FROM THE TRANSACTIONS OF THE ROYAL SOCIETY OF CANADA

SECOND SERIES—1896-97

VOLUME II SECTION IV

GEOLOGICAL AND BIOLOGICAL SCIENCES

SOME OBSERVATIONS TENDING TO SHOW THE OCCURRENCE OF SECULAR CLIMATIC CHANGES IN BRITISH COLUMBIA

By G. M. DAWSON, C.M.G., F.R.S., LL.D.

Director of the Geological Survey of Canada

FOR SALE BY

JOHN DURIE & SON, OTTAWA; THE COPP-CLARK CO., TORONTO

BERNARD QUARITCH, LONDON, ENGLAND

1896

X.—*Some Observations Tending to show the Occurrence of Secular Climatic Changes in British Columbia.*

By G. M. DAWSON, C.M.G., F.R.S., LL.D., Director of the Geological Survey of Canada.

(Read May 20, 1896.)

In a report by the writer on a portion of the Rocky Mountains, proper, comprised between latitudes 49° and 51° 30′, the following remarks occur,[1] referring particularly to the years 1883 and 1884 :—

"Evidence of a remarkable character has been found, which seems to show that a somewhat rapid increase in the total annual precipitation, has taken place during late years, and deserves to be recorded here. The evidence referred to is that afforded by the abnormal height of small lakes, without outlets, occurring in regions characterized by moraine hills. These serve as natural gauges, but instead of measuring the actual rainfall, give a result dependent on this and the counteracting effect of evaporation. The abnormal character of the rise of water in these lakes is shown by the fact that it has killed a belt of trees, some of large size and at least fifty years in age, along parts of the margins of some of these lakelets. Both the Douglas fir (*Pseudotsuga Douglasii*) and the yellow pine (*Pinus ponderosa*)—the latter never naturally growing even in damp soil—have been found in numbers thus killed. The condition of the trees shows that they have been killed within a few years, and their size indicates that the waters of the lakes in question have not been for any considerable time during a period of fifty years or more, at the present high level. These observations were made both in 1883 and 1884. The lakelets observed to be so affected were numerous, and scattered over a belt of country along the western part of the range for a length of about 140 miles ; three of the principal districts in which such facts were noted being the Tobacco Plains, the Kootanie Valley between the Lussier River and head of Columbia Lake, and the upper valley of the Kootanie, near the mouth of the Vermilion."

It was further recorded, that most of the small streams flowing westward from the Rocky Mountains in the same region, showed signs of excessively heavy flood-water in the early part of the year 1884. "This evidence was of such a character in relation to trees of great age which had been undermined, and belts of wood through which the water had rushed with devastating force, that I was led to believe no such flood could have occurred for fifty or a hundred years previously."

---

[1] Annual Report, Geol. Surv. Can., 1885, p. 32 B.

In the course of geological work carried on in the southern part of the Interior Plateau of British Columbia, particularly in the years 1888, 1889 and 1890, to the west of the region above alluded to, but in similar latitudes, much further evidence of the same kind and possessing a similar significance has been found. This, indeed, is so universally met with where circumstances favourable to its observation occur, that I will cite only a few of the more notable cases, in a general way, in order to render its character obvious.

1. In the angle between the main Thompson River and its north branch, not far from Kamloops, is a tract of rather low grass-covered hills, forming an excellent cattle range and containing in its hollows many small lakes and ponds without outlet. Several of these are fringed by dead trees, comprising aspen poplars twenty years or more old and a few specimens of yellow pine forty or fifty years of age. The water was standing about their roots in October, 1888, and it was then estimated that the trees had been dead for five or six years.

2. The point of open plateau between Stump Lake and Douglas Lake, is somewhat similar in character to the last, though with fewer lakes and ponds. Very clear evidence of the same kind was here seen in a lake about three miles north of Douglas Lake, which is bordered by dead trees at least twenty years of age, together with many large, dead, willow bushes. The state of the dead wood led to the conclusion, as noted at the time, that these had not been killed more than ten or less than five years before. It also appeared that there was here some evidence to show that the water had, for a year or two, been again decreasing (30th July, 1889).

3. The Green Timber Plateau, with an elevation of about 4,000 feet, situated to the north of Clinton, consists partly of woodland and partly of natural meadows or prairies of small size, and is characterized by very numerous lakes and ponds, most of which have no outlets and are more or less distinctly saline. Many of these are bordered by zones of dead trees, killed by the rise of water in the lakes, as in the former cases. In October, 1889, it was noted that most of the trees appeared to have been dead for two, three or more years, while a few had been killed in the preceding year. Also that in these lakes the water had fallen to its old normal level, or nearly so, at the date above mentioned; the decrease from its highest point being in some instances as much as ten feet.

4. Lake to the east of Eight-mile Creek, in Pass Valley. This lake, without outlet, is again bordered by dead trees, some of which were estimated as being of forty years growth. The roots of these trees were observed to be still flooded in October, 1889, although it might be supposed that the water of the lakes generally should in that month be not far from its annual minimum.

5. One of the little lakes in the valley running northwestward from the head of Okanagan Lake was noted, in October, 1890, as exhibiting a similar fringe of dead wood. At the date mentioned the water stood lower than the roots of the trees which had been killed.

The above are only a few selected instances, in which the circumstances seem to be quite unexceptionable, and such as to render the character of the evidence met with clear. All the lakes and pools above mentioned have no outflow, and must be distinguished from numerous cases of lakes in which the natural outlet has been interfered with by beaver-dams, accumulations of drift-wood, or otherwise.

Stump Lake, situated about thirty miles south of Kamloops, seems capable of affording some further evidence on the general question of climatic changes. This lake and its features are somewhat fully referred to in my report of work done in 1877,[1] and the main facts need therefore here alone be noted. The lake is about five miles in length, with a breadth of from half a mile to a mile, and is therefore larger than any of the lakes or ponds above referred to. It occupies the bottom of one of the characteristic wide valleys by which this part of the Interior Plateau is traversed, with a height of about 2,450 feet above sea-level, and discharges at the present time by a small stream which reaches the north end of Nicola Lake. Its supply of water is derived in part from the immediately bordering slopes of the valley, but chiefly from two small brooks, which enter its northern end from the plateau to the eastward. The name of the lake, which appears on maps at least as long ago as 1859,[2]

[1] Report of Progress, Geol. Surv. Can., 1877-78, p. 29 B.

[2] Little information can unfortunately be gathered from the older maps of the region. An examination of some of these has afforded the following results :

1840. Map accompanying "Northwest Coast of North America," R. Grenhow. Nothing definitely recognizable as Stump Lake. 1841. Map in U.S. Exploring Expedition volumes. Shows a lake which may be intended for Stump Lake, discharging to Nicola Lake. 1844. Not shown on Duflot du Morfras' map. 1846. Apparently indicated on map accompanying "L'Oregon" by M. Fedix; streams connect what may be Stump Lake both with the Thompson to the north and Nicola Lake to the south, but the indications are very uncertain. 1850. Not recognizable on Arrowsmith's map of this date, but in this, as in the foregoing maps, the scale is too small and the geographical data for the region in question too inaccurate, to enable any definite conclusions to be drawn. 1859. Commander R. C. Mayne, R.N., in an account of a journey made by him in this year describes "Stump Lake or Lake Hamea as it is called by the Indians" (Journ. Royal Geog. Soc., vol. xxxi., p. 215) giving the dimensions as 6 miles long by 1 to 1½ wide; a fairly correct approximation to its present size. 1861. Shown under its present name, and with outflow to Nicola Lake, on map facing page 213 Journ. Royal Geog. Soc., vol. xxxiii. 1862. Mayne on map accompanying his "Four Years in British Columbia," shows the lake as in the last-quoted map. Apparently shown, but not named, on map in "Vancouver Island and British Columbia" by A. Rattray; outflow to Nicola Lake. Shown under name of Chicot Lake, with outflow to Nicola Lake, on map by Arrowsmith accompanying "British Columbia and Vancouver Island" by D. G. F. Macdonald. 1864. Shown, without name, but with outflow to Nicola Lake, on map accompanying paper by Lieut. H. S. Palmer. Journ. Royal Geog. Soc., vol. xxxiv. 1865. Shown under name Stump Lake, but without outlet, on map in "Vancouver Island and British Columbia" by M. Macfie. 1868. Shown, as in last case, on map accompanying paper by A. Waddington. Journ. Royal Geog. Soc., vol. xxxviii.

is derived from the fact that its borders and some part of its bed are characterized by an abundance of submerged stumps and prostrate trunks of trees, chiefly those of *Pinus ponderosa*. I was informed by Indians, in 1877, that some among them still living, could remember a time when no lake existed in this part of the valley. "The lower end of the lake is shallow and reedy, but is well rimmed round by bold mounds and ridges of drift material on all sides but that now giving issue to the stream, showing that no former channel in a different direction is possible." The outlet had been slightly deepened artificially a few years before the date of my first visit, at a time when the water (which is employed for purposes of irrigation in the lower valley) had for some reason ceased to flow. The existence of a ledge of hard rocks, however, rendered it impossible, without blasting, to deepen the outlet much. In 1890, I found, on again visiting the outlet, that an attempt had been made to dam the lake, but had been abandoned, and the dam was completely broken through. No evidence was found on either occasion of high-water marks, other than slight traces such as might be accounted for by annual seasonal changes, but in 1877 I satisfied myself that the existence of an outlet to the lake was a comparatively recent event, by the following observation:—"A short distance beyond the actual outlet of the lake, stumps of the ordinary yellow pine (*P. ponderosa*) are found in the bed of the brook, where the circumstances render any diversion of the stream impossible. This tree never grows in damp ground, far less with its roots surrounded by water, but is frequently found on hill-sides, rooting in the gullies down which a little water may run for a few days in the spring. The valley now carrying the brook must have been of this nature at the time the trees flourished, and this, in itself, would show either that the lake did not exist at the time or that no water flowed from it. The circumstances show that the natural diversion of the streams feeding the lake is not possible."

In my report above cited, and dealing with this as an isolated case, I suggested that the possible stoppage of some subterranean drainage-channel might explain the existence of the lake; but in view of the facts since observed and in the absence of any proof of such a channel, it now appears to me more probable that Stump Lake may be accepted as another instance of a general change in climatic conditions. The circumstances, it is true, are somewhat more complicated than those in the cases previously cited, and it would also appear that, if thus explained, the increase of humidity called for must date back to an earlier period by many years than that necessitated by the other observations.

While none of the facts here cited possess numerical accuracy, and we are without such data as would allow of the satisfactory separation of the ordinary annual seasonal changes in level from those of a secular character, the general tenor of the evidence is sufficiently clear. It shows

that since the year 1880, or possibly earlier, the water of many small lakes and ponds without outlet, throughout the whole southern part of British Columbia, has stood either permanently or for prolonged intervals at levels higher than those attained (except possibly for very brief periods) for forty, fifty or more years previous to that date. The period of continuous low water in these lakes is thus carried back from the above date, continuously, to about 1830 or 1840 at the least. If the evidence of Stump Lake be accepted, it would, however, tend to show that a gradual increase in humidity had been in progress for at least thirty years, of which the smaller lakes are found capable of registering only the later stages, many of these having possibly been entirely dry in earlier years. The observations show also a distinctly noticeable tendency towards a decline in the general water-level at the present time.

If it be supposed that the indicated change in climatic conditions may be due to human agency, the partial removal of the naturally thick grassy covering of open tracts of country, and the destruction of forests by fire, are the two most obvious possible causes. It may be suggested that the first-mentioned circumstance might result in a freer drainage of the bordering slopes toward the natural reservoirs, but in the cases of the lakes referred to in the Report of 1885, and in that of those of the Green Timber Plateau, the adjacent country has not yet been employed for pasturage, or only to an insignificant extent, while the change in the conditions of Stump Lake antidates the stocking of any part of the country with cattle. Respecting the destruction of forests, which has been considerable, the only result which appears to have been proven to follow such destruction elsewhere is that of decreasing the natural humidity of the country, and it can therefore scarcely be called in to account here for change in an opposite sense. Again, the permanent occupation of any part of the inland portion of British Columbia did not begin before 1860, and the changes so far affected in any direction are very small compared to the entire area of the country.

It appears thus to be more than probable that the observed facts point to some general climatic variation of a secular kind, rather than to any change in conditions produced by man. It will be noted that all the lakes and ponds referred to, lie within the area of the Cordillera, between the Rocky Mountains proper and the Coast Ranges, and that all are situated in the naturally more arid portions of the southern part of British Columbia.

Numerous observations of change in level in lakes without outlet have been made in late years in the southern part of the Cordilleran region contained in the United States, but the most satisfactory and continuous of these refer to the Great Salt Lake in Utah. In his monograph on Lake Bonneville[1] Mr. G. K. Gilbert has collected and collated all the

[1] Monograph of the U. S. Geological Survey, vol. i., 1890.

available data referring to that ancient lake, and gives a comprehensive discussion of the various facts bearing on the whole subject. On page 243 of this work, the fluctuations of the Great Salt Lake, which are known with tolerable certainty since 1840, and have been accurately determined in late years, are represented in a diagram, which affords a basis of comparison for the more isolated facts noted in British Columbia. This diagram shows that the Great Salt Lake stood low and was affected by no very strongly marked variations in level, from 1840 (and probably much earlier) to about 1865, when a steady and continued rise began. This culminated in 1870, but the great height of the water was maintained to about 1877 with slight variation. It then began to decline, and in 1890 was not far above its approximate mean level for the period between 1840 and 1865. The diagram thus shows a change of precisely the same kind with that which would explain the phenomena met with in southern British Columbia, but, so far as can be ascertained, the maximum epoch of humidity was reached in British Columbia nearly ten years later than in Utah. It thus seems possible that the climatic change may have been of a progressive character, and that its effect was first rendered apparent in the more southern latitudes. It may be conjectured that a progressive change of this kind might result from modifications in position or size of the ruling anticyclonic areas of this part of the northern hemisphere. Thus the decrease in importance, or movement to the southward, of the permanent anticyclonic area of the adjacent North Pacific, would permit a greater rainfall and more humid conditions generally in the southern part of British Columbia, tending to assimilate these to those now characteristic of the northern part of the province.

Clarence King, writing in 1878, after referring to what had then been ascertained respecting the oscillations of Great Salt Lake, quotes other facts from the area of the 40th Parallel Survey, which led him to believe that a period of increased moisture and greater snowfall had been entered on in late years. He refers to the occurrence of avalanches in the Sierra Nevada which had "begun to pour down into the true forest belt and to sweep before their rush considerable areas of mature tree growth," adding "it is obvious that no such avalanches could possibly have occurred during the germination and growth of this forest." He also makes the following further statement which appears to favour a similar belief: — "On the summit of the Central Pacific Pass are a considerable number of well grown coniferous trees. An examination of them during the construction of the Pacific Railroad [about 1867] showed that they were at that time being seriously damaged, and in some cases actually killed, by the drifting snow-crystals borne on the strong west winds during the winter storms, the notch or depression of the pass making a sort of funnel, through which the wind blew with unusual violence, concentrating its freight of sharp snow-crystals, which not only wore away some of the

foliage of the trees, but actually cut off the bark from exposed positions and sawed into the wood for several inches. An inspection of the branches thus cut showed that the annual rings had formerly perfected themselves, and that the snow had worn off a considerable portion, often several inches, of the thickness of the wood, leaving a smooth polished surface, displaying the cut edges of the layers of annual growth." From these observations, taken in connection with the age of the trees on the upper part of the mountains, he arrived at the conclusion that the "existing climatic oscillation began before the year 1870, and was the first of its kind for over 250 years."[1] This, it will be noted, agrees remarkably well with the evidence afforded by Gilbert's diagram for the Great Salt Lake.

Facts of a similar kind are not wanting in that part of the Cordillera comprised in British Columbia. Both in the Rocky Mountains and in the Selkirk ranges many recent cases of avalanches or "snow-slides" which have mowed their way through forests of large trees are found, and each such case must be accepted as showing the occurrence of long unprecedented accumulations of snow on the higher slopes. It must, however, be added that there are very many gorges and slopes where no trees appear to have grown at any time, in consequence of almost annually recurrent avalanches, and that the exceptional cases in which old trees have been destroyed, are in their nature so striking as to attract perhaps an undue degree of notice.

It has also been noted, both by the writer and others, on the higher mountains of British Columbia, near the snow-line, that dead trunks and stumps of larger and better grown trees than any now found living in the same situations, frequently occur; and that in places where the original growth of trees at altitudes approaching 6,000 feet has been destroyed by fire or by storms, it often shows no tendency to renew itself. Mr. J. McEvoy, who assisted Mr. A. Bowman in his surveys of the Cariboo mining district in British Columbia, has furnished the following note on his observations on the point in question in that district:—

"On many of the higher parts of the mountains in the Cariboo district, the presence of large dead trees is noticeable, where the only living ones are of a very stunted character. These large trees have died long ago, as only the resinous parts remain. This state of things is most marked on the Goose Creek Mountains. The damp climate, with the fact that the Indians do not appear to have hunted in these mountains, make it less reasonable to suppose that fire has been the cause. Even if fire had killed the forest, sufficient time has elapsed for its renewal, and there appears to be enough soil to maintain such growth. A change in climate seems to be the only satisfactory explanation."

---

[1] U. S. Geological Exploration of the 40th Parallel, vol. i., pp. 526-527.

It has further been remarked that, in many places within the dry 'bunch grass' region of British Columbia, great numbers of young trees, particularly of the yellow pine, are now found springing up from seed where not many years before a few solitary old trees only stood.

Observations of this kind are of course exceedingly indefinite in character, but taken in connection of those previously cited, they appear to deserve mention, and to tend, so far as they go, toward a like conclusion. There is indeed, and necessarily, a lack of precision in the whole of the data presented here, but it has been thought worth while to place them upon record, if only as a plea for further and more satisfactory investigations.

Having been able, in 1874, to show a distinct though not perfectly commensurate connection between the levels held by the Great Lakes of the eastern part of the continent and the periodic changes in solar activity as indicated by the observations of sun-spots,[1] it naturally occurred to me to compare the changes in respect to humidity of the western regions with these two classes of phenomena. It was found, however, that the data are insufficient to enable any definite conclusions to be reached, though such comparison as is possible, tends to show that there is no correspondence in high- and low-water periods between the Great Salt Lake and the Great Lakes, but rather some reason to believe that the changes may bear an inverse relation to each other in these two areas respectively.

[1] Nature, vol. ix., p. 504 ; Canadian Naturalist, November 1874, p. 310.