# PRIMITIVE MAN AS AN ECOLOGIC FACTOR[1]

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> "But it is not true to say that the progress of civilization liberates man from the influence of mother-earth: on the contrary it is always knitting him with it more and more intimately and comprehensively." (Kirchoff, 1906, p. 108).

We are all aware of the general apprehension felt by certain governmental agencies and authors of recent books over the problem of the reckless dissipation of the world's natural resources. I mention Stanley Cain, William Vogt, Fairfield Osborn and Harrison Brown as recent authors who argue that the world's supply of natural resources, whether or not they can be described as cyclic or renewable, do not exist in sufficient quantity to allow indefinitely continuing consumption at present rates, and that the world either must face and find a solution to the twin dangers of increasing population and decreasing natural resources, or continue in its headlong rush for self-destruction. This view seems to deny or at least deprecate the technological ability of man to find surrogates, or to develop synthetically new resources with which to feed, house, and clothe the increasing numbers of the species.

One assumption is made by most, if not all of the authors of recent books on the dangers which man faces in the future if he persists in squandering the resources which Nature gave him. This assumption is that, although man has inhabited the planet for a half-million or million years, he existed until recently in such small numbers and with such simple cultural equipment that he can be disposed of as having had no appreciable effect in altering the nature of the physical world. That is, during the whole span of the Stone Age and until four or five thousand years ago, man constituted a minor element in the natural environment, living as a hunter and gatherer who ate what he could find, lived and died for thousands of generations, never being present in sufficient numbers to leave any permanent impression of his presence on the landscape. In short, until say 5000 years ago, the earth retained its pristine form, and any modifications of its physiography, fauna or flora are ascribable to natural causes.

This view is one with which I do not agree, and the alternative is offered that anthropologists have now accumulated sufficient evidence to argue that at any point in time or space where man has occupied a region he has materially affected the soil, the fauna, the flora, and even the climate, through the intermediacy of that one distinctive human possession which we call culture.

I would define human ecology in simplest terms as the interrelationship of human populations and their physical environment. As living men adapt their life routine to an environment, so do they alter that environment in certain ways, and the alterations thus caused in turn react on man. Ecology, therefore, is a dynamic situation, and its true significance can only be understood in the milieu of time and when analyzed by the historical method (cf. Wissler, 1924; Sherlock, 1922; Fischer, 1915; Darling, 1951).

The theater of man's action is the earth's surface which, as Harrison Brown says (1954, p. 3), "is covered with a .... film of stuff which we call life. The film is exceedingly thin, so thin that its weight can scarcely be more than one-billionth that of the planet which supports it. If we were to collect all living matter and mold it into a single lump, it would appear, when placed next to the earth, as a mosquito appears in relation to a melon." The film of life is continuous, and the forms of plants and animals occupying it are for the most part, short-lived. "Life on earth has consisted of a steady flow of births and deaths, not only of individual organisms, but of groups of organisms. These groups have evolved, cut out niches for themselves in the scheme of life, and exploited these niches to the fullest extent until they could progress no farther. They have then become extinct or have ceased to change" (Brown, 1954, pp. 3-4). In animal evolution the last form to appear and become dominant has been man. The uniqueness of man as the only animal with the power of conceptual thought, added to the practical biological advantages of the mammalian form, has made him an organism whose imprint on the physical world has far exceeded that of any other single organism, even though he has not been present for more than one-fifteen-hundredths of the total duration of animal life on earth.

Of the beginnings of man, when he first became distinguishable from his anthropoid ancestral form and lived as an animal, with his principal activities consisting of avoiding death from enemies, finding a mate, and securing enough food to support life, we know nothing. Our oldest human fossil remains are already large-brained forms who probably used speech, made tools and controlled the precious, but destructive, use of fire. Throughout the Pleistocene Epoch of the past three-quarters or one million years, man gradually increased in numbers and expanded slowly over the face of the planet. This numerical increase was principally the result of culture, for as time went on the ever-expanding quantity and quality of culture allowed the expansion in numbers and in space of the human animal. In particular the controlled use of fire allowed the range of things to be eaten to be enlarged and in this way encouraged numerical increase of the species. Fire and tools also provided protection and warmth and permitted the extension of range of the species into environments which in a feral state would have been denied the tropical hairless animal we call man, by allowing encapsulation in houses and clothing. By ten or fifteen thousand years ago all the habitable world had been occupied except perhaps for the Arctic regions. In all this time man lived as a hunter and gatherer, not as a food producer. This last, food production, came with the decision of man, somewhere in southwestern Asia about 5000 B. C., to settle down and rely upon agriculture, growing crops which for a long time may have been under haphazard

selection and tending (Braidwood, 1953). This change, called by Childe the Neolithic revolution, marked a new phase of man's history, and was characterized by a population explosion and a greatly accelerated rate of cultural development. The earth's population 10,000 years ago could hardly have exceeded 10 million, and since that time it has expanded to 2400 million (Brown, 1954, p. 68).

The societies of man who, until recent times, existed either by hunting, fishing, and gathering, or who practiced simple farming with hand tools, are those which for practical purposes may be considered as economically and technologically equivalent to Paleolithic foragers and early Neolithic farmers (cf. Birdsell, 1953, p. 171). This equivalence is correct on the analogic level, but any assumption that Paleolithic groups actually duplicated the customs followed by peoples of recent date, notwithstanding the fact that these last live on what we might call the Paleolithic level of organization, would be impossible to prove. What I hope to demonstrate by the following data is this—that the precise condition of the palpable organic environment over most of the habitable world is in all probability and in measurable part a result of man's occupation and the application of human culture. This is another way of saying that I do not agree with the assumption often made by human ecologists, conservationists, and demographers that the natural resources of the earth were in their pristine state and the product only of natural forces up to the time the Neolithic culture spread in the Old World on the world-wide exploitative expansion of European culture beginning at the end of the fifteenth century at which time the great physical modifications marked by profound alterations of the earth's fauna, flora, mineral resources, etc., began to be made (cf. Allee and Schmidt, 1951, pp. 668-669).

In any area where man first appears, we have a new species of animal introduced who is primarily equipped to alter the delicate natural ecological balance which is, up to the moment of man's appearance, the result of a long historical development determined by natural forces. That is, cultural processes are added to the existing natural ecological processes already in operation. The result is a new development which Laura Thompson (1949) terms "eco-cultural," and which involves all the plants, animals, and humans in a new web of continually adjusting relationships (ecosystem). In this view the cumulative effects of man's influence as it has been impressed upon nature for the past half million or more years must be very large.

Man is sometimes characterized as a destroyer, sometimes as a conservator. Both of these are true, for any use of the resources of nature is destructive, and few human societies engage in deliberately unrestricted and wasteful use of natural products. If a single word characterization is needed to denote man's influence, perhaps it is "changer." This idea was expressed as long ago as 1867 by George Perkins Marsh in his book, The Earth as Modified by Human Action.

Let us now review some of the available data on primitive man's influence upon the earth and the life forms which it supports. First we may look at direct measures of the conservation of plants and animals. Primitive game laws serve to limit over-hunting and to protect the supply of animal life.

Such laws may be deliberately restrictive, or they may be masked under guise of magic or ritual.

All human groups, with the exception of the Orang Laut, the maritime sea gypsies of the East Indies, own the land upon which they live and protect it from unauthorized trespass (Hoebel, 1949, pp. 331-340). The existence of territoriality, whose overt expression lies in the complex of social behavior displayed in the defense of an area, is generic to terrestrial vertebrates (see review by Bartholomew and Birdsell, 1953, pp. 484-486). Summaries of data on land ownership among primitive peoples have been presented and discussed by Hoebel (1949), Speck and Eiseley (1942), Powell (1891, pp. 30-45), Hallowell (1949), Speck (1928), Steward (1936), Linton (1942), Herskovits (1952, Chap. XV), Lowie (1951, pp. 134-142), Macleod (1924, pp. 43-46). Perhaps the most common cause for war among primitive peoples is trespass whose motive is usually the acquisition of plant or animal foods. In this light, much of primitive warfare may be said to be motivated not by innate aggressive tendencies, but as a conservation measure. Within group-owned territories there is commonly family ownership of food resources such as grass seed areas, patches of nut-bearing trees, fishing holes, hunting tracts, etc., which are inherited in either the male or female line. Private ownership of this sort is generally accompanied by requirements of regulated and limited gathering together with the physical protection of the resources. These concepts point up the awareness that future generations of users must be provided for (Speck, 1939, p. 25). The general proposition may be made that a culture pattern is likely to become distorted when its bearers ignore the necessity of a responsible relationship to its basic resources (soil, animals, wild plant foods, etc.), and that this necessity is the main reason for conservation measures so widely employed by primitive peoples.

The regulated and judged exploitation of natural resources may be illustrated by examples. The Indians of the Great Lakes region strip basswood fiber off only one part of the circumference of a tree so that the wound may heal and the tree continue to grow (Jones, 1937, p. 3; Densmore, 1928, p. 386). Similarly the Kwakiutl of Vancouver Island never fully strip the bark from a cedar tree lest the tree die and its spirit curse the man who peeled the bark and he die also (Boas, 1921, pp. 616-619).

Among the Choctaw of the southeastern United States laws were made "governing the amount of game that might be killed by each family on the 5 rivers and how much by the whole band" (Swanton, 1931, p. 101). The game laws were very strict and the amount of game killed was determined in advance by the captain of each of the five bands who kept account of how much game was killed by his group each month, so that the head chief could regulate any over-hunting (Swanton, 1931, p. 54). Among the Kaska of the Liard River on the border of Yukon Territory and British Columbia certain beaver colonies are never trapped, but are left alone to reproduce so that the supply does not disappear (Honigmann, 1949, p. 71). The Kaska trap marten areas only every two or three years to enable the supply of animals to recover (Honigmann, 1949, p. 71). The Iroquois hunters spared the females of all species at the breeding season in order that there be no diminution in the supply of food animals

(Flannery, 1939, pp. 15-16; Waugh, 1916, p. 131), and the sparing of pregnant animals is widely noted among American Indians (Osgood, 1937, p. 32, Tanaina; Flannery, 1939, pp. 15-16, Wyandot). The ancient Maya rulers of Guatemala punished with death any man who killed the rare quetzal bird (Morley, 1946, p. 440). In the Inca Empire was what might be termed a Department of Conservation which regulated the use of natural resources. Among the Algonkian tribes of the eastern subarctic from Hudson's Bay and the Great Lakes to the Atlantic there were family owned hunting territories inherited in the male line. These territories were subdivided into quarters, and one quarter was hunted and trapped each year. This system of rotation enabled the game to replace its population. Since each man was intimately acquainted with his area, he knew about what the animal population numbered, and never took so many that the breeding stock was reduced below the proper level (Speck, 1940, p. 207; Cooper, 1939; Flannery, 1939, pp. 15-16; Macleod, 1936; Speck and Eiseley, 1942, pp. 283 ff.; Speck, 1915). Frank Speck, a long-time student of the northern Algonkians, says that the supply of game would have disappeared long ago under unrestricted hunting, and that the conservation measures practiced are for insuring the survival of the human groups (Speck, 1939, p. 23). The Yurok Indians of the Klamath River in northwestern California prefer to hunt male deer, and kill females only in time of severe food shortage. They do not take quail and grouse in the nesting season. Any person who violated such game laws would lose his hunting luck (Roberts, 1932). The Andamanese islanders whose main food is the tubers of the yam (Dioscorea glabra Roxb.) observe a taboo on digging the roots in the season of new growth. This taboo is ordered by the tribal elders who say that Puluga, the rain god, needs the yams during that season. The actual effect of this restriction is to insure next year's crop. They similarly protect the seed crop of other plants (Entada scandens Benth.) and the palm cabbages of Caryota (Burkill, 1953, p. 12). The Menomini of Wisconsin when gathering wild rice always allow some of the rice to fall into the water in order to insure a crop the next year (Densmore, 1928, p. 314). The Lapps of northern Europe control game killing through the local group (Lowie, 1945, p. 451); the Yukaghir of northeastern Asia never killed off all of a wild reindeer herd but deliberately left some for breeding, and when closing a stream with a fish weir they were careful to allow part of the run to pass upstream in order to spawn (Macleod, 1936, p. 562). This last situation is duplicated by the Yurok of northern California who close off the Klamath River with a weir for not more than a week or ten days, for they recognize that a complete blocking of the run will deprive them later of salmon (Thompson, 1916, pp. 135-136; cf. Roberts, 1932). The Klallam tribe of Washington always leave an opening under the salmon trap so that some fish can ascend the river to spawn (Gunther, 1929, p. 199). Kroeber (1925, p. 220) has briefly recounted the story of how the Clear Lake Pomo changed a stream course to alter the run of a particular kind of fish. The incident, though insignifant by itself, illustrates nevertheless a deliberate modification by man of natural drainage and distribution of a species.

In the Fiji Islands, each island had a master fisherman whose life was devoted to the study of the habits of fish in relation to tides, the seasons, etc. "The institution of the master fisherman functioned to increase the total catch by protecting the local fishing grounds from over-fishing and undue disturbance, and by taking advantage of the various group-fishing

techniques in relation to the weather, the seasons, and the habits of the various edible species. In a community where fishing provided the major protein constituent of the daily diet . . . this institution operated as a public health measure of prime importance in creating and maintaining a balanced relation between the community and its main food supply" (Thompson, 1949, p. 261).

Economic expediency probably accounts for restrictions on the exploitation of plants and animals, but many primitive peoples do not seem to be aware of this, and observe conservation as a ritual or magical activity. Conservation measures may have at first been practiced as a practical expedient, and were later transferred to ritual so that the measures became reinforced by magical sanction. The Naskapi of Labrador may be cited as typical of the numerous tribes of northeastern North America in their belief that all animals and plants were created to help man (Snyderman, 1951; Speck, 1939; Tantaquidgeon, 1942, p. 50). Each species in nature is reincarnated after death, and when man kills he must discharge his spiritual responsibility in acknowledging his debt by making a ritual apology and preserving the dead plant or animal from being profanely treated. Failure in the chase is attributed to the hunter's failure to observe properly these responsibilities. For example, there must be no wasting of a dead animal, and the dogs must not be allowed to gnaw the bones lest the animal take offense at the hunter. Each animal species has a "master" or "king" who must be propitiated. The master of the fish is the moose fly (Tabanus affinis) who hovers over the freshly caught fish to see that nothing is wasted. Waste is offensive to the moose fly, and if it is practiced, he will cause the man to fail in later fishing. The Canada jay (Perisoreus canadensis) is never killed, since he is believed to be the protector of small animals and helps man to find and kill large predators so that small animals will be saved (Speck, 1940, pp. 77, 91, 117, 124; Speck, 1938; Speck 1938; Speck, 1939). The Indian of the northeast views nature as having been created with a unity and balance which must be preserved, and to accomplish this he exercises moral restraint which is an effective means of preventing extinction which would mean economic loss (Gilmore, 1927; Speck, 1938).

The world-wide spread, among the various groups of primitive peoples, of supernatural prohibitions against killing one or another kind of bird or animal is conservation on an extremely localized level, but the custom has undoubtedly had its ecological effect. That sparing of certain organic forms which is practiced through the rationalization that these animals or plants are the embodiment of dieties or ancestral spirits is a part of the complex called totemism. Groups who trace their ancestry to these forms usually do not kill or harm them (Goldenweiser, 1933). The Zulu of South Africa believe snakes are the homes of ancestral spirits and do not kill them (Tylor, 1871, vol. 2, p. 212), and the Kwakiutl of British Columbia believe every man's soul lives in the body of an owl, so owls are carefully protected, since a man dies whenever an owl is killed (Goldenweiser, 1933, p. 235). In the Georgia Islands group herons, woodpeckers, and kingfishers are sacred and never harmed because deities reside in their bodies. The Tongans never kill sharks, whales, or certain birds because these animals are shrines occupied

by gods who are visiting the earth (Tylor, 1871, vol. 2, p. 211). The belief that game is under the watchful care of supernatural authorities is also widespread. The Popoluca of Vera Cruz believe that chanekos or dwarfs are the masters of fish and game and have the power to grant or withhold hunting luck. They become angry with men who kill too many deer or with persons who wound, but do not kill, deer, and they punish such offenders by capturing their soul and thereby cause their death (Foster, 1945, p. 181). On the southern end of Madagascar wild pigs cannot be killed for religious reasons, and they increase to such large herds that they interfere seriously with crop-growing (Berkusky, 1913, p. 495). On the island of Nias in the East Indies no more wild pigs can be killed than are needed lest the God of the Forest, to whom these belong, be angered and cause the hunter to fall ill (Berkusky, 1913, p. 498). The Yukaghir believe each wild animal has a protective spirit who will harm the hunter who practices wasteful killing (Berkusky, 1913, p. 498), and the Puyallup of the State of Washington kill only as many dog salmon as they need lest the salmon take the soul of the wasteful person (Gunther, 1928, p. 152). Such beliefs are of very common occurrence (see Speck, 1940; Sullivan, 1942, p. 76), and there are two instances recorded of native peoples in Asia and northeastern North America who say the elk and moose left their territory because of wasteful killing of their species (Macleod, 1936, p. 563). Salmon to the Yurok Indians of northern California were a gift of the creator, and their taking was a solemn undertaking, in the same sense that Speck (1938) describes the northeastern Indians as viewing nature as Thoreau did and conceiving of hunting or gathering as a "holy occupation." The Yurok held a ceremony at the mouth of the Klamath River whose central feature was the capture, cooking, and eating (often as a communion, in which everyone present ate a morsel) of the first fish of the season. Such festivals are known the world over wherever people live on seasonal products, and are called increase-rites or first-fruit ceremonies, their main purpose being to insure by magical compulsion a bountiful crop for the next year (Gunther, 1928, 1929; Foster, 1944, p. 165; Kroeber and Gifford, 1949; Curtis, 1926, p. 97). The Hopi of Arizona hunt mountain sheep by surrounding a herd of animals of which all but two, one male and one female, are killed. The Hopi say they do this "so as to make more sheep for the next hunting" (Beaglehole, 1936, p. 11). Beaglehole (1936, p. 23) says, ". . . to understand the use of ritual as an aid towards conservation, it may be recalled that the Hopi attitude towards animals, like that of all other Pueblo peoples, is one of respect and esteem. Animals may not be ruthlessly destroyed or wantonly exploited just for love or excitement of the chase. They must be protected, entreated humbly not to become angry if killed, and urged to give themselves or their young for the use of their human kinsmen. . . . The dead body [of a rabbit or antelope] is respectfully treated and food is sacrificed, that the soul of the animal may be appeased and find no occasion to warn away living companions from the hunter and his needs. Taken in conjunction with the fact that prayer sticks are placed on shrines or buried in fields during the winter solstice to ensure fertility of all animals . . . it is evident that this propitiatory aspect of ritual serves to preserve animal life for continued use by checking evil results that would inevitably follow from uncontrolled carelessness, neglect, ill-treatment, or the operation of obscure otherworldly forces. . . . The nature of the chase is determined primarily by economic and social values. Ritual, and not specifically religious, patterns

are used within this sphere to help secure success and to preserve the fauna of the environment from thoughtless exploitation." Hopi hunting ritual appears to have for its general purpose "the stabilization of a definite psychological attitude toward the fauna in such a manner . . . as to conserve and protect the fauna by ritual propitiation."

Let us now turn to what data have a bearing upon the extinction of animal or plant species by the hand of man. The most ancient evidence of species extinction by man is the disappearance of the manlike Australopithecine apes of Africa and southeast Asia through lower Pleistocene tool-using hominids, of whom Pithecanthropus was one (Bartholomew and Birdsell, 1953, pp. 492, 495). Sir Charles Lyell (1873, pp. 418-419) and Alfred Russell Wallace (1911, p. 264) argued that man may have helped to hasten the extinction of some of the more bulky Pleistocene animals who were already on the decline (see also Eiseley, 1954, p. 56; Macgowan, 1950 pp. 150-151). There is abundant archaeological evidence that early man in North and South America knew and hunted many animals now extinct (Sellards, 1940, 1947), and the proposition is probably true that their extinction was hastened by human hunters equipped with fire and weapons. That primitive hunters know the effects of over-hunting is clear from recorded evidence. For example, the Kaska of Yukon Territory are aware that over-hunting has caused the moose to disappear from their area (Honigmann, 1949, p. 71), and the Carrier tribe of northern British Columbia say that the elk, which once lived in their land, was long ago hunted out. Egyptian records are clear on the point that the crocodile and hippopotamus once ranged as far north as the mouth of the Nile, but their present range is limited to the falls at Assuan. Ritchie's book entitled The Influence of Man on Animal Life in Scotland (1920) produces a long list of species (e.g., lynx, Lynx lynx; brown bear, Ursus arctos; wolf, Canis lupus; wildcat, Felis silvestris; beaver, Castor fiber; reindeer, Rangifer tarandus) which were known up to or past Neolithic times, but which have either been hunted out or starved out through competition by domestic animals or deforestation. In New Zealand recent excavations in sites occupied by the ancestors of the aborigines, the Maori, or their predecessors, have yielded numerous remains of the extinct, flightless moa bird. These sites were occupied in the period from the 5th to the 13th centuries. A. S. Deevey (1954) concludes that man was responsible for the final extinction of the moa (see also Murphy, 1951, p. 572). Overhunting, such as the instance of a heap of 64 antelope killed by Indians in the Sacramento Valley noted by John Work in 1833 (Maloney, 1943, p. 327) or the mass bison killings of the Plains Indians (Newcomb, 1950, p. 326) certainly would have an effect on the local game population, but such instances of wasteful hunting are rarely reported and are not typical of primitive peoples. Local depletion of a game resource by overhunting may have caused a temporary absence of the species, but if that animal was not completely reduced, after a few years the population would regenerate itself. To illustrate, Steward (1938, p. 35) gives an account of the antelope drive by the Gosiute of Deep Creek. An old man said that the last drive was 12 years before, and that this span of time was required for the animals to increase in sufficient numbers to make the communal hunt worth-while.

Plants, like animals, may be over-exploited, and to cite a few examples we may note that the carob or locust bean tree (Ceratonia siliqua) once more

widespread survives in Egypt only in scattered remnants along the coast from Alexandria to Syria, and the papyrus (Cyperus papyrus) which formerly grew abundantly in marshy areas of Lower Egypt no longer occurs there (Lucas, 1948, pp. 162-163, 503). Sauer and Meigs (1927, p. 274) noted in the San Fernando de Velicatá area of Lower California that the agave plant was unaccountably rare, and suggest that its scarcity is probably due to intensive Indian collecting in the past.

The deliberate destruction of species was probably emphasized by man after he became a farmer and herder, for at this time he classified the flora into "useful plants," which were worth preservation, and "weeds," which should be rooted out. Animals, likewise, were categorized as "good" or "bad" and the latter which included beasts and birds of prey were marked for unremitting persecution. Thus, the care of domestic flocks and herds and crops, which are by themselves conservation techniques, increased in another way the enmity of man and nature, and with the invention of gunpowder the representatives of a considerable relict fauna were finally exterminated.

The deliberate interference of man with the natural fauna, flora and soil has become more marked with the increase of his numbers together with improved industrial efficiency. Man who is by custom (not nature) a disturber of nature thus has not only introduced a cumulative influence through past time, but also this influencing has increased in a quantitative sense relative to the development of culture.

Of all the items in man's cultural tool box, fire is the most important (Eiseley, 1954). In recent years Omer Stewart and Carl Sauer have been studying the whole matter of land burning by primitive peoples, and have concluded that the world's great grasslands are not natural climaxes, but are man-made and should properly be called fire-vegetation (Stewart, 1951, 1953, 1954; Sauer, 1950; Daubenmire, 1947, Chap. 8; Phillips, 1936). This idea is not original to these students, for O. F. Cook in 1920 (also Cook, 1908) proposed it, and cites a monograph by Busse of 1908 who concluded that periodic burning had formed the African grasslands. Sauer (1950, p. 19) says, "The fire-setting activities of man perforce brought about deep and lasting modification in what we call 'natural vegetation,' a term that may conceal long and steady pressure by human action on plant assemblages." Stewart (1954, p. 235) concludes that nearly all of the world's vegetation is fire-made, and he excludes from the category of fire-vegetation those areas where fire will not take, as in arid regions, high rugged mountain areas, and wet bottomlands. Thus, if Stewart is correct, the world's grasslands are not necessarily climatic or ecologic climaxes, but ecologic assemblages established and maintained by the recurrent cultural use of fire. Major grasslands, in short, are a part of the cultural rather than natural landscape (cf. Sauer, 1925). Stewart (1953) believes the western or high plains, had not man interfered, would have supported drought resistant trees such as juniper, ponderosa pine and hackberry, plus sagebrush in the north and mesquite in the south, and that on the east the brush and pines would have met the eastern hardwood forest where the tall grass prairie now merges with the short grass plains. Similar arguments have been advanced for the fire origin of the Argentine Pampa (Schmieder, 1927),

the African grasslands (Bews, 1929, p. 293; Braun-Blanquet, 1932, pp. 278-283), New Zealand grasslands (Levy, 1937), and Puget Sound lowland prairies (Rostlund, 1954, p. 32). Where climatic conditions strongly favor tree growth, recurrent firing may not cause grasslands to appear, but will selectively favor one tree type and make it dominant over others. Three examples may be cited (after Stewart, 1954). The teak forest of Burma flourishes and is productive only when annually burned. The British stopped this practice for 25 years, but finally resumed it when they realized the absence of fire encouraged less useful trees to flourish and eliminate teak (Chapman, 1950, pp. 131-132). The long-leafed chir pine of India maintains itself similarly only through fire which eliminates floristic competition (Gorrie, 1935, pp. 807-811). The long-leaf pine forest of the southern United States flourishes only under continuous burning, which kills off seedlings of other trees and gives advantage to the pine (Pinus palustris) in various ways such as burning out the brown-spot fungus needle disease which lives in dead grass and needles on the ground (Stewart, 1954, pp. 238-243; Daubenmire, 1947, p. 333). The great pine stands of southern New York and westward to the Great Lakes according to Gordon (1940, p. 15) were due to Indian burning (see also Gleason, 1913; Byers, 1946, pp. 18-23; Day, 1953, pp. 334-339; Hawes, 1923; Bromley, 1935). Raup (1937) does not agree with the opinion held so widely (Day, 1953, pp. 336-337) that parklands and grasslands were caused by Indian fires. It is not so much that primitive man has labored consciously to create pine forests or grasslands, but that his burning proclivities have caused the appearance and maintenance of such floristic assemblages, and as the animal populations there have accommodated to the changes, so has man altered his activities and put his creation to good use for his own purposes. Thus, cattle raising by the peoples of East Africa is partly accounted for by the lack of shady forests. At least in some areas, such as in the Anglo-Egyptian Sudan along the Nile River south of the Bahr el Ghazal, the parkland is fire-vegetation and the man-made floristic pattern thus favors cattle both by reason of the absence of the tsetse fly and the presence of grass for cattle feed (Stewart, 1954, pp. 233-234). In northern California the country was far less overgrown with brush and trees in Indian days than at present (Thompson, 1916, p. 230; cf. Jepson, 1951, p. 6), and the cessation of land burning is the chief cause. Yosemite Valley, when surveyed by J. D. Whitney in 1866, was more open than today, the amount of meadow now being less than one half what it was 80 years ago. The increase of forest is ascribable to cessation of Indian burning (Ernst, 1949). It is noted by present day foresters that cows and deer prefer to graze on recently burned over land, probably for the reason that shoots from burned back brush and new grass growing in ash compost contain more minerals which are attractive to the animals (Stoddard, 1935, pp. 346-350; Longhurst, Leopold and Dasmann, 1952, p. 11; Storer, 1932, p. 324). Bromley (1945) is of the opinion that Indian forest burning in Massachusetts encouraged growth of plants upon which game birds and deer subsisted, the effect being increase of these animals (see also Stoddard, 1935, pp. 346-350). The isolated occurrence of Torrey Pines on the southern California coast has been explained as due to their position in a fire-protected area (Carter, 1950, p. 75). Although firing the ground cover as a means of hunting is effective, the peoples of the subarctic forests and tundra avoid using it, since the tundra lichen which supports caribou will not regenerate for from 50 to 100 years after being burned off (Leopold and

Darling, 1953, p. 54; Rousseau, 1950). The Gosiute Indians of Utah do not like to use fire for the rabbit drive "because it takes years for the brush to grow up again" (Steward, 1938, p. 39).

A hint as to the climatic effects of deforestation comes from the study of Harsh and Connaughton in 1938 (summarized after Stewart, 1954, p. 231) of 19,000 acres of Tennessee hardwood forest deforested by copper smelter fumes. They found the temperature to be 3 to 4 degrees higher on denuded areas than in the near-by forest, wind velocity to be 7 to 10 times greater in winter and 34 to 50 times greater in summer, and rainfall to be 25 percent less in the cleared area than in the forest. Some of the major floristic alterations by the hand of man alluded to earlier have undoubtedly been reflected in climatic modifications with resultant effects in the resident fauna and flora.

The shifting type of milpa agriculture in the tropical New World involves forest clearing, cultivating for a brief period until the forest encroaches, or the thin soil is exhausted, and then starting the process over. In the tropics where there are thick forest cover, heavy rain, and thin poor soils a burned area will yield a crop for one or two years and is then abandoned to revert to forest, a process which may take 15 to 20 years (Linton, 1940; Cook, 1920; Morley, 1946; pp. 141-158). Repeated burnings may produce a grassland in tropical regions which will then be succeeded by forest growth only after a very long period of time (Cook, 1920; Beals, 1945, p. 130). The milpa method of farming is known throughout the tropical areas of Southeastern Asia, Africa, and the New World (Whiffen, 1915, pp. 103-105; Cook, 1920; Swingle, 1937; Riley, 1932; Tudimura and Matui, 1940, pp. 941-942; Pendleton, 1940). Fire-clearing of forests was also practiced through large parts of the temperate forests of North America with far-reaching floristic modifications. Thus, one explanation advanced for the unusually high proportion of nut-bearing trees in the Eastern hardwood forest is that the Indian farmers who for the past two or three thousand years fire-cleared farm plots here have spared the nut trees, and the cumulative influence of such selective burning has thus altered the composition of the woodland (Carter, 1950, p. 77). A study of Maya farming and inspection of the Yucatan forest led Hightie (1948) to conclude that slash-and-burn farming of the Maya may account for the abnormally high incidence of the chiclé (Achras zapota) and the ramón tree (Brosimum alicastrum), both of which yield edible fruits. These trees were apparently spared by the Maya when clearing fields, and in the abandoned fields they were favored and have become dominants in the second-growth forest.

I am able to add a note from personal observation while engaged in archaeological investigations at La Venta, Tabasco (Mexico) in 1955. The main corn crop of the year (milpa del año) is planted in an area cleared from the virgin forest. While clearing the people save certain useful trees such as the "palma de coyal" whose leaves are used to thatch houses, the "mamey" (large sapote) and "chico sapote" whose fruits are used for food. Milpas in the area almost invariably have these trees of economic value standing at random. We were told this practice is customary through southern Vera Cruz and Tabasco.

The work of the Danish school of palynologists (pollen analysts) has shown that the European forest was first attacked by man in the Neolithic

period (Clark, 1952, p. 92). Pollen profiles show a charcoal layer interpreted as due to forest clearing by fire. Tree pollens show a marked decline following the fire period and grass pollens become abundant. Along with cereal pollens are those of weeds such as plantain (Plantago major) which are accidental imports along with cultivated plants (Iversen, 1941, 1949; Linkola, 1921; Godwin, 1948). One tree pollen which persists is that of the oak, and Iversen (1949, p. 21) believes that the Neolithic farmers, who were also swine raisers, protected the oaks whose nuts were valuable as food for pigs. Taken all together, the influence of simple farming peoples who clear forests for growing crops has been both pronounced and varied in the tropical and temperate woodlands.

The innumerable camp and village sites of primitive man over the earth through the past history of man have undoubtedly had a tremendous local effect upon soils, plant cover and the like. Precisely what these micro-effects are and how enduring they may be cannot be answered readily with data at hand, but it is not too late for ecologists to study the problem and thus secure a sampling of data from which reasonable inferences can be extrapolated. As man moves from one spot to another for the various reasons that impel him, he may bring along with him new plants and animals. We shall ignore here such deliberate introductions as cultivated plants and domesticated animals and refer to unintentional and accidental importations. Many uncultivated plant distributions are best explained as due to having been spread by man. This is the explanation invoked by Carter (1945, pp. 29-30) to explain the wide distribution of Cucurbita foetedissima, the inedible wild squash, whose seeds are eaten by man. Archaeologists and botanists have often noted the particular association of certain plants with sites where man has lived, the disturbed surface and enriched soils of such spots apparently furnishing an ideal place for such volunteers to flourish. Such plants (adventives they are called) have been introduced by the agency of man, and may be either local species which volunteer in the sunny, rich, disturbed soil of the village site, or species used for food brought to the place by man in seed form, there to become scattered and spontaneously grow. This process may be presumed of such antiquity, that it has often been pointed to as the probable means of the origin of agriculture. It may be observed that any long-continued and persistent collecting of a certain edible grass seed, digging of a particular bulb, and the like by man may very well be in effect a selective process of sorts which will have an effect upon the plant species. It seems not improbable that certain subspecific forms could have thus arisen.

Early historical accounts of Virginia Indians commonly refer to the numbers of mulberry trees in and around native villages. These were not deliberately planted, but accidentally seeded from living refuse (Maxwell, 1910, p. 96). Willis Jepson (1910) believed that many of the isolated stands of native black walnut trees in California were due to their having generated from nuts collected for food and lost around Indian camps. Throughout foothill Sierran and Coast range Central California I have repeatedly noted the association of buckeye (Aesculus) trees and Indian camp sites, and a clear case refers to Brooks Island in San Francisco Bay just off the Richmond wartime shipyards where buckeye trees are clustered on the Indian shellmounds. From Alaska,

where elderberry (Sambucus) and nettle (Urtica) invariably cover former native village sites (Hrdlička, 1937; Bank, 1953) to Tierra del Fuego where wild celery and scurvy grass grows luxuriantly on ancient shell middens (Bird, 1938, p. 255; Lothrop, 1928, p. 179; Darwin, 1945, p. 202) we have records of such associations (see also Clark, 1947, p. 39). The soil chemistry of man-made midden or refuse deposits apparently retains its peculiar characteristics for many thousands of years as judged by Iversen's observation that goosefoot (Chenopodium) and nettle (Urtica diocca) have a predilection for Danish sites of Mesolithic age (Iversen, 1949, p. 9). A California instance of human interference with natural distribution of vegetation comes from the account of Lt. George Derby, who in 1849 observed that in the Southern San Joaquin Valley Indian rabbit traps were made by sticking willow poles in the ground, and that these poles had "sprouted into trees" (Derby, 1933, p. 39). Instances of isolated patches of plants growing several hundred miles out of their normal range and associated with old Indian trails or village sites are ascribed by reputable botanists either to deliberate or unintentional introduction by Indians. These plants were known to the Indians as useful for food or medicines and illustrative examples include the calamus or sweet flag (Acorus calamus), black walnut (Juglans nigra), prairie crab-apple (Malus ioensis), buffalo berry (Shepherdia argentea), cactus (Opuntia rafinesque), lotus (Nelumbo lotus), and others which are found in isolated stations in the plains-prairie region between the Rockies and Mississippi River (Gilmore, 1931; Moseley, 1931).

The transportation of seeds used for food could be one means of distribution. Note, for example, the general picture of Great Basin Shoshoneans given by Steward (1938) of small groups wandering from one known spot to another where water could be had and where certain seed-bearing plants were ready for gathering. Other examples come from Robbins et al. (1916, p. 69) where the Tewa are said to have collected wild walnuts when they hunted buffalo in the Arkansas River Valley, and various seeds used for food or medicine from Oklahoma, Texas and southern New Mexico were secured by the Tewa by trade. Any such outland elements could become established far from their original home.

The Achomawi of northeastern California secured tobacco seed to plant from the neighboring Shasta because tobacco did not grow in their territory (Curtis, 1924, p. 141). Such an instance could readily provide the means of extending the range of Nicotiana in this region. Seibert's study of the South American rubber trees (Hevea) led to the observation that the nuts of this plant are used for food. In the Upper Amazon and Rio Negro districts former Indian planting of Hevea seedlings from the uplands in milpa clearings led to interspecific crossings with local lowland forms, which has resulted in the wide variability observed in Hevea types (Seibert, 1948; Anderson, 1952, p. 130). Seibert (1948, p. 119) also points to the range of the peach palm (Guilielma gasipaes (HBK) Bailey) from the eastern Andean slopes where it is native through the Amazon Valley to Central America and the West Indies as due to human action.

All of our familiar cultivated plants were first domesticated in ancient times and most of them can be traced back to not more than 5,000 or 6,000 years ago. Even at this date they are far removed from wild ancestral forms, the

implication being that a very long process of plant alteration must be assumed as having taken place before a true farming-urban economy, Childe's "Neolithic revolution," occurred (Braidwood, 1953; Ames, 1939; Anderson, 1952). The "garbage-heap hypothesis" of the origin of agriculture was advanced by Walter Hough (1929) and later argued with more vigor and detail by Oakes Ames (1939, Part V) and Edgar Anderson (1952; see also Sauer, 1947, pp. 22-24). The essence of the theory is that untraceable ancestries of most of the cultivated economic annuals important for food are due to ancient hybridizations and subsequent selection occurring while these were adventive heliophytic plants living on the fringes of the open camp sites of seed-gathering peoples. These improvements, which Burkill calls "ennoblements," apparently usually involved hybridization. When they happened to take the direction of larger, more, or better flavored seeds, or whatnot, man may have noticed them and taken to collecting the seed and deliberately sowing it (Burkill, 1953, p. 13). W. A. Setchell (1921, p. 412) believed that the distinctive Clevelandii species of tobacco (Nicotiana) found only on Indian shell heaps around Santa Barbara was possibly a hybrid of N. attenuata and N. Bigelovii. We may add that such hybridization could easily have occurred adventitiously between the two parent species which commonly grow wild around California Indian village sites (Heizer and Whipple, 1951, p. 286.)

Man can alter the faunal inventory by bringing new animals with him without intent. Human body lice are believed to have been adopted from the lice of bats when our ancestors of Upper Paleolithic times lived in caves, and the human flea (Pulex irritans) is a true parasite of the English badger (Ritchie, 1920, p. 420).

The effect of man upon the soils of the world has undoubtedly been important. Thus, the deep, black prairie soils of North America are believed to be a result of the grass cover which is fire-vegetation (Thorp, 1948, p. 55; Billings, 1941, pp. 448-456; Christy, 1892, pp. 78-100; Wedel, 1953, p. 500). Soil erosion is an old story in human history. The deforestation of the uplands and over-grazing by domestic animals with resulting soil depletion in the Old World from Cape Verde to Mongolia dates from two to four thousand years ago, and the damage is clearly apparent today for the reason that such severe human pressure on a vulnerable landscape is not easily repaired (Sauer, 1938, p. 766; Toynbee, 1950, pp. 169-170; Sears, 1953, pp. 44-45; Lowdermilk, 1940; Judd, 1954, p. 3). In Central Mexico the studies of Sherburne Cook have proved that destruction of the upland oak forest for agricultural land, wood for burning lime and household firewood dates from the pre-Conquest period of about 1000 A. D. (Cook, 1949a, 1949b; Vaillant, 1941, p. 65). In some areas, as in eastern and southeastern Asia, Peru, and the northeastern United States, soil conservation measures involving fertilizers, soil retaining terraces, and fallowing were practiced. In Peru the laws of the Incas prohibited anyone on pain of death from visiting the guano islands during the breeding season lest they disturb the birds or spoil the nests, and it was unlawful at any time to kill the guano birds either on or off the islands (Goode, 1880, p. 477; Browne, 1935, p. 407). In east Asia, parts of Peru and perhaps other areas human night soil was employed as agricultural fertilizer (Goode, 1880, p. 477). Along the Atlantic coast from Massachusetts to Virginia 1,000 menhaden (word from the Algonkian language which means "fertilizer") fish were used per acre, and the Indian corn yield from a field so

treated was three times that of an unfertilized field (Goode, 1880, p. 475). In some coastal Peruvian valleys fish heads were used to fertilize farm plots (Goode, 1880, p. 477). The terraced slopes of Peru were made necessary, according to Wickes and Lowdermilk (1938), because the ancient forests were removed and slope erosion required checking. The stone-walled terraces which are irrigated, fertilized, and have new soil added when necessary, have remained productive for many centuries.

The large matter of the size of human populations and the problem of population pressure as it bears upon the use of the environment according to the economy and cultural equipment of the people involved cannot be developed at length here. I am inclined to accept the general proposition of Carr-Saunders (1922, p. 214) that "normally in every primitive race one or more. . . customs [such as prolonged abstention from intercourse, contraception, abortion, infanticide, etc.] are in use, and that the degree to which they are practiced is such that there is an approach to the optimum [population] number" (see also comment by Bartholomew and Birdsell, 1953, pp. 486-489). Supporting evidence for this theory has been collected for the Eskimo (Weyer, 1932, Chap. 8; Garber, 1947), the California Indians (Powers, 1877, pp. 178, 322, 416; Aginsky, 1939; Cook, 1943, pp. 90-92), and the Fiji Islanders (Thompson, 1949, pp. 263-264). The idea that all animals, including man, tend to develop populations which in time vary upward or below the point of equilibrium between numbers and available food supply has recently been discussed by Bartholomew and Birdsell (1953) who have emphasized that in addition to the multiple biological factors which are complex and variable, one must also consider the factor of learned behavior as influencing the population equilibrium. In lower animals such learned behavior patterns are fairly readily identified, but with man these cultural patterns are infinitely more complicated and significant as ecological factors. Sherburne Cook (1946) has developed the thesis that human sacrifice in pre-Cortesian Mexico which began as a religious institution became perverted to a socio-biological one of population control, and concludes (Cook, 1946, p. 98) that warfare and human sacrifice which increased the normal mortality rate by 20 percent "were an important instrumentality in controlling population increase and maintaining a proper balance between the number of inhabitants and their maximum available economic resources."

A summary of the foregoing data would be tedious and a few generalizations derivable from them are here offered.

Primitive hunting and gathering societies, which I take to exemplify the mode of human existence through the Paleolithic period of man's cultural development, have dealt with Nature in many ways. With animals they are careful, and in general their attitudes are those which we would call conservation-minded. Some species extinction has occurred, but by and large the emphasis of primitives is to preserve most species from extinction or serious depletion. The number of non-useful species, and therefore the destructive application of culture aimed at the eradication of species so classed, increases greatly beyond the hunting-gathering state among farmers and herders. With reference to the flora man may be called either a destroyer or a modifier, and I prefer the latter classification. Few are the areas of the earth which do not show the measurable result of human interference, these

modifications ranging from transformation of forests into the great grasslands of the world, to the enlarged geographical distribution of some uncultivated floristic species spread unintentionally in the wake of man's wanderings. Indeed, from such adventive or ruderal plants which flourished around the habitation spots of ancient gathering peoples, it is believed that the germ of agriculture was born.

Harrison Brown (1954, p. 222) has correctly seen how far the human species has succeeded in changing the external world when he says, ". . . if machine civilization were to stop functioning as the result of some catastrophe, it is difficult to see how man would again be able to start along the path of industrialization with the resources that would then be available to him." By this he means that the ready supply of native metals, wild animals, food plants with the potential for domestication, fertile river valleys for the beginning of agriculture and urban civilization, new fertile land, and the like are now pretty much used up or so fundamentally altered that if man were ever reduced, as science fiction writers would have it, by some world-wide event, to the economic and technological level of the Paleolithic hunter-gatherers, the Neolithic and Metal Ages could not, through lack of means or opportunity, ever repeat themselves.

## ENDNOTE

1. Read before the Kosmos Club, University of California, January 21, 1955.

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