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AUTHOR Darling, F. Fraser
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ABSTRACT

After summarizing the development of ecology from botanical and zoological studies to a study of entire biological communities, the history of wool growing in England and the development of nomadism on the Asian steppes and the North American prairies is described. These examples are interpreted ecologically and used to illustrate the theses that human civilization is a result of learning how to use the stored wealth of ecological climaxes, and that any ecological approach to the study of human society--whether historical, sociological, agricultural, anthropological, or economic--must recognize the changing nature of man's habitat and society. However, the scope of ecology should not be expanded to become all-embracing, or the ecologist will become "the supreme irritating busybody." Suggestions for the organization of ecological research are made. (AL)

THE UNITY OF ECOLOGY

Dr. F. Fraser Darling

THE UNITY OF ECOLOGY*

By Dr. F. FRASER DARLING
Vice President, The Conservation Foundation

It is rather extraordinary to be asked by educated people, what is ecology?—the more so, as economics is a word used by everyone and the substitution of the letter 'e' for the diphthong 'œ' disturbs nobody. Both ecology and economics, so properly derived from the Greek *oikos*—the home, are concerned with the ordering of the habitat and income and expenditure. Both sciences deal with communities and are, at simplest, observational studies of communities. Economics has tended to deal with income and expenditure symbolised in money and the most dangerous economists have been those who have mistaken the symbol for the reality. There is now a refreshing trend to consider wealth as availability of resources, often natural and renewable and organic resources. The changes in the status of availability are subtle, depending on history, growth and movements of populations, and on technology. The resources themselves change in economic status with changes in human needs and desires, emergencies and fashions.

Ecology deals with income and expenditure in terms of energy cycles in communities of plants and animals, deriving from sunlight, water, carbon dioxide and the phenomenon of photosynthesis by which organic compounds are built. This raw definition is made more interesting by what I would emphasise as the *observational* study of communities of animals and plants. Here comes the possibility of that more general definition of ecology as the science of organisms in relation to their total environment, and the inter-relations of organisms interspecifically and between themselves. The total environment includes all manner of physical factors such as climate, physiography and soil, the stillness or movement of water and the salts borne in solution. The inter-relations of organisms and environment are in some measure reciprocal in influence; in animal life it is becoming increasingly

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clear that important environmental influences are operative in what may be called psychological factors. Social behaviour can be of critical quality ecologically, and this field serves, perhaps, to show how inadequate and imperfect as yet is our observation, especially of interspecific social behaviour apparent in a complex biological community which includes man. The ecologist tends ultimately to consider man as a member of the indigenous fauna if man is a primitive hunter-foodgatherer, or as an introduced species if he is buffering himself against the environment by civilisation, developed technology, and an export trade in natural resources. But there is one outstanding difference between man and the rest of creation ecologically. He is a political animal and in our day and age it is quite unreal to ignore the political nature of man as an ecological factor.

I am already giving the impression, perhaps, that there is such a subject as human ecology, a matter which has called forth some tart difference of opinion until very recently. For myself, there is no such subject as human ecology; there is ecology only, which must accept man as part of the field of reference; but man can have an ecological outlook in studying his own problems, whatever they are—medical, agricultural, or those of labour relations.

Haeckel coined the word oecology in 1869 and he had animals in mind. There is something ironical in the speculation that so ecologically perceptive a man as Charles Darwin probably set back the study of ecology for half a century because after 1859 the palaeontological data concerning evolution had necessarily to be gathered. Ecology as we knew it fifty years ago was a botanical science primarily, handicapped by a certain restriction of vision associated with those whose eyes are focused on the sward. The early literature of ecology gravely neglected the influence of the biotic factor on vegetation; indeed, it was not until 1932 that the British Ecological Society published its second journal of *Animal Ecology*. Shelford was reacting to animal ecology in his studies of succession in the first decade of this century and his book on animal communities appeared in 1913, the same year in which C. C. Adams published his *Guide to Animal Ecology*.

Perhaps the First World War explains the gap between 1913 and the early 'twenties, when

Charles Elton's series of papers appeared, culminating in his *Animal Ecology* of 1927, giving us the fundamental ecological ideas of cyclicism in populations, food chains of varying complexity between species, leading to the concept of what is now known as the Eltonian pyramid, and the idea of animals filling *niches* in the functions of conversion of matter. Charles Adams, to whom I have already referred, made a profound remark to the effect that ecology was a study of process—process which is not necessarily progress, although the developmental quality apparent in the slow building of biological communities was tacit in the phenomena of plant successions elucidated by the Clementian school of ecologists in America. Adams saw that the orderly thread of developmental succession could easily be broken or influenced by all manner of factors, but there was still the unbreakable thread of process or, in fact, history. There is at present some reaction against the idea of orderly succession to a climax state which is stable and continuing, because so many examples can be brought forward to show how natural phenomena such as hurricane, fire and frost-heave—each at certain moments of biological significance such as a seed year or not—can make nonsense of orderly progression within the community under investigation. But they do not make nonsense of the idea and the trend, and the plain record of process of history brings us to a perspective of reality. It is part of the thesis of this essay that man was able to civilise by being a breaker of climaxes, giving him the stored wealth of the ages in plants, animals and soil fertility with which to buttress himself against the environment and to enjoy the immense capacity for social evolution provided by the new ability to be permanently gregarious.

The concept of the dynamic biological community took a long time to mature—if we admit that it is even now much advanced beyond adolescence. Its development shows all the signs of what most of us detect some time or other in our personal investigations, inability to see much more than what we are looking for, or seeing without apprehending significance. Edward Forbes saw the concept of community clearly in his classic marine work of 1843–5, but his early death robbed Scotland and ecology of a luminous mind. The plant ecologists of the late nineteenth century, headed by

Warming, made the concept of community a corner stone of a growing science, and Tansley's famous paper of 1920 codified it and gave it greater significance. Tansley emphasised in this paper that conceptual arguments and hypotheses must be firmly based on observation of the vegetation itself and that one must constantly go back to the field. It was a necessary admonition in that laboratory era. Tansley developed then the idea of the community as a quasi-organism or organic entity, of the whole being greater than the sum of its parts. He made comparisons of plant communities with human communities, and remarked that lacking psychical awareness, instinctive co-operation did not develop—only symbioses of varying degrees—and that competition was the law of relationship. It was later, in *Vegetation of the British Islands*, that Tansley gave lengthy consideration to the biotic or animal factor in the expression of communities, realising for example that a landscape of chalk downland, so old and English and accepted as natural, depends completely on the continued grazing of sheep. The very habitat of chalk grassland is man-produced by way of the sheep, yet it is a habitat with well-defined floristic and entomological characteristics. We see here an example of organic evolution aligning itself with the long pursuance of human activity towards development of habitat. We have much to learn in this field in Africa, one of the main cradles of humanity, where man-produced habitats such as savannah by the agency of fire, have developed their own ungulate faunas. Time has had its chance, unaffected by glaciation or major changes of climate.

Some of the shocks of human impact on biological communities may have turned the Americans the more surely to study such organic entities as inextricable webs of plants and animals; one of Shelford's pupils, W. C. Allee, expressed the notion of unconscious co-operation in biological communities, a concept so much easier to elucidate from studying plants and animals together. Some measure of the 'psychic awareness' not obvious to Tansley in 1920 was now seen to be present in the enlarged wholes of biological communities which we accept nowadays. Allee's unconscious co-operation was entirely scientific and utterly removed from the wishful thinking or pious hopefulness of Kropotkin's *Mutual Aid*. All the same, Allee

brought warmth and light into a field which had tended to be chillingly botanical.

But the strings of past philosophy trail round our feet, making us conservative from a sense of prudence rather than reason. Judaic monotheism put man and nature apart, an idea strengthened by Cartesian dualism of mind and matter. The older Dionysian intuition of wholeness was heresy, and the ancient Chinese comprehension of a universe of checks and balances and compensations, in which man was essentially a part and no more, was unknown and unscientific anyway. Hence, far into our own day, man was not a proper part of the study of ecology. If you studied man you might have been an anthropologist or an archaeologist or an historian, but if you studied ecology you dealt with nature as she was conceived to be and not with man. The notion of human ecology was considered not to be scholarly, though such a man as Patrick Geddes had made most illuminating contributions to the ecology of human life and had collaborated with J. A. Thomson who held this rostrum so long. Also, there were several people in manifestly defined fields such as geography, sociology, epidemiology and social anthropology, who were jumping on this new bandwaggon and calling their subjects human ecology. Ecologists would have none of it. They were aware of the wide spread of their subject and of their dependence on good taxonomy; there was some suspicion already that an ecologist might be a jack of all trades and master of none, and it was academic suicide to be an ecologist except incidentally to an acknowledged position in botany or zoology. The ultimate necessity of considering the biological community as a working whole, ecology being as it were the physiology of community, produced crops of errors where good botanists were less good zoologists, and good zoologists very inadequate botanists. In such an atmosphere of the titter behind the hand, it was not easy to embrace man and his possible ecology as well.

But for several reasons the intellectual climate is changing. The archaeologist has shown in recent years that proto-civilisation is several thousand years older in the Old World than we had thought, and the primitive Folsom Man in the New World was much earlier than the accepted Quaternary immigration from north-east Asia. As we have learned

how man lived, what he ate, how his houses were built, and what his devotional buildings signified, what movements he made, we have been compelled to speculate on the influences man has had on his environment through many thousands of years. Also, the dynamic world of this century, particularly of the past twenty years, has made us intensely and often painfully aware of change in the landscape. We have been rather roughly pitchforked into a world of democracy, so called; into a world of human population explosion, into a world of mobility made possible by the invention of the internal combustion engine and the exploitation of fossil fuels. Land use has changed in character and so much more land has been used, often uncritically, following earlier patterns in different climates. The immense planetary buffer and reservoir of wilderness has shrunk in area and influence. Quite suddenly in these past twenty-five years and particularly since the last war there has been a shaking of confidence. The all-conquering technological man whose mind had the same characteristics as the bulldozers employed to grow groundnuts on a prodigious scale in Tanganyika is already out of date, although the breed is highly inventive and has in no way accepted defeat. There is apparent in politicians an unsureness: they look longingly and hopefully at the extreme technological man, but now it is perhaps as well to listen also to the biologists, not merely the ones who overcome noxious insects with magical rapidity, but ecologists as well.

What do ecologists offer? No panaceas or quick returns, so much as a point of view which restrains, shows the consequences of different types of action, and possibly how mistakes in land-use can be rectified, and why they were mistakes. Ecology is a science of identifying causes and consequences.

Here, I think, is where we may consider the place of history: the political situation and the changes brought about by individuals and ideas are the stuff of history and it is difficult to find out what influence man was having on his environment and what accommodations the organic world of nature was making. But it can be done to a considerable extent if we will give time to it and reconsider history in ecological terms for enrichment of our experience in making future decisions.

I would like to take as an example at random, pulling out one thread of English history, the

course of sheep farming from Saxon times until the latter end of the Middle Ages. England was once a country of deep forest in the vales, with scrub on the chalk hills and wolds. Neolithic man could tackle the scrub with his tools of stone and bone, but not the forest. The Roman, better equipped, drove his roads through everything, making islands in the sea of forest. The Saxon came from forested lands, and working in his own ecological fashion soon reduced the forest to islands in a sea of cultivated or cleared land. The Saxon was a swineherd who undoubtedly valued the pig's snout in life as its hams after slaughter. Large numbers of herded swine must have been effective implements in scarifying the forest floor, disturbing or eradicating the pristine flora, influencing the physico-chemical state of the ground and preventing regeneration, so that forest with undercover would decline and open woodland with fewer and fewer standards would be left. The food-gathering, soil-working pig may be looked upon as a pioneer when present in sufficient numbers, creating conditions in which a sward of grass could form in an increasingly parklike terrain. At this stage the sheep could take over, living on the sward, maintaining it and quite surely preventing the regeneration of woodland. The cattle grazing among the sheep also helped in the establishment of permanent grassland and were creating the possibility of fairly rapid conversion into arable land when pressure of population demanded extension.

Historical research has revealed that England and parts of southern Scotland were already important wool-producing country in Saxon times. That was the main economic function of the sheep, to produce wool; mutton was welcome but incidental. Some of the wool was used at home but it was an important item of export which allowed importation of Continental luxuries and even goods from the Levant. The great early development of medieval sheep-farming did but build on the existing Saxon foundation. England was the principal European producer of fine wool. Italy, and later the Low Countries, were the large manufacturers of fine textiles. This interdependence must have helped in the unification of the medieval world. When England eventually produced her own fine cloth and cut down her export trade in wool, she inevitably crystallised more sharply. Italian bankers

and merchants were prominent in the early trade and the Church was a pioneer agent in the spread of sheep-farming to new areas. The Cistercian order particularly was responsible for extension into the north and west, where flocks of several thousands were kept by each foundation, such as Fountains and Rievaulx. Lords of the manor and peasants were all in this golden age of English sheep-farming. The late Eileen Power gave a vivid impression in her Oxford series of lectures entitled *The Early English Wool Trade*. Reckoning from the number of sacks exported and allowing for some being used at home, there were probably fifteen million sheep in England in the early fourteenth century.

It has probably been insufficiently realised what effect this vast sheep-farming enterprise must have had on the landscape and wild life. Despite the patches of forest, the fringes of parklike country in transition and gorse-clad commons, there must have been extensive bald spots where open-field cultivation and sheep-farming between them would have destroyed all tree growth. The land of England was being mined of its stored fertility, but in such a favoured area do we live that regeneration made good part of the loss in flora and fauna, seen and unseen, and consequently that much of the lost fertility.

Now comes the political act with its ecological consequences: this economically prosperous sheep-farming era was wrecked by taxes in wool and on wool. Edward III was on the warpath, and wars, as we know all too well, are an expensive form of dissipation. The lords of the manor began to let their ploughed lands, and later their sheep also as going concerns. The rates of exploitation probably increased as the small men came in and had to create their capital. But the removal of the Wool Staple to Calais was the disintegrating blow. A system of husbandry was pretty well at an end, and before long the Reformation and the advent of American gold started a period of enclosure of land. This enclosure undoubtedly made for stabilisation and a husbandry based on maintenance rather than pure extraction. The eighteenth-century introduction of leguminous crop plants and the more skilled application of the principle of rotation produced a conversion cycle of energy flow vastly in excess of that of the centuries immediately pre-

ceding. Not all of it was translated into human increase and economic prosperity. Hedges, hedgerow timber, increased leisure (for the few) for such country pursuits as hunting and shooting, which needed a varied landscape, and not least the emergence of the Romance poets in their delight in landscape, all contributed to diversification of habitat which the wild flora and fauna were quick to exploit in this favoured climate.

The story in Scotland has been less happy. The more acidic soils did not withstand the sheep-farming as well as those in England, if we exclude the millstone grits of the English Pennine Chain; the Southern Uplands of Scotland are still in sheep, but are deteriorating slowly. The Highlands, poorer and wetter and steeper, suffered their hardest blow of deforestation and the coming of the sheep in the eighteenth century, and have deteriorated to an ecological decrepitude which is plain for those with eyes to see. The political situation is not yet sufficiently ecological in climate to tackle this essentially biological problem of rehabilitation in a biological and geographical manner, although, as I said at the outset, it is improving. I will say no more; for the conservation of hill lands is to be the subject of a joint symposium later in this Meeting.

Let us now look at an older and larger pattern of animal domestication which has profoundly influenced the characteristics of flora and fauna over a vast area of the land surface of the Old World. The development of the highly specialised husbandry known as nomadism is far from primitive, though because it shows so many examples of arrested cultural growth we are apt so to consider it. Nomadic pastoralism is one of the surest means of breaking ecological climaxes. It is an insidious means also. There is not the primary traumatic onslaught of tree-felling, brush-grubbing and ploughing that agriculture demands. Pastoralism is a penetration of terrain by a relatively small number of human beings. The landscape is not altered immediately and there are no considerable works of man evident to the eye. But numbers of grazing animals and close treading place selective pressures on the vegetational complex. Where fire is used, selection is more rapid. In effect, the herbage complex is simplified, and that means gaps in the original niche structure, with consequent overall loss in biological efficiency of the com-

munity. Broadly, the vegetation moves towards the xeric.

Nomadism post-dates agriculture by an undetermined period running to some thousands of years. The specialisation is like that of the seafaring man, no longer content to paddle about in the shallows with primitive raft or formless dug-out canoe, who has built himself a ship, beautiful in form because it is functional in crossing uncharted seas of uncertain temper, and who has developed the skill to navigate by the stars and sail the ship as if it were a live thing. Equally, the nomad did not just walk out into the sea of the steppe which stretches from the Crimea of Europe to the Yellow River of China: he was a riverside dweller, a forest edge dweller venturing no further than his domesticated animals could go and come in a day, or perhaps a little further in the season of rains. Domestication itself probably arose on religious grounds, for the animals in sight, touchable and ready for sacrifice, were the embodiment of that which was desired, life-giving and life-enhancing. One of the characteristics of nomad stock is the capacity to herd close, and to move and feed and rest as one, a matter for selection conscious and unconscious, before man could go forth with flocks and herds on to the ocean of the steppe.

The sheep is the mainstay of nomadism just as it is the mainstay of the husbandry of wild lands today. The goat provides brains for the most part. The multiplicity of mouths are wealth-gatherers activated by four times as many superbly adapted legs and feet. Water is needed in minimal quantities, and the animal itself provides man with milk, meat and warmth. But the nomad, interposing animals between himself and the generally inhospitable environment of the steppe, realised quite well that the several sorts of domesticated animals gave him different securities and desirable ends in an environment not as uniform as our school geography books would lead us to believe. Cattle are much more efficient converters as individuals, of forage into meat, milk and leather, and they can be used for traction and as weight carriers; but their heavy water requirements govern the possible nomadic routes. The camel, on the other hand, gives the nomad the greatest penetration or retreat into arid regions. Lastly, the horse was of great benefit as a producer of meat, milk and trac-

tive power. Domestication of these animals meant their presence where and when they were wanted, their mental and even physical characteristics so far modified that they did not move as quickly as wild ones. In consequence, the animals were in general on the ground for a longer period and in greater numbers than when they were wild. The nomad society arising gradually from the more sedentary agricultural group would early realise that over-grazing hung like a sword of Damocles. The price of the life-way of grazing animals is movement, the brand of Ishmael. In the ideal, agriculture is concentration of effort, or intensification: pastoralism is conscious, well-organised diffusion.

Yet man does not prefer constant or random movement. Even the most highly developed nomads do not go far, no more than 150 or possibly 200 miles of farthest distance in the year, and relatively long spells of pitched tents are desired. The women wish it so, caring nothing for floristic composition of the grazing. At best the nomad was on the chernozem soils of the Ukraine or in delectable valleys: at worst in the wastes of the Gobi or the Tarim Depression. Nomadism in its highest development did not occur until after 1500 B.C. and it came with achievement of that maximum state of mobility, the mastery of riding horses, as distinct from using this animal for traction.

Horse riding seems to have arisen on the plateau of north-west Persia. If you have ever ridden a pony of stocky Prjewalski type you will know the relief of getting off it for a rest: but once you have ridden one of the delicately-controllable, long-gaited creatures of what we now call the Arab type, one's whole outlook changes on the mounted state. Man well mounted is a superior being, and the nomad soon geared his way of life to that which gave the male element swift and far range; even his eyes are a yard higher above the ground—no mean advantage. We cannot know the details of the dominant mutation which produced the dish-faced, long-necked, sloping-shouldered, fine-boned 'horse of heaven', as it came to be called, but nomadic man quickly made use of it. Even his status changed, producing the chevalier, the caballero, and the knight, who were with us till the Land Rover came and the girls took over the pony clubs.

Now came maximum exploitation of the steppe environment, not only nomadism which, as I have said, is never over a very long distance, but in migration. The Indo-European tribes began their great easterly migrations of thousands of miles through a thousand years, by which time they reached the Ordos country of the Yellow River. Within this time the civilisations of the Near East had learned the survival value of cavalry, and the Chinese finally learned the same lesson. They became an equestrian nation in all its élite grades. Expeditions were sent into Turkestan to bring back these 'horses of heaven'. One of the Pazirik felts, so miraculously preserved in the ice of an Indo-European grave since some hundreds of years B.C. in Siberia, shows a gay cavalier with impeccable military moustache on his Arab-type steed, meeting a seated man of Mongol type in Mongol dress.

Even the bronze art of the Indo-European nomad travelled over this whole region. These people knew their animals: just as a Navajo Indian boy today does not need to look at a horse to draw it in any posture, so the Indo-Europeans thought their animals—horses, cattle, sheep, goats—in lifelike simple terms; yes, but wild animals were of immense importance to them as well, whether ungulate or carnivore, and the dramatic moment of the lion's attack on the stag or antelope is often captured in a stylised but dynamic bronze plaque. There are the Scythian bronzes of the Kuban, the animal bronzes of Luristan, and at the eastern end the bronzes of the Ordos bend, which show a remarkable sensitiveness to animal form. The involved twisting stylised representation can be found also in the Celtic and Nordic scroll-work in metal and stone on the Atlantic seaboard. Tamara Talbot Rice has brought out this wide spread of nomad art in her book on the Scythians.

The archaelogists have produced much of this material for us and set it in perspective, but zoologically they have not done so well. I suggest that it is up to zoologists to examine it with care, so that elk are not called stags, antelopes deer, or Urial sheep ibexes. The Saiga antelope also appears in these bronzes, unrecognised as such, and crested cranes seem of some significance. I myself have a complete Luristan bit, the cheek pieces of which are representations of elk. The use by the elk of the two posterior toes has been faithfully observed

by this bronze-caster of nearly three thousand years ago. How did this bit get into the Zagros Mountains? Had it come from the Caucasus? I also have what must be one of the earliest surviving representations of a peacock from Amlach in the Elburz country south of the Caspian. Forgive my digression, but I hope this nomad animal art will be examined in relation to possible distribution of species in the past and to ecological history.

Once the Mongols became equestrian, the backward, westward surge began, culminating in the empire of Genghis Khan which frightened Europe and conquered China for a spell until Kublai was himself conquered by Chinese culture. So many of the remaining nomads of Central Asia are Mongoloid, even as far west as Kazakstan, but the Indo-Europeans also survive in pockets as far east as northern Afghanistan. By the end of the Mongol Yuan dynasty it is estimated that the human population of China had been reduced by forty millions, which in itself must have had interesting ecological consequences for a generation or two.

The original fauna of this great region of the steppe survives in the mountain ranges, and the Saiga antelope is back on the plains in millions thanks to an enlightened policy of conservation by the Russians. But how long can nomadism survive? The brand of Ishmael produces this highly specialised form of society which in effect finds itself in a cultural *cul-de-sac* unable to evolve, whereas the less specialised and once handicapped societies at the edge of the steppe did evolve into the civilisations of today. Political feeling is against nomadism and the biological necessity of movement in pastoral nomadism if the habitat is to be conserved, is ignored. If there can be irrigation of the steppe, the obvious access of foods and fibres thus made possible means the nomads must change or go, and going is no longer possible in our contracting world. Farming nibbles at the alluvial river flats and the bore hole brings up fossil water also and cripples the wholeness of the habitat for the nomad. The Russians seem definitely to be eliminating nomadism, and such western nations as have any seem to be doing the same thing. Individual Britons have admired nomads and their way of life, but collectively or politically Britain is depressing nomadism: the Masai of the semi-arid East African steppe are

being eased out of their culture of arrested development in favour of Kikuyu and Sukumba, rapidly increasing tribes under the Pax Britannica, which were formerly despised and harried by the nomads. The reindeer Lapps are also finding their winter grounds falling within the agricultural penumbra and there is the social urge towards education, which tends to make the winter communities static. Nomadism will die, at the expense of sterilising large areas of back country which only nomads could utilise, as far as domesticated livestock is concerned. Whether in the future we may return to controlled cropping of wild animals on wild lands unfitted to human settlement remains to be seen, but despite the tentative experimentation in Africa and the successful Russian work on the Saiga antelope, I have the feeling that man is still going to degrade much good wild-life country in an effort to farm it, before it is fully realised that the nature of such country in its water relations and soil characteristics precludes agriculture. There is some false moral self-delusion which makes modern governments try and fail rather than consider the wholeness of land-use ecology before formulating a land-use plan.

The mention of the pastoralism of wild lands by wild animals brings me back to a form of nomadism in the New World which has several points of interesting comparison with the early development of specialised nomadism in the Old World through use of the horse. We may take it for granted that the late flowering of civilisation in the Americas was the result of having fewer and less convenient domesticable plants, especially cereals, and certainly fewer and less convenient domesticable animals. At the more primitive level, the North American Indians were forest and forest-edge and river-valley people. Their beast of burden was the dog, sometimes dragging a travois—a sorry means indeed. They too were near a great central steppe of prairie where the wild bison conducted its own seasonal movements which took it away from the haunts of men. Hunting of this animal meant enticement to newly burned grazing, and stalking which even included wearing a bison mask—a most unenviable method. Nevertheless, it would seem that from about the sixteenth century man was increasing the range of the bison by burning at the forest edge.

The advent of the horse by way of Mexico and the

Rio Grande far into the south-west was a major liberation for the American Indian. Horses were stolen or went feral and the terrain was that dry steppe phenologically perfect for this animal. Here man did not need to wait for the mutation which produced the 'horses of heaven', for it was the less carefully bred examples of this type which so rapidly colonised the American steppe. The Spaniards lost their advantage when the horse went feral and spread northwards and came into the hands of the Indians, who immediately rode.

There now occurred that specialisation towards nomadism. The Indian could leave the forest edge and follow the bison. Thus, from the beginning of the seventeenth century until the middle of the nineteenth there was a strong man-induced extension of the bison's range and there was a rapid specialisation by certain tribes to become horse nomads, in effect pastoralising the wild bison instead of domesticated stock. Agriculture was minimal, carried on by the women, for the water situation was generally easier than in the Old World steppe.

This situation could have gone on indefinitely as a biological continuum, for the wild animal prevented overgrazing by its migratory habits, and the enlargement of bison-inhabited country by Indian fire seems merely to have been an enlargement of soil conserving prairie grassland rather than extension of less biologically productive savannah such as we see today in South America and Africa. It was the white man overrunning the West with domesticated stock, packing it and going away with the proceeds that devastated millions of acres at a much faster rate than the Old World nomads reduced the productive potential of the Asian steppe with close-herded domesticated animals. Just as the Ukraine country of the Scythians came ultimately to wheat, so did the Middle West prairie become a bread basket. The Indians of the Middle West have gone the way of the Scythians.

We will not pause to consider the nineteenth-century calamity that befell the bison and the Indian, but what must be pointed out is that the sudden disintegration of this nomadism imposed by the wanderings of the bison, hit hardest those tribes which had specialised farthest in this way of life. Even today the observer can see that the horse tribes have come off worst in social and economic adaptation. The tribes which remained in the forest

or at the forest edge are now woodsmen and construction men; the Pueblo Indians of the Rio Grande valley may be anything that the white man is, because of their urban tradition; but the horse tribes who accepted the exhilaration of liberty of distance and became what we have come to call Plains Indians, have found themselves in the deepest bondage of the drastically changed economic base. Now, as pastoralists, they are finding movement cut down, and yet a dawning ecology of land use is demonstrating the old truth, that the pastoralism of wild lands imposes movement of the animals. There is the continuing paradox of political tendencies to restrain the movement of people on wild lands, and scientific evidence that animals on wild lands must be kept moving. Only wild animals conduct this aspect of their lives without human direction, and on this shrinking planet of exploding humanity even the wild animals are having their necessary movements constricted. The threat to the elephant in Africa is not the killing that goes on but the merciless restriction of range and movement. Without the movement, habitat is destroyed and other species of wild animals suffer in train. A dramatic example of this trend has been the build-up of elephants in the sanctuary of the Tsavo Royal National Park in Kenya. Destruction of trees and bush by the elephants endangered the food supply of the rhinoceros, so that a period of long drought made this painfully apparent in the starvation of over two hundred rhinoceroses. They were not short of water themselves, for the river never dried, but they died with their bellies full of indigestible cellulose fibre. I saw some of these creatures die and helped in the *post-mortem* examinations. I saw the wrecked bush which would not even become a fire-climax savannah. I did not put the blame on the elephants.

I began this address with the statement that ecology was the observational study of communities of living things in time as well as space, and I repeated Charles Adams's dictum that it was essentially concerned with process. I have allowed myself to range about the world seeing man, plant communities, the communities of his own domesticated animals and some wild animals in dynamic process through some thousands of years of man's most fertile years of culture, and you may agree with me that in any synecological studies it is difficult to

exclude man or to be a plant or an animal ecologist. There is only one ecology. If we are to follow an ecological approach to the study of society—be it historical, sociological, agricultural, anthropological, or economic, we must keep in mind that man's habitat and human societies are not static. The cross section presented by a socio-anthropological study needs amplification in time. Cultures are altering continually, progressing or retrogressing, and these trends, though subject inexorably to natural laws, are also the results of human behaviour. Such action may have been unseeing of consequences in the past, but if ecology is to concern itself with human influences, and take its place at the council table of human affairs, it should accept the premise that our species has in many parts of the world arrived at the stage of mental evolution at which it is possible to foresee the consequences of various kinds of direct and indirect modifications of habitats and their biological communities. The well-being of the habitats and the human communities therein can be influenced and sustained by understanding the interrelationship of the biological communities in which we co-exist.

I have put forward the thesis that man has been able to enjoy gregariousness and civilise as a result of learning how to tap the stored wealth of ecological climaxes—soil fertility, timber and other plants, and animals. His agriculture of annual or biennial plants sets back ecological succession and demands a high skill to maintain fertility; the general history of animal exploitation is of over-use. Are we faced with the proposition that civilisation is a contradiction in terms; that civilisation carries its own seeds of decay because ecologically retrogressive processes once begun cannot be checked? I believe there is some danger of this, but there need not be in an ecologically conscious world. The suffering planet has immense power of natural rehabilitation if given its chance and we are also learning how these wonderful integrated processes of healing take place. As I said earlier, ecology is the physiology of community. Understanding it we can avoid undesirable consequences. Perhaps it is necessary to say that I am not crying 'back to nature'; our growing understanding of the physiology of community gives power of planned manipulation, finding other ways round to desired ends. The history of the Nature Conservancy in this country is a vivid example of

men learning how to manage biological communities in a manner simulating the natural.

Man often reminds me of the Irish Elk in that the elk's antlers could develop non-adaptatively in evolution as a by-product of increase in body size, what Julian Huxley calls heterogonic growth. The enormous drain on the organism of growing so much non-functional calcium phosphate every year was too much once the prodigality of the Pleistocene had passed. Well, man conjures from his mind ways of using resources unproductively, be it pyramid building in Egypt, temple building and human sacrifice in Mexico, and now defence and nationalism. Nationalism is the modern Irish Elkism. In a world where the only hope for man is internationalism, nationalism is the political ecological factor which prevents any constructive action to curb population increase. And withal, we are faced with the ironic paradox of splintering nationalism and pseudo-national costumes, with the dismal destruction of individuality inside them, which variability is as desirable in the social system as in the eco-system. Furthermore, I believe that the pressure of population on land is presenting us with an emergency earlier than the problem of growing enough food for the increase. Mobility by way of the internal combustion engine, vastly increased leisure by way of automation, and sophisticated modes of outdoor recreation are changing the land-use pattern far quicker than we are learning how to cope with it. Fifteen years ago the excuse of increased food production was enough to get rid of hedgerow trees in England; but at this moment the amenity value of such trees in such a populous country, needing the balm of the green leaf, far outweighs the small increase of food production which might accrue from their removal. The picture in the United States is of food surpluses but a very real shortage of recreational land. An Outdoor Recreation Bureau has been established as a department of government to help in planning the solution of this very considerable problem of land-use ecology in its widest sense, and I am glad to say ecologists have been brought in at the beginning.

It would be fantastic, nevertheless, to make the mistake now of so expanding the scope of ecology that it would become all-embracing, so that the ecologist would bog down in a morass of his own ignorance, and become the supreme irritating busy-

body. That, I think, was feared by those who years ago wished to exclude man from their studies and would not admit human ecology. Neither do I; there is no human ecology—only ecology—but in those sciences dealing with man, from political economy to social anthropology and archaeology, there is plenty of room for the ecological slant of mind. As a corollary, I think that ecological research must become more and more the effort of teams of workers; the single worker will continue to discover beautiful expressions of phenomena, but the syn-ecological studies in depth of habitats and communities which we need today demand far more than what one man can compass. Ecological studies are not designed *ad hoc* to solve land-use problems but to discover truth, and this high scientific approach must be jealously guarded, but thereafter ecologists can have a social conscience and apply their discoveries to the problems of land-use by man. The teams I envisage are not collections of specialists, if they are to be successful, but, to borrow Tansley's expression, organic entities.

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