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The recognition of
Pleistocene faunas

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THE RECOGNITION OF PLEISTOCENE
FAUNAS

BY

OLIVER P. HAY



(PUBLICATION 2139)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
AUGUST 17, 1912

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THE RECOGNITION OF PLEISTOCENE FAUNAS¹

By OLIVER P. HAY

The determination of the history of the faunas and floras of a great region like North America in a geological period such as the Pleistocene, during which there were numerous and extreme changes of climate, great variations in elevation and therefore in rates of erosion and redeposition, in cold and heat, in rainfall and drought, in kind and amount of food and shelter, is a most difficult subject. The botanists, of course, have their special troubles, but the student of the Vertebrata labors, perhaps, under greater difficulties. The species which he studies are rarely represented by complete skeletons, most of them by scattered teeth and disassociated bones. Most of his species lived on land and the individual animals usually perished without leaving a trace of themselves.

As in the case of other geological periods, the unraveling of the history of the living beings of the Pleistocene has had to await a somewhat accurate knowledge of the geology. On account of the fact that in the larger part of the region studied in North America the deposits are usually disconnected and relatively little differentiated, while another region has been subjected to glaciation, a perplexing phenomenon, it has been difficult to determine the relations of the formations as regards synchronism and succession. The labors of geologists have made great breaches in the wall that stands between us and complete knowledge, but an enormous amount of work is yet to be done.

In the first edition of Dana's Manual of Geology, published in 1863, this great author divided the Post-tertiary, equivalent to the term Pleistocene, into two epochs, the Glacial and the Champlain. The latter was followed by the Terrace epoch, "a transition epoch, in the course of which the peculiar Post-tertiary life ends and the Age of Man opens." As to the life of the Post-tertiary Dana says (pp. 458-459):

The Drift epoch in America has afforded no organic relics except half-fossilized wood. There is as yet no evidence of any quadrupeds until the milder Champlain epoch had set in.

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That statement was not changed in the second edition, published in 1864.

In the third edition, 1874, the term "Terrace epoch" is replaced by the expression "Recent period" and this is divided into "the Reindeer, or second Glacial era," and "the Modern era." The term Quaternary is employed to include the Glacial, the Champlain, and the Recent eras. Most of the species of fossil mammals found within the glaciated areas were regarded as having lived during the Champlain, but the opinion is expressed that such mammals may have existed during the Glacial epoch beyond the borders of the ice-covered region.

In the fourth edition of this work, published in 1895, the same classification of the Quaternary is employed and the opinion is held that the animals which spread themselves over the glaciated area during the Champlain had probably all been in existence during the middle and later parts of the Glacial period, if not earlier.

In 1895, Cope (Amer. Naturalist, Vol. 24, p. 593), in discussing the antiquity of man in North America, expressed the opinion that there had existed during the Pleistocene two distinct faunas, one of which he called the *Megalonyx* fauna, the other, the *Equus* fauna. The *Megalonyx* fauna included the genera *Platygonus*, *Smilodon*, *Megalonyx*, *Myiodon*, *Mastodon*, and extinct species of *Bos*, *Dicotyles*, *Equus*, *Tapirus*, *Ursus*, *Castor*, *Arvicola*, and *Lagomys*. With these were found teeth and other fragments of a number of animals yet existing. The *Equus* fauna included extinct species of horse, species of *Myiodon*, four species of camels, and a peccary. *Elephas primigenius* was abundant; the mastodon rare, if occurring at all. The *Equus* beds which contain this fauna are said to be found in Oregon, Nevada, California, southern Texas, western Nebraska, and part of Mexico. His *Megalonyx* fauna was regarded as having occupied the region east of the Great Plains. Cope recognized the fact that in both these faunas there was a South American element. This element contained the great edentates, the saber-tooth cats, the peccaries, tapirs, and probably the giant beaver. He concluded that the two faunas were contemporary and had existed during pre-Champlain time. After the Champlain, which Cope regarded as a time of submersion, there came in a new fauna consisting mostly of now existing species, but containing also a few of the pre-Champlain forms, among them one or more species of megalonyx and the giant beaver.

Chamberlin and Salisbury, in their Geology, recognize a number

of glacial and interglacial stages, and they express the view that during the interglacial times the glaciated regions were occupied by numerous animals, among them many mammals. During the glacial stages the animal and vegetable life was pushed southward, and at each interglacial stage, it again migrated northward. The authors likewise recognize the fact that there was a strong tropical element in the fauna, made up partly of the great edentates and peccaries. A northern element is believed to include the mammoths, mastodon, bear, bison, reindeer, and musk-ox. Mingled with all, in mid-latitudes, were forms on the verge of extinction, horses, tapirs, llamas, and saber-tooth cats.

In his *Age of Mammals*, 1910, Osborn adopts, in general, the views of Cope, recognizing, however, four faunas, which he named the fauna of the first or *Equus-Myلودon* zone; the fauna of the second, or *Megalonyx* zone; the fauna of the third, or *Ovibos-Rangifer* zone; and that of the fourth, or *Cervus* zone. The latter fauna is that which existed at the time of the discovery of the continent by Columbus. The third fauna includes the musk-ox (*Ovibos*), the reindeer, the mastodon, the hairy mammoth, and several species of bison. The first and second faunas seem to be practically the corresponding ones of Professor Cope. Professor Osborn holds that the *Equus-Myلودon* fauna occupied the dry Plains regions, but also the coast of Florida (p. 452), while the *Megalonyx* fauna had possession of the forested regions of the eastern part of the United States and of the Pacific coast (p. 467). Professor Osborn, like other students of the subject, recognized a South American contingent in both of the earlier faunas.

As to the time of the existence of the *Equus-Myلودon* and the *Megalonyx* faunas, Osborn (p. 454) is inclined to believe that they were to a great extent contemporary, but that probably early phases of the *Equus-Myلودon* fauna antedated the beginning of the *Megalonyx* fauna.

In 1909 (*Science*, Vol. 30, p. 890) the present writer called attention to the fact that no trustworthy discoveries of remains of extinct horses had been made in deposits lying above the Wisconsin drift, and he reached the conclusion that these animals had, in our country, by that time, become extinct.

Since that time the author has pursued the subject, and he wishes here to present additional facts and conclusions. To aid in this undertaking, he has prepared a base map of the mid-latitude regions of North America, and represented on it the distribution of

the various glacial sheets. In preparing this he has made use of the maps in Leverett's Monographs 28 and 41 of the U. S. Geological Survey, and of a map in the office of Dr. W. C. Alden, of the Survey, on which map is shown the distribution of the drift of different stages in the region west of that considered by Leverett in the works mentioned. On the maps here shown the various drift-sheets are mapped as accurately as is possible on a scale so small. The drift-sheet most important for our purpose is the Wisconsin. This sheet covers more or less completely Labrador, Nova Scotia, and New England; while farther west it extends southward to a line running through Pennsylvania, a part of New York, Ohio, and Indiana. Near the center of Illinois the line turns northward into Wisconsin, where it passes to the east and north of a driftless region. A great lobe of the sheet descends in Iowa to Des Moines, and in eastern South Dakota is seen a smaller lobe. Thence the southern border of the sheet continues westward to the Pacific coast in Washington.

In Ohio and Illinois the Illinoian drift-sheet extends southward beyond the edge of the overlying Wisconsin. In northeastern Iowa and the adjoining part of Minnesota is found the exposed part of the Iowan sheet. West of the Mississippi River the Kansan sheet extends southward beyond the Wisconsin, and a fringe of it is seen along the western border of the driftless region of Wisconsin and Iowa. The Nebraskan drift-sheet is wholly covered by the later ones and is not shown. The various drift-sheets are theoretically separated more or less completely by interglacial deposits. It may be convenient to have the order shown here in which the glacial and interglacial stages succeeded one another. The interglacial stages are italicized.

9. Wisconsin.
8. *Peorian*.
7. Iowan.
6. *Sangamon*.
5. Illinoian.
4. *Yarmouth*.
3. Kansan.
2. *Aftonian*.
1. Nebraskan.

On these maps it is proposed to indicate where remains of various Pleistocene mammals have been discovered. The writer has endeavored to make a thorough examination of the literature on the subject, and believes that very few mentions of discoveries of the

forms here treated have escaped him. He has, besides, examined a considerable number of collections in our museums and universities and noted the materials found in them.

Figure 1 is intended to show the distribution of the American mastodon (*Mammot americanum*). The writer has records of over 325 finds of this animal. In some regions, as New York and Indiana, it is impossible to indicate on the map all the localities; hence, one dot represents often two or more neighboring localities. In Indiana more than 30 are known. While the remains of this great proboscidian have been found from Cape Breton Island to the Pacific coast and to Florida and Texas, they are seen to be especi-

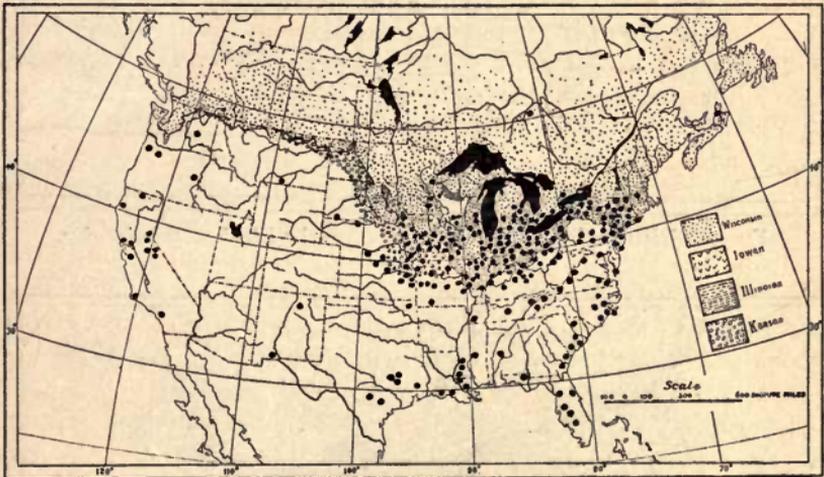


FIG. 1.—Distribution of the Pleistocene mastodon, *Mammot americanum*.

ally abundant in undisturbed deposits that were laid down in lakes and ponds on the Wisconsin drift. It is certain, therefore, that the animal lived in those regions long after the last ice-sheet had retired from the country. Inasmuch, too, as teeth and bones not yet distinguishable from these post-Wisconsin mastodons have been found in Aftonian deposits, we must conclude that the species inhabited parts of the country during nearly the whole of the Pleistocene.

Figure 2 represents the distribution of known discoveries of the hairy mammoth (*Elephas primigenius*). The number is not large, but it is intended to indicate specimens that have been determined with considerable certainty. The writer has notes on more than 200 discoveries of remains of elephants which cannot be assigned

with any certainty to either *E. primigenius* or *E. columbi*, being accompanied by neither description nor figure. From the map it will be seen that most of these finds of *E. primigenius* lie on some one of

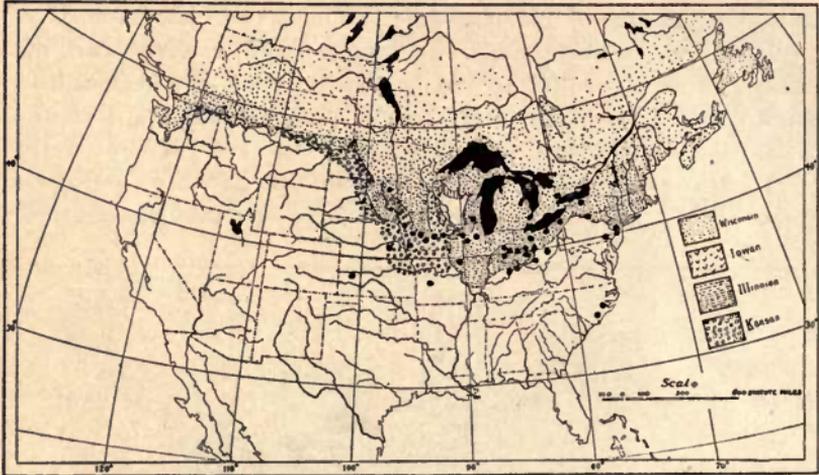


FIG. 2.—Distribution of the hairy mammoth, *Elephas primigenius*.



FIG. 3.—Distribution of the Pleistocene elephant, *Elephas columbi*.

the drift-sheets or not far away from them. Two cases occur in North Carolina. Possibly, at the height of some glacial stage, some individuals, that found a congenial dwelling place on the mountains of this region spent their winters on the sea-coast. It is especially

to be noted that several localities are on Wisconsin drift and the remains were found in muck and peat of old marshes. It cannot be doubted that the animal lived in post-Wisconsin times.



FIG. 4.—Distribution of the Pleistocene giant beaver, *Castoroides*.



FIG. 5.—Distribution of Pleistocene peccaries.

Figure 3 is intended to represent localities where remains of *Elephas columbi* have been discovered. It is evident that also this species lived after the last ice-sheet had withdrawn from the country. Inasmuch as this animal extended its habitat to the Gulf of

Mexico, it seems probable that it was a species that affected a warm climate; and that it made its way into the northern States only after the climate had become quite mild.

Figure 4 shows the distribution of known specimens of the giant beaver, *Castoroides*, except that it is now known to have lived at one time on the Old Crow River in Yukon Territory. The map shows that it was well represented in the old swamps that formed on the top of the Wisconsin drift-sheet in Ohio, Michigan, and Indiana.

On the next map (fig. 5) are shown the localities where remains of extinct species of peccaries have been discovered. The existing



FIG. 6.—Distribution of Pleistocene musk-oxen.

members of this family range from Texas to far down into South America. In Pleistocene times, so far as shown by specimens, they hardly came so far south as Texas. Several specimens have been found in deposits overlying Wisconsin drift, as in New York, Ohio, Indiana, and Michigan. That these animals existed in these States long after the last glacial ice had disappeared, there can be no doubt.

Figure 6 is intended to represent the known distribution of musk-oxen in mid-latitudes during the Pleistocene. The writer has records of over 30 specimens. These belong to 4 or 5 genera. Among the species is an *Ovibos* not yet distinguishable from *O. moschatus*. Four specimens are known: One from Youngstown, Ohio; one from Richmond, Indiana; a third from northeastern Iowa; and a fourth from southeastern Iowa. The Indiana specimen, secured by

Prof. D. W. Dennis, certainly came from post-Wisconsin deposits, while the Youngstown, Ohio, specimen was found within the area of the Wisconsin drift-sheet. Specimens of *Symbos cavifrons* are most numerous, and several of these are found above Wisconsin drift, especially in Indiana.

The next map (fig. 7) shows the distribution of the great edentates, belonging mostly to the genera *Megatherium*, *Mylodon*, *Paramylodon*, and *Megalonyx*. It will be observed that the localities lie almost wholly south of the border of the Wisconsin drift. However, there is in the collection of the Ohio State University a mounted skeleton, to a considerable extent restored, which was



FIG. 7.—Distribution of Pleistocene gigantic edentates.

discovered several years ago, near Millersburg, Holmes County, Ohio. Here the terminal moraine of the Wisconsin ice-sheet had dammed back the water, and formed north of it a lake that eventually became a marsh, and in this, about a mile north of the moraine, was found a part of the skeleton of *Megalonyx jeffersonii*. This existence of *Megalonyx* after the Wisconsin ice had withdrawn from the Great Lakes region, is confirmed by the finding of a claw of probably the same species above Wisconsin drift near Champaign, Illinois. None of the other genera of this order has yet been found at so high a geological level in the glaciated region.

These maps, therefore, furnish us with incontestable evidence, that, after the passing away of the last glacial ice-sheet and yet within Pleistocene time, the country had become fitted for animal

life, and that creatures of such different habits of life, as the mastodon, the hairy mammoth, the Columbian mammoth, the giant beaver, one or two genera of peccaries, at least three species of musk-oxen, belonging to as many genera, and a species of megalonyx invaded and took possession of the new-made land. We do not need to suppose that all these occupied the country at the same time. It seems probable that the hairy mammoth and the musk-oxen followed up pretty closely the retreating ice-sheet, while the Columbian mammoth, the mastodon, the giant beaver, the peccaries, and the megalonyx pushed in only after the climate had become greatly ameliorated. It cannot be doubted that a host of other but



FIG. 8.—Distribution of Pleistocene horses of the genus *Equus*.

smaller mammals, as well as reptiles, amphibians, and fishes, accompanied each of these groups, the cold-loving and the heat-loving, and it will need close observation of the materials thrown out of ditches and canals in the region covered by Wisconsin drift, in order finally to make out what these animals were.

Figure 8 presents, so far as known, a view of the distribution of fossil horses, of the genus *Equus*, during the Pleistocene epoch. The writer has records of more than 130 localities where extinct horses have been found in North America, including Alaska and excluding Mexico. Now, there occur within the area covered by Wisconsin drift only two authentic discoveries of remains of extinct horses. One of these is on the Susquehanna River, near Pittston, about 20 miles north of the terminal moraine. Leidy stated

that the two teeth which he described had come from a stratum full of bones. So far as the writer knows, there is nothing opposed to the idea that the deposit along this river, as in the case of some others, had been made at some time prior to the Wisconsin epoch. Certainly, the deposit needs investigation.

The other locality referred to is Columbus, Ohio. As long ago as 1848, Whittlesey reported the finding of bones and teeth of a horse here, but they were lodged in fissures or clay-seams of the limestone. They might have been deposited there at any time during the Pleistocene. In 1875 Mr. J. H. Klippart reported that the fossil jaw of a horse, with molars in good condition, had been



FIG. 9.—Distribution of Pleistocene tapirs.

found while excavating for the exterior wall of the penitentiary. Unfortunately we are not told what the depth was, nor the character of the deposits where the jaw was found. The penitentiary is not far from the banks of the Scioto River, and the deposit with the included jaw, if post-Wisconsin, may have been derived from a pre-Wisconsin bed; but more probably, this deposit is of older date than the Wisconsin stage.

It is very interesting to study the distribution of the fossil horses, with respect to the Wisconsin drift. They appear to have extended northward to the south boundary of this drift all along the line without having crossed it, except in the two cases mentioned. There can hardly be a doubt that if this drift could be cleared away, horse remains would be found beneath it far northward, and such remains

are sometimes likely to be met with in digging wells and in places where streams may have cut through the Wisconsin, so as to reach an underlying interglacial deposit. And this suggests that, in the case of every discovery of a Pleistocene fossil, accurate record should be kept of the exact locality, and of the depth and the character of the deposit. Especially ought the record of the locality to be so detailed that anybody can relocate the exact spot.

The next map (fig. 9) shows the relatively few localities where tapir remains have been found. None of these occur north of the Wisconsin terminal moraine; in fact, none north of the border of any glacial sheet, except at Big Bone Lick where a thin varnish of the



FIG. 10.—Distribution of extinct species of bison.

Illinoian sheet covers the locality. It is doubtful whether the relation to the Illinoian drift of the tapir remains found there can yet be determined.

Figure 10 is intended to display the distribution of localities where bisons of extinct species have been found. The writer holds that no authentic discovery of an extinct bison has yet been made in deposits overlying Wisconsin drift. To prove the presence of such a bison it will usually not be sufficient to present teeth only, for the teeth of some of the extinct bisons resemble so closely those of the living species that they cannot be distinguished. As in the case of the horses, remains of undoubtedly extinct bisons have been found close up to the border of the Wisconsin drift, and doubtless will yet be found to occur beneath it.

What conclusions are we to draw from the facts presented regarding the horses, the tapirs, and the extinct bisons? To the writer it seems almost necessary to believe that the species of *Equus*, of *Tapirus*, and of *Bison*, except *Bison bison*, had become extinct before the Wisconsin ice-sheet had retired from its southernmost limit. Here was a tract of country stretching from the Atlantic to the Pacific, finely adapted to support a varied fauna, but, if horses and tapirs, and bisons existed, they came up to the border of this fertile land, and, excepting the living bison, did not venture to pass this border. To them it was a dead-line; if, again, they existed.

To the writer, basing his opinion especially on what the maps shown above have revealed, it appears justifiable to make a distinction between the fauna which occupied this country when first visited by white men, which may be called the Recent fauna, and that which immediately preceded it. The latter included many genera and species that are found in the Recent fauna, but it embraced also a species of megalonyx, the American mastodon, at least two species of elephants, the giant beaver, one or two extinct genera of peccaries, at least three extinct genera of musk-oxen, and the extinct moose, *Cervalces scotti*. The latter belonged here, for the fine skeleton which is at Princeton University was found in swamp deposits in northern New Jersey which overlie Wisconsin drift. The distinguishing genera of this fauna are probably better revealed in the northern part of Indiana than in any other State, and especially in the valley of the Wabash River and its tributaries. The beds containing these fossils hold the same relation to the Wisconsin drift that each of the interglacial deposits holds to the drift sheet underlying it. Inasmuch as it has this definite position and, moreover, contains a fauna marked by a number of extinct genera, it seems to be worthy of a distinctive name. It is proposed, therefore, to call these deposits, consisting mostly of the fillings of old marshes, ponds, and lakes, the *Wabash* beds, and the fauna contained therein, the *Wabash* fauna. As the type locality of this formation, the writer chooses the region about 4 miles east of Fairmount, Grant County, Indiana. Here in a drainage canal which empties into the Mississinewa River, a tributary of the Wabash, at a depth of from 12 to 15 feet, was found the nearly complete skeleton of *Elephas primigenius* which is mounted in the American Museum at New York. Somewhere in the neighborhood was found the partial skeleton of *Castoroides* which is in the Field Museum of Natural History,

Chicago. In the 13th Annual Report of the Indiana Geological Survey, on page 143, it is stated that some years ago the tooth of a mastodon was found in one of the marshes south of the lake in the eastern part of Fairmount township, a lake that has been greatly reduced, now possibly obliterated, since the time of settlement of the region by white men.

The Pleistocene fauna which occupied our country before Wisconsin time differed in many respects from that of the Wabash stage. It embraced edentates of several extinct genera, *Megatherium*, *Mylodon*, *Megalonyx*, and *Paramylodon*; horses of several species; a number of genera and species of camels; tapirs; bisons of a number of extinct species; peccaries belonging to the genera *Platygonus* and *Mylohyus*; bears of the extinct genus *Arctodus* and extinct species of *Ursus*; saber-tooth cats of more than one genus; some extinct dogs; and various other forms, besides many genera and species yet in existence. The question arises: Can this assemblage be divided into two or more faunas? It would appear possible to do so when we consider, on the one hand, the Port Kennedy collection with its 80 per cent of extinct species, and the Hay Springs collection with about 70 per cent extinct, and, on the other hand, the Conard fissure collection with only 47 per cent of extinct species.

The latter has been referred by Professor Osborn to his third, or Ovibos-Rangifer zone, of which he says: "The third mammalian fauna is apparently that of the final glacial advance and, perhaps, of a cold dry loess period" (Age of Mammals, p. 440). Arguments may be offered to support this assignment, but the high per cent of extinct genera and species, among them horses and saber-tooth cats, makes it more probable that it is to be referred to the Illinoian stage, whose ice-sheet approached much nearer the locality than did the Wisconsin sheet. The absence of edentates and proboscideans probably means nothing in this respect, for both were represented after the Wisconsin.

If the contents of the Conard fissure are rightly assigned to the Illinoian stage, the number of extinct forms at the onset of the Wisconsin stage must have been far less than 47 per cent—a conclusion that seems to be reasonable. It would then appear to be possible to divide the pre-Wisconsin Pleistocene mammals into two faunas, an earlier and a later; but when the attempt is made it is not found to be so easy, and, if done at all, can be done only provisionally.

When we consider the rarity of horse remains that have been found in deposits overlying Kansan, Iowan, and Illinoian drifts,

and the apparent fact that all belong to *Equus complicatus*, we may conclude that the numerous species which have been described belonged mostly to the older Pleistocene stages.

Camels are well represented in the collections made in Nebraska and Oregon, and are represented in the Aftonian. We might expect that the group would be represented in the Port Kennedy cave collection, but its presence there is doubtful, and no remains are known to occur in the Pleistocene of Florida. It is possible that the camels had already died out in the eastern part of our country.

On the other hand, no bisons are represented in the collections made at Hay Springs, Nebraska, Christmas Lake, Oregon, and in the Oregon Desert, as shown by Matthew's lists (Bull. Amer. Mus. Nat. Hist., Vol. 14, p. 317). The group appears, however, to be represented in the Port Kennedy collection by a few bones, and a bison occurs possibly in the Aftonian. It looks, therefore, as if the earliest Pleistocene was characterized by the existence of numerous edentates, horses, camels, tapirs, and saber-tooth cats, and few bisons, while during the later pre-Wisconsin Pleistocene there were few edentates, few horses, no camels, few saber-tooth cats, but numerous bisons.

The writer is inclined to the opinion that the mammalian fauna, discovered in the Aftonian beds of western Iowa, is the equivalent of that found in the Nebraska and Oregon localities referred to above, as well as that of Port Kennedy cave, in Pennsylvania, and, inasmuch as the level of the Aftonian beds is fixed in its relations to the glacial drift-sheets, it seems proper to call the earliest known assemblage of Pleistocene animals the Aftonian fauna. The succeeding fauna, if it shall prove worthy of recognition, may be known as the Sangamon. Some fortunate discoveries in the interglacial deposits known as the Yarmouth, the Sangamon, and the Peorian, may enable future students to characterize accurately this Sangamon fauna. It is the opinion of the writer that the contents of the Conard fissure represent this fauna, but here few of the large mammals have been preserved.

The mammals that are included in the Aftonian and the Sangamon faunas are practically those divided by Professor Osborn into his *Equus-Myloodon* and *Megalonyx* faunas. This division appears to be based on the presence of abundant moisture or the lack of it, producing respectively forested and grass-covered regions. The existing animals of North America have been divided by some writers, into those of the forested region and those of the dry plains ;

but Dr. C. H. Merriam has shown that the controlling factor in the distribution of recent animals and plants in North America is temperature (Proc. Biol. Soc., Washington, Vol. 7, 1892, pp. 1-64, pl. 1.; Nat. Geog. Mag., Vol. 6, 1894, pp. 229-238, pls. 12-14). It would seem, too, that if there was ever a time since the beginning of the Pleistocene epoch when differences in amount of moisture would determine the distribution of life in our country, that time is at present.

It cannot, of course, be denied that humidity and drought have their influence on both animals and plants, and that at all times during the Pleistocene the distribution of species of mammals was modified thereby, although this was subordinate to more powerful factors.

It might, therefore, be expected that the Pleistocene faunas recognized here would be a northern and a southern, with, perhaps, an intermediate one and, certainly, we must recognize the presence of arctic, temperate, and subtropical elements in our lists of species of Pleistocene mammals. However, since, through the influence of four or five glacial ice-sheets, the arctic and cool-temperate animals have again and again been driven southward upon the warmth-loving species, and the latter have as many times swarmed far north, and the remains of all that existed at each stage are often mingled in practically the same deposits, it is impossible to base faunal divisions on predilections for a warm or a cold climate.

A factor far more potent in determining modifications of faunas than either moisture or heat is *time*. It never ceases to act and its influence is inexorable. A great assemblage of animals is swept away and another is put in the place of the old, and this is doomed itself to disappear in its turn. The classification of the mammalian faunas of the Pleistocene here proposed, is, therefore, based on the changes supposed to have been wrought by this potent agency.

Had one, however, lived during any of the interglacial stages, one would doubtless, as now, have recognized a number of faunas that occupied zones determined by temperature.

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