THE FIRE-DRIVE AND THE EXTINCTION OF THE TERMINAL PLEISTOCENE FAUNA

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I

THE subject of extinction has a perennial, an almost morbid fascination. The total disappearance of a species, of a unique and never-to-be-duplicated genetic pattern, has in it, moreover, something of the mystery that lingers about the origins of those same patterns. And when, in addition, that disappearance is found to be correlated in time with the first human intrusions into the New World, then, indeed, our speculations multiply. The adage "let there be some uncertainty about your departure" is sure advice for the creation of that romantic aura which lingers about the unknown and the unexplainable. The terminal Pleistocene fauna took just that mode of exit from the stage of life. As a result its scientific immortality is certain, not alone among paleontologists, but among students of mankind as well.

Yet fascinating though the subject of extinction is, it is perhaps significant that—so far as I am aware—there exists no volume in English devoted to its elucidation. There is a simple reason for this. Theories are many, but most unprovable. Or pertinent objections to their general usefulness can be raised, even if we grant their applicability in particular instances. It is this situation that causes the biologist to despair as he surveys the extinction of so many species and genera in the closing Pleistocene. Are there many particularistic explanations chancing to correlate roughly in time? Or did the climatic events attendant on the glacial retreat in some manner affect animals of quite diverse habits and physical structure? In beginning a survey of this subject, one can not do better than to peruse Henry Fairfield Osborn's now almost forgotten paper, "The Causes of Extinction of Mammalia," which appeared in 1906.[1] In addition to valuable data, there appear in this paper certain theories which, interestingly enough, have been repeated in later times by writers deeming themselves original. Actually only two new theories have added anything of a very startling nature to the information assembled by Osborn nearly forty years ago. And even in one of these instances, Osborn had already projected—in the less exact terminology of that time—something of the underlying idea of the Sewall Wright hypothesis.

One fact which constantly confronted Osborn in his treatment of extinction was the extent to which natural disasters in the shape of epidemic disease or climatic catastrophe are sufficient to explain an enormous reduction in the numbers of a particular species, but are yet inadequate to illuminate the reason for the inability of the species to rebound, in a few years, from its decimated condition. He comments on the fatal influence of inbreeding, noticeable in some

[1] Osborn, 1906. (See bibliography at end of article.)

instances, on much diminished herds such as those of the protected European bison.

To-day, according to Sewall Wright and his co-workers, such an initial restriction in the size of a given population would, first of all, greatly reduce the number of breeding animals. This, in turn, would lead to a reduction in the amount of hereditary variability present in the stock, increasing homozygosity and a more or less random fixation of genes without reference to their adaptive value. Such circumstances in an already numerically circumscribed group may accelerate the trend toward extinction. It has been noted that isolated islands are, in a sense, "evolutionary traps," that, by the process described, often bring about extinction because of the increased genetic uniformity in a small population. Admittedly, of course, the extinction of certain of the widespread Pleistocene animals cannot be viewed in exactly the same light as disappearances in island "traps." Even if we grant the validity of the Sewall Wright theory, something—some other potent factor—would have had first to decimate the Pleistocene fauna before gene fixation could get in its work. In fact, in Simpson's eyes, number has to be so reduced before the Sewall Wright effect can function that its importance in relation to evolution has probably been overemphasized.[2]

The second of these newer theories—one brought forward recently by Dr. Carl Sauer—is of peculiar interest to the archeologist. In the course of an extensive summary of late discoveries connected with human intrusion into the New World and the relation of the early comers to the geographical environment in which they found themselves, Dr. Sauer has advanced the hypothesis that the terminal Pleistocene fauna was destroyed by hunters making widespread use of fire-drives in the pursuit of game.[3] This weapon, he argues, would have been far more effective, in terms of mass destruction, than the lance or atlatl. Great body size in itself would have made the Pleistocene forms easy victims to wind-driven fires, since the huge animals would have been lumbering and unwieldly runners. Sauer deems it probable, furthermore, that the great grasslands are of relatively recent origin, and that man-made fires have played a major part since prehistoric times in the creation of circumstances favoring the dissemination and evolution of the grasses. This process, he suspects, began with the intrusion of man into the New World during the closing Pleistocene, say fifteen to twenty thousand years ago. Dr. Sauer does not clearly limit his comments to the American scene, but suggests a somewhat similar type of extermination in the Old World. It is Man, not the climatic shifts of the Pleistocene, he feels, that destroyed this great fauna.

In presenting these provocative views, Dr. Sauer is pioneering in one of the most fascinating fields of scientific speculation. Archeology is indebted to him for this contribution. Only by the constant testing and discarding of theories, the propounding of better hypotheses based on what has survived this unceas-

[2] Simpson, 1944, p. 67. [3] Sauer, 1944.

ing refinement of raw data, can advancement ultimately be made. Dr. Sauer's theory may very well have merit as an explanation of certain Pleistocene events. At the same time a close appraisal of it reveals the need for a certain careful and objective analysis. With the theory of grassland origins we shall not attempt to deal here, primarily because it is not highly germane to the problem of extinction and because it would, in addition, demand a wide excursion into botany.[4] Instead, we shall be at pains to examine point by point Sauer's contentions in regard to the fire-drive. It will be apparent at the close of this survey—or so the writer believes—that Dr. Sauer's thesis, interesting as it is, does not satisfactorily answer a good many questions about Pleistocene extinction. But, in that respect, Dr. Sauer is none the worse off than the rest of us, who must continue to be baffled by the mysteries of extinction. He, at least, has contributed another item to Osborn's list of long ago.

II

Probably the easiest manner of approaching Dr. Sauer's paper is to take his major contentions, italicize them and then append such material as seems pertinent to their discussion. Let it be emphasized that these data will not be used in a mood of outright refutation, but only to make clear the difficulties of accepting *any* single and exclusive view of Pleistocene extinction.

1. *It was the big and clumsy animals that disappeared and the new element added was hunting man.*

Most certainly a large and spectacular fauna disappeared, but it was not all big, clumsy, or gregarious. Besides certain molluscs, *Bufo nestor*, an extinct toad; the Archaeolaginae, a sub-family of rabbits; the dire wolf Aenocyon; Capromeryx, Tetrameryx and Stockoceros, three forms of swift antelope; the sabre-tooth Smilodon; Arctodus, the short-faced bear; and, among others, *Equus tau*, a small horse, disappeared. A full coverage of the literature would add other items to this list. Grant that man was interested in parts of this fauna. Nevertheless a number of these forms were swift-moving or solitary and not easily cornered — even with fire. Moreover, of all forms least apt to be seriously threatened by primitive man, birds are preeminent. Fires do not destroy a bird fauna capable of flight. Yet amidst this terminal Pleistocene assemblage, several birds became extinct. It must also be taken into account that, up until quite recently, all of the great American museums have concentrated to a very considerable extent upon the collection of the large and spectacular fauna of the Pleistocene. Small forms have been neglected; in fact it is only recently that techniques have been devised for obtaining them. Hence the extinction of the large forms has taken on a somewhat exaggerated importance. Our knowledge of birds and of other small fauna is not nearly so extensive.[5]

[4] It is to be noted, however, that Clements and Chaney do not accept this view of grassland origins. See pp. 33–34 of their monograph.

[5] "The reconstruction of the past mammalian life has until recently been based almost en-

2. *The fire-drive was a basic hunting practice among modern Indians. It is a reasonable assumption that it was introduced by the early comers and that its effects were catastrophic.*

To survey the literature dealing with the hunting practices of the Plains peoples would lead far afield and need not be attempted here. Let us accept the fact that fire was indeed used. Yet we still encounter the same problem which the present writer pointed out in connection with assumptions that the Folsom people exterminated their game by the lance or atlatl. Why, if this method was so deadly, did the living bison and the living antelope roam the plains in countless numbers? It is known that both these animals perished in occasional fires and floods, but the great life-stream flowed on in vigor until the riflemen came. It seems difficult to accept the destruction postulated for a scant number of early hunters and then to find that the same methods were having no observable effect on bison or antelope numbers within historic time.[6]

3. *Archeologic proof is difficult to establish, but nothing else is known that would explain the high frequency in these campsites of the large, powerful and protected mammals.*

We must note several things here. In the first place large animals are always preferred for food. The meat is generally better, and a single kill is sufficient to nourish several people for days, whereas small animals have to be pursued in numbers and with persistence. Big game, therefore, is always sought in preference to small forms. Bison were the most numerous of the Plains fauna and their attraction is clear. It is to be noted, however, that horse, camel and antelope—in no wise formidable animals—seem to be the forms next most enumerated from Folsom sites. Evidences of elephant association are far less numerous, and in the Plains region, to date, there are no evidences of great fire-drives in connection with mammoth killing, no traces of great herds driven over the rim rock of valleys, no evidence of the piling up of numerous individuals, no remains of the scorched bones of victims. Folsom man knew the mammoth, but to date there is little evidence that he hunted him with the same assiduity with which he pursued the bison and certain less formidable beasts.

This is not to say that the Folsom people feared the mammoth or could not hunt him—there is clear evidence of kills. But there exists a very genuine possibility, only to be clarified by further work, that the great beast may already have been less numerous than his confreres. However this may be, there

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tirely on the larger and more conspicuous forms. Only occasionally have the remains of the smaller mammals been taken in association with the larger species. In fact, it was believed for years that the remains of the smaller vertebrates were mostly missing from the deposits. The demand for spectacular exhibits has led each field party to search for larger and better specimens, constantly overlooking, without a doubt, deposits containing small vertebrates." (Hibbard, 1941.)

[6] The bison held their own even after the domestication of the horse and the introduction of fire arms. The destruction of the herds actually began only with the advent of the railroads and the robe hunter (Clements and Chaney, 1936, p. 33).

is absolutely no trace of his extermination in anything like the catastrophic numbers demanded by the theory of the fire-drive. The bison, by contrast, obviously was trapped in drives of some nature, but this method employed on the existing bison still did not lead to its disappearance in spite of vast kills. Moreover, the Folsom point, whether used with lance or atlatl, was quite capable of killing bison. Instance the point found at the Lindenmeier site, driven between the vertebrae of *Bison taylori*. These weapons were not ineffectual even if employed cunningly from ambush or in the midst of a stampede over gullies or rim rock. As for horse, camel, and antelope, here again there is no evidence of mass kills.

Obviously we need more extended data from such vast camping sites as Lindenmeier, but the amazing thing about this particular site is the paucity of any elephant bones (confined, I believe, to just one fragment at the present time) whereas in Europe mammoth bones were much in evidence in the late paleolithic sites, being utilized, apparently, for a variety of purposes. Whether Lindenmeier eventually proves to be an exception in this regard remains, of course, to be seen.

4. *Predators, such as wolves, should have increased in response to the increase in numbers of injured herd animals, thus tending to destroy them.*

Interestingly enough, Smilodon, *Felis atrox*, and the dire wolf vanish with the fauna upon which they preyed. It is, of course, reasonable to assume that Smilodon, a highly specialized beast, passed with the elephants he hunted. But why, so long as bison and antelope continued to exist, did such forms as Aenocyon and the Arctotherine bears, to mention just two forms, fade out of existence? Presumably there was still game in plenty. Nor were they reachable by fire.

5. *The bisons and the mammoths ranged pretty well across the continent but made their principal domain the Plains.*

Though an exhaustive study of this problem would demand a careful differentiation of the late Pleistocene species of mammoths and the ecological distinctions among them, we may make one brief observation. The eastern mastodon was a forest dweller. He was not, typically, a part of the Plains fauna. He was not concentrated in the Plains that the Folsom people frequented. He was not susceptible to mass attack by fire. Yet he, too, perished along with the eastern forest sloths and *Castoroides ohioensis*, the giant beaver. Nor does the fire-drive adequately explain what transpired in the bone-strewn wastes of Siberia, Alaska, or certain of the Arctic islands.

Even the charge that the Folsom weapons would not have sufficed for large beasts of thick hide and fur overlooks the fact that the Eskimo used to attack the great sea mammals of the Arctic—whale and walrus—with no more elaborate equipment.

III

This survey of Dr. Sauer's main contentions reveals, I believe, the impossibility of using any one specific explanation to dispose of so complicated an

array of events, either here or in the Old World. It is quite probable that man played some small part in the final drama. But something which we may suspect as being at least partially linked with the mysterious climatic changes of the closing Pleistocene had already started that rich fauna down the road to disappearance. Sauer has doubted the possibility of epidemic disease striking across so many genera of animals. We may, with restrictions, agree with the evidence that Osborn has marshalled-evidence that certain diseases *do* strike through several forms as taxonomically remote from each other as camels and elephants. Furthermore, the humidity of the period of ice retreat might have encouraged the spread of such diseases. Such items may have contributed here and there to the final result. Nevertheless we may agree with Sauer that it is quite unlikely that epidemics alone produced the final disappearance of all the Pleistocene fauna. Forty years ago, after an exhaustive study of extinction, Osborn could only write: "Following the diminution in number which may arise from a chief or original cause, various other causes conspire or are cumulative in effect. From weakening its hold upon life at one point an animal is endangered at many other points."

We may, if we wish, attribute the failure to make a comeback to the Sewall Wright hypothesis of fixation under conditions which demanded a quick efflorescence of mutations which, in many instances, could not longer be made. We may note that some forms were adjusted to extreme cold, not to heat, or we may just as readily give some part at the close to man. But all of the amassed data, the strange disappearances in parts of the world where man had little or no foothold, argue against the reality of any simplistic explanation. Dr. Sauer's contribution is apt and impressive, but as a treatment of Pleistocene events, it raises as many problems as it seeks to lay. It would be better added to that list of cumulative factors proposed by Osborn which make toward the death of species, but taken alone are seen not to be sufficiently embracing to encompass the destruction of an entire fauna. The Pleistocene still keeps its mystery, probably because it has no single secret to lose.

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