000 feet. The water from the pot holes seeps slowly down through the sand and gravel until it reaches the water table, and then it gradually finds its way by means of the underground drainage systems to the springs. A certain amount is retained in the finer sand formations by capillary action. Water pressures may play some part in the distribution of the water at the lower levels. At any rate we know that the springs flow all summer with a very even discharge. Fluctuations of flow in the summer are more liable to be from thunderstorms and resultant surface drainage.

To present the picture of the relationship of the pot hole area to the ten main streams in Durham County, a map has been traced from the Dominion Government Topographic map on the scale of one mile to one inch and later reduced. The height of land between the pot hole area and the streams has been ascertained fairly accurately by the use of the aerial photographs in the field, while the divides between streams has been sketched roughly by use of the contour lines on the topographic map.

The area of each has been planimetered and is shown in the following table in square miles and in acres.

	Square Miles	Acres
Drainage Units Flowing South to Lake Ontario		
Bowmanville Creek	36.2	23,200
Soper Creek	31.6	20,200
Wilmot Creek	34.4	22,000
Ganaraska River	104.6	66,900
Drainage Units Flowing North To Trent River System		
East Cross Creek	42.2	27,000
Pigeon River	56.1	35,900
Fleetwood Creek	27.5	17,600
Cavanville Creek	60.1	38,500
Baxter Creek	31.9	20,400
Squirrel Creek	23.2	14,900
Pot Hole Areas		
Burgeton Area	2.1	1,345
Pontypool Area	26.9	17,215
Fourteen smaller areas	1.6	1,050
Durham County	580.	371,337

It should be pointed out that, while the total area of the county has been shown, this is only for reference, as the drainage units mentioned, plus the pot hole area do not make up the total area of the county.

The survey was not continued west of the Burketon area but there is every reason to believe that a similar formation continues westerly into Ontario County and York County. It may not always be as compact as the one in Durham County, but this can be ascertained only by a ground survey with the assistance of the aerial photographs and contour maps.

Map of Durham County showing the location of the Pot Hole Area and its relation to the streams flowing northerly and southerly from the sides of the glacial moraine.

It can be seen by a study of the map that the main pot hole area is located quite centrally in Durham County. It remains, now, to construct a mental picture of conditions which existed for hundreds of years before the county was explored and settled; to follow the progress of land clearing and land use to the present day conditions; to study the relation of changes in forest conditions to the changes in soil conditions and water conditions; and finally to decide what steps must be taken to improve the present improper use of all three, with special reference to the sand lands of higher elevation.

The compact forest growth which covered Durham County for a long period of years prior to settlement would be dense enough to reduce to a minimum the evaporation from the surface of the snow. No meteorological records are available for this region during the period in question, but it can be assumed² that there was a slightly greater amount of precipitation due to the forest growth and the increased elevation than what the figures for

² "Forests and water in the light of scientific investigation," by Raphael Zon. Page 10—Table showing precipitation within and outside of the forest at different altitudes. Page 13—Example of increased precipitation over newly established forests in Europe.

Toronto show for ninety-five years, or the figures for Orono for seventeen years. Forest soils built up over hundreds of years by decaying vegetable matter were porous and, in combination with root channels, held large quantities of water and made it readily accessible to the lower soil strata. In the pot hole area in the spring of the year the melting snow water was collected in the holes and ponds and gradually allowed to seep into the sand and gravel moraine. Over a long period of time a reservoir of ground water was built up in the sand and gravel hills. In the drainage units, the water from the melting snows was gradually drained off to the larger bodies of water. There were floods but they were not like present day floods as stream courses were blocked to a considerable extent by debris of the forest. Banks of streams were protected by roots of shrubs and trees. The flow of water in the drainage units started very close to the height of land and due to the fact that the ground water reservoir under the pot hole area was well stocked, the springs of higher elevation were fed continuously. In fact the first settlers did not have to bother about digging wells. All soils were covered by a rich forest humus which was cultivated into the mineral soils or burnt off during land clearing operations. One of the problems of the early farmer was to drain the surface water off the land quickly so that crops could be sown earlier. Gradually the forested area was reduced and cultivation of more land was accelerated. The protection afforded by tree growth being removed, the winds helped to dry out the soils, and in areas of light sandy soils it even blew away the dried up humus content that had been built up by long periods of decaying forest vegetation. Evaporation of both snow and rain was accelerated by the force of the winds in the opened-up agricultural areas. This became particularly serious in winter as the snow could not accumulate as it did when there was a protective forest cover. It is possible that there was a slightly decreasing amount of snow. To this was added the fact that frost went into the open soils in the early fall and made them impervious to water during the spring thaw, increasing the sudden surface run-off of melting snow water. Naturally this is what the farmer wanted, and being intent on immediate crop production he neither cared where the water came from, nor where it went, and at the same time he was unable to see or comprehend what was happening to his soil. Fertility of the soil decreased and crop yields decreased. Farmers who used to have small streams on their farms, found that they were drying up part time and finally only contained water during spring floods. Wells, which were very shallow, had to be deepened, and later some had to be abandoned. Some farmers had to resort to drilled wells which would tap a deeper water table. Some farmers on the

POT HOLE LOCATED ON LOT 27, CON. IX, CLARKE TOWNSHIP

Fig. 1. April 9, 1940. The collection of snow water is well advanced.

Fig. 2. April 23, 1940. The water is seeping into the ground and the level is now five feet below the point where it was when the above picture was taken.

Fig. 3. The same pot hole in the spring and early summer when it is used as a grazing area for cattle.

GLACIAL POT HOLE AREA--CARMAN

115

THE PONTYPOOL PONDS

Fig. 4. This pond is located east of Highway 35 and has been used by residents and summer visitors as a bathing pool. In 1941 it is too shallow for that purpose. Note line of willow shrubs located along one of the former water levels.

Fig. 5. This pond is located west of Highway 35 and to the southwest of the village of Pontypool. The former water levels are not as prominent as in Fig. 4, but can be traced on the ground.

highlands, who could not afford to drill wells, had to arrange to store rain water for cattle. Sand and gravel hills, which were opened to cultivation first and which produced good crops, while properly protected, were gradually reduced to grazing areas and then on account of overgrazing to blow sand or water eroded waste lands. Rural population, which increased rapidly after 1810, in Darlington, Clarke and Hope Townships, reached an upper peak in 1861 and then gradually receded till in 1931 it was approximately one-half of the highest count. There were several reasons for this, but the increase in the amount of poor soils was a factor of no small importance. The remaining forest was seriously exploited and opened for grazing. The ground, becoming packed by trampling herds, permitted frost to enter more easily and penetrate more deeply. The wooded areas were not able then, to act in their capacity as a protection to the winter snows and were, on the other hand, unable to absorb the spring snow water. This, of course, reduced the seepage which is neces-

sary to maintain ground water tables and ground water reservoirs. The location of woodlots on the high land is the result of individual land clearing operations and no thought was given to the possible relation of the woodlot to moisture conditions. Assessment values of all light lands, denuded of timber, were lowered to a point where the owners could continue to pay taxes and make a mere existence. When certain of these sand areas were sold at tax sales they were bought up and held as grazing areas or fuel-wood supply by more prosperous farmers located in the better agricultural sections. Township councils make an effort to keep these light lands in circulation and as a result there is very little of it available.

The conditions which have been sketched above refer to the pot hole area as well as to the headwaters of the drainage units. The main difference in the former is that there is no surface drainage beyond the limits of the area. The pools of water which are found in the pot holes in the spring of the year are the result of the winter precipitation. It is necessary, therefore, to break down the figures of the average precipitation³ taken at the meteorological stations at Toronto and Orono, and reconstruct them by seasons. During the five winter months from November to March there is an average of 13.14 inches at Toronto and 15.92 inches at Orono. During the five months of the growing season from April to August, the average is 13.61 inches and 13.41 inches. In the balance of the year, September and October, it is 5.33 inches and 5.16 inches, respectively.

Unfortunately no one knows what happens to that precipitation which occurs in the five winter months but this is a problem which should be studied in the thirty square miles of the pot hole area. It is contended that with a protective forest cover the amount of evaporation can be reduced and the amount available for deep seepage increased. The amount of precipitation might even be increased. These statements, based as they are on circumstantial evidence, are open to discussion, but there has been a definite trend from bad to worse, and it would seem reasonable to make an attempt to bring back some of the conditions which were found by the early settlers. At least the waste areas would again be productive.

That the ground water reservoir has been depleted can be proved by the following points: (1) The drop in the water levels of the Pontypool

3. TABLE SHOWING AVERAGE ANNUAL PRECIPITATION

Toronto					
(Period—95 years, Annual Average 32.08 inches)					
Nov.	2.79	April	2.46	Sept.	2.91
Dec.	2.64	May	2.82	Oct.	2.42
Jan.	2.74	June	2.66		
Feb.	2.44	July	2.90		5.33
Mar.	2.53	Aug.	2.77		
	<u>13.14</u>		<u>13.61</u>		
Orono					
(Period—17 years, Annual Average 34.49 inches)					
Nov.	3.64	April	2.88	Sept.	2.98
Dec.	2.85	May	2.52	Oct.	2.18
Jan.	3.62	June	2.84		
Feb.	2.80	July	2.66		5.16
Mar.	3.01	Aug.	2.51		
	<u>15.92</u>		<u>13.41</u>		

ponds; (2) The disappearance of other ponds; (3) The failure of streams and permanent springs above the 1000 foot contour line; and (4) The trend to deepen wells.

Constant records should be kept from the present time upon which plans for the future can be based. These would include meteorology, soil erosion, stream flow and forest data.

The problem of the control of the spring flood waters in the drainage units surrounding the pot hole area has no bearing on the subject except for the lessons which can be learned by the natural barriers of sand and gravel which were deposited in the upper tributaries of some of the drainage units and the ponds which are formed for a short period of time each spring. Artificial dams (large mounds of sand and gravel) could be constructed very easily and very quickly by large tractors in the dry tributary ravines of all drainage units. They could be placed in such a way that the spring snow water would never gain momentum. Not only would this policy reduce the amount of spring flood water by reducing the area of the drainage unit, but it would increase the area of the reservoir under the pot hole area. This impounded water would seep into the sand and gravel soils and not only augment the reservoir but would keep springs in the lower elevations of the same drainage unit running stronger during the summer.

No definite figures are available at the present time in regard to the amount of land that could be added to the pot hole area by this method of conservation, but it is estimated that the thirty square miles could be doubled. Again there are no figures as to the amount of reduction in each of the ten drainage units, but from the standpoint of conservation as well as the economic problems of the county, control of flood waters in the higher elevations of each drainage unit far surpasses the value of any flood control by large dams in the lower reaches of the unit. Naturally, all work on small dams and conservation of water in this manner would be co-ordinated with proper protective soil cover. The holding of spring snow water by small ponds in the dry tributaries of a drainage unit reduces the volume and momentum of the flood. This in turn reduces the amount of soil erosion by water as well as offsetting the possibility of having good soils at lower elevations buried under sand and silt washed down by the force of the flood. The problem of soil erosion of hilly sites in southern Ontario is not as serious as it is in the United States, but there is evidence of it every spring and summer, not only on sand soils but on the heavier agricultural soils. Photographs have been taken and general observations made on the problem of soil erosion and there is reason for all farmers on the glacial moraine to be alarmed at the annual loss of the fertile top soils. Part of this can be controlled at the headwaters of streams.

With these details properly oriented there seems to be no doubt that the past and present generations have been wholly occupied with their immediate problem of making a living, and in so doing they have mined and misused their natural resources of forest, water and soil to a point where a continuance of the present policy will mean a continued lowering of the productive capacity of the remaining good soils.

A complete return to the conditions which the early settlers found cannot be expected, but it is contended that, with the proper management of all lands included in the boundaries of the pot hole area, in conjunction with the sand lands of the upper parts of all ten drainage units, a partial restocking of the water reservoir could be attained. This would help to solve the problem of water supply for springs and wells in the agricultural areas of lower elevation. The area in question is undoubtedly of major importance in the county of Durham. It has possibilities for recreational uses, as a wild life sanctuary, and as a moderating influence on climate. It should be made a provincial or a national reserve, subject to a carefully prepared working plan, and held as a protection to stream flow in the ten separate units. The first essential would be to make a soil survey. Areas where the use of the land would have to be controlled or restricted would have to be bought outright. If agricultural lands have to be purchased and included in the reserve, then these should be leased to private individuals under specific terms. Reforestation should proceed as quickly as possible. Grazing of cattle, horses and sheep should be prohibited and even the number of deer should be kept under control. Since the aerial photographs used were made in 1927, it would be more satisfactory to obtain an up-to-date set. Further detail of the working plan would have to be elaborated upon when required, but another essential would be a meteorological station and a soil erosion experiment station with authority to put their findings into practice in the hilly section adjacent to the reserve. Consideration would have to be given to private individuals who have had the foresight to establish plantations on these light soils, but the acreage involved is very small and should not be a problem. The counties of Durham and Northumberland have purchased and reforested approximately eleven hundred acres in concessions IX and X of Clarke Township.

To say that this poor, light land should be purchased from the private individuals now owning it, is really not the proper term, particularly where this is the only means which they have of making a living. The sum of money which they would receive in the open market would not buy much land in the agricultural sections, and at the same time carry the cost of becoming re-established. If the present ownership is a detriment to the community, as a whole, then it should be worth something to that community to see that light lands are put to their proper use and the unfortunate owners properly rehabilitated in a locality where they will be a benefit rather than a hindrance. Rehabilitation is a major problem, and if the township and the county cannot do it then it is a provincial or federal responsibility. Unrestricted private enterprise has made a very unfortunate showing of its stewardship up to the present time.

No estimates have been made of the cost of a project of this kind but it should not be a difficult problem to prepare a detailed accounting. However, in the opinion of the writer, costs should not be allowed to influence the decision as to whether this should be a reserve or not. If present conditions continue, it will be impossible to calculate the loss to the community, disregarding the damage by floods, or just one resource, namely, water for springs, wells, and ground moisture for crops. Naturally the crops will always have the benefits of the summer rains but are these always sufficient and reliable? Not according to the records of the Meteorological Service. In

1937 the Orono records show 0.45 inches and 0.73 inches of rain in July and August. The averages are 2.66 and 2.51 respectively. In April, May and June, 1941, there was 3.40 inches of rainfall as compared to the average of 8.24. The agricultural lands on all sides of the glacial moraine are dependent to some degree on the resources in or on the height of land, and it would be a progressive step for any governing body to sponsor or to promote the project of a protection forest on such a strategically located site.

As mentioned before there is every reason to believe that similar conditions can be found in other stretches of the same moraine. This should be a challenge to all organizations interested in conservation, and an effort should be made to compile additional information on this particular area as well as on similar areas in the other sections of Southern Ontario.

It should be noted that in the arguments brought forward in this report the value of the timber from this area in a 75 to 100 year period has not been mentioned. It is contended that the economic value of the project to the agricultural sections would be sufficient to warrant its adoption. If and when the forest crop is ready for harvesting it should be carried out under a very restricted plan so that the value of the protection forest is not impaired. The income from this source, when it eventually does begin to come in, could then be considered as a bountiful gift of Mother Nature to be used in reducing the burden of taxation.