


livestock. But the scourge of deer and elk which followed their removal on many ranges has simply transferred the role of pest from ivore to herbivore. Thus we forget that no species is inherently a pest, and any species may become one.

The same false premises characterize rodent control. Overgrazing is probably the basic cause of some or most outbreaks of range rodents, the rodents thriving on the weeds which replace the weakened grasses. This relationship is still conjectural, and it is significant that no rodent-control agency has, to my knowledge, started any research to verify or refute it. Still if it is true, we may poison rodents till doomsday without effecting a cure. The only cure is range-restoration.

The same false premises beset the hawk and owl question. Originally rated as all "bad," their early defenders sought to remedy the situation by reclassifying part of them as "good." Hawk-haters, and gunners with a trigger-itch, have had lots of fun throwing this fallacy back in our faces. We should have been better off to assert, in the first place, that good and bad are attributes of numbers, not of species; that hawks and owls are members of the native fauna, and as such are entitled to share the land with us; that no man has the moral right to kill them except when sustaining injury.

It seems to me that both agriculture and conservation are in the process of inner conflict. Each has an ecological school of land-use, and what I may call an "iron heel" school. If it be a fact that the former is the truer, then both have a common problem of constructing an ecological land-practice. Thus, and not otherwise, will one cease to contradict the other. Thus, and not otherwise, will either prosper in the long run.



The Outlook for Farm Wildlife

Leopold contributed this essay in 1945 to the North American Wildlife Conference. It is a somber appraisal. His particular concern, reflecting his by then firm understanding of the land as community, was the "accelerating disorganization of those unknown controls which stabilize the flora and fauna, and which, in conjunction with stable soil and a normal regimen of water, constitute land-health." Leopold aptly contrasts the farm-as-food-factory philosophy with his own conservation view, in which "the criterion of success is a harmonious balance between plants, animals, and people; between the domestic and the wild; between utility and beauty." He also sees looming on the horizon even greater problems stemming from industrialized agriculture, citing DDT as an example.

TWENTY YEARS have passed since Herbert Stoddard, in Georgia, started the first management of wildlife based on research.

During those two decades management has become a profession with expanding personnel, techniques, research service, and funds. The colored pins of management activity puncture the map of almost every state.

Behind this rosy picture of progress, however, lie three fundamental weaknesses:

1. Wildlife habitat in fertile regions is being destroyed faster than it is being rebuilt.
2. Many imported and also native species exhibit pest behavior. A general disorganization of the wildlife community seems to be taking place.
3. Private initiative in wildlife management has grown very slowly.

In this appraisal of the outlook, I deal principally with the first two items in their bearing on farm wildlife.

Gains and Losses in Habitat. Wildlife in any settled country is a resultant of gains and losses in habitat. Stability, or equilibrium between gains and losses, is practically non-existent. The weakness

in the present situation may be roughly described as follows: On worn-out soils we are gaining cover but losing food, at least in the qualitative sense. On fertile soils we are losing cover, hence the food which exists is largely unavailable.

Where cover and food still occur together on fertile soils, they often represent negligence or delay, rather than design.

There is a confusing element in the situation, for habitat in the process of going out often yields well.

For example, on the fertile soils of southern Wisconsin, the strongholds of our remaining wildlife are the woodlot, the fence-row, the marsh, the creek, and the cornshock. The woodlot is in process of conversion to pasture. The fence-row is in process of abolition; the remaining marsh is in process of drainage; the creeks are getting so flashy that there is a tendency to channelize them. The



cornshock has long been en route to the silo, and the corn borer is speeding the move.

Using pheasant as an example, such a landscape often yields well while in process of passing out. The marsh, grazed or drained or both, serves well enough for cover up to a certain point, while the manure-spreader substitutes for cornshocks up to a certain point. The rapid shift in the status of plant successions may in itself stimulate productivity.

The situation is complicated further by a "transmigration" of land use. Originally uplands were plowed and lowlands pastured. Now the uplands have eroded so badly that corn yields are unsatisfactory, hence corn must move to the lowlands while pasture must move to the uplands. In order that corn may move to the lowlands, they must be either tilled, drained, or channelized. This, of course, tends to destroy the remaining marsh and natural stream.

The upshot is a good "interim" crop which has a poor future. I don't know how widely a similar situation prevails outside my own state, but I suspect that the basic pattern, with local variations, is widely prevalent.

Runaway Populations. Wildlife is never destroyed except as the soil itself is destroyed; it is simply converted from one form to another. You cannot prevent soil from growing plants, nor can you prevent plants from feeding animals. The only question is: What kind of plants? What kind of animals? How many?

Ever since the settlement of the country, there has been a tendency for certain plants and animals to get out-of-hand. These runaway populations include weeds, pests, and disease organisms. Usually these runaways have been foreigners (like the carp, Norway rat, Canada thistle, chestnut blight, and white pine blister rust), but native species (like the June beetle and various range rodents) are clearly also capable of pest behavior.

Up to the time of the chestnut blight, these runaways did not threaten wildlife directly on any serious scale, but they now do, and

it is now clear that the pest problem is developing several new and dangerous angles:

1. World-wide transport is carrying new "stowaways" to new habitats on an ascending scale. (Example: *Anopheles gambiae* to Brazil, bubonic plague to western states.)
2. Modern chemistry is developing controls which may be as dangerous as the pests themselves. (Example: DDT.)
3. Additional native species, heretofore law-abiding citizens of the flora and fauna, are exhibiting pest behavior. (Example: excess deer and elk.)

These three new angles must be considered together to appreciate their full import. Mildly dangerous pests like ordinary mosquitoes evoked control measures which severely damaged wildlife; desperately dangerous pests will evoke corresponding control measures, and when these collide with wildlife interests, our squeak of pain will not even be heard.

Moreover, wildlife itself is threatened directly by pests. Sometimes they hit so fast and hard that the funeral is over before the origin of the malady is known. Thus in Wisconsin, we have a new disease known as burn blight, the cause of which is still unknown. It threatens to destroy young Norway pine and jack pine, especially plantations. Oak wilt, the cause of which was only recently discovered, is steadily reducing red and black oaks. Our white pine is already blighted except on artificially controlled areas. Bud-worm is in the spruce. Hickory can't grow because of a weevil which bites the terminal bud. Deer have wiped out most white cedar and hemlock reproduction. Sawfly has again raided the tamaracks. June beetles began years ago to whittle down the bur and white oaks, and continue to do so. Bag worm is moving up from the south and west and may get our red cedars. Dutch elm disease is headed west from Ohio. What kind of a woodlot or forest fauna can we support if every important tree species has to be sprayed in order to live?

Shrubs are not quite so hard hit, but the shrub flora has its troubles. On the University of Wisconsin Arboretum, an area dedicated

to the rebuilding of the original native landscape, the Siberian honeysuckle is calmly usurping the understory of all woods, and threatens to engulf even the marshes.

In Wisconsin woodlots it is becoming very difficult to get oak reproduction even when we fence out the cows. The cottontails won't let a young oak get by. One can't interest the farmer in a woodlot which reproduces only weed trees.

Of the dozen pests mentioned here, four are imported, seven are runaway native species, and one is of unknown origin. Of the twelve, six have become pests in the last few years.

Farm crops and livestock exhibit a parallel list of pests, of which the worst now rampant in my region is the corn borer. The corn borer can be controlled by fall plowing, but what that will do to cornbelt wildlife is something I dislike to think about.

It all makes a pattern. Runaway populations are piling up in numbers and severity. In the effort to rescue one value, we trample another. Wild plants and animals suffer worst because we can't spend much cash on controls or preventatives. Everything we lose will be replaced by something else, almost invariably inferior. As Charles Elton has said: "The biological cost of modern transport is high."*

In short, we face not only an unfavorable balance between loss and gain in habitat, but an accelerating disorganization of those unknown controls which stabilize the flora and fauna, and which, in conjunction with stable soil and a normal regimen of water, constitute land-health.

THE HUMAN BACKGROUND. Behind both of these trends in the physical status of the landscape lies an unresolved contest between two opposing philosophies of farm life. I suppose these have to be labeled for handy reference, although I distrust labels:

1. *The farm is a food-factory*, and the criterion of its success is salable products.
2. *The farm is a place to live*. The criterion of success is a

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harmonious balance between plants, animals, and people; between the domestic and the wild; between utility and beauty.

Wildlife has no place in the food-factory farm, except as the accidental relic of pioneer days. The trend of the landscape is toward a monotype, in which only the least exacting wildlife species can exist.

On the other hand, wildlife is an integral part of the farm-as-a-place-to-live. While it must be subordinated to economic needs, there is a deliberate effort to keep as rich a flora and fauna as possible, because it is "nice to have around."

It was inevitable and no doubt desirable that the tremendous momentum of industrialization should have spread to farm life. It is clear to me, however, that it has overshot the mark, in the sense that it is generating new insecurities, economic and ecological, in place of those it was meant to abolish. In its extreme form, it is humanly desolate and economically unstable. These extremes will some day die of their own too-much, not because they are bad for wildlife, but because they are bad for farmers.

When that day comes, the farmer will be asking us how to enrich the wildlife of his community. Stranger things have happened. Meanwhile we must do the best we can on the ecological leavings.



The Land-Health Concept and Conservation

Leopold left this extraordinary essay in pencil draft at his death. Written in December 1946, it presents the idea of land health with greater clarity and detail than do any of his other writings. It is published here for the first time. Leopold presents land health not just as a desirable attribute of

a landscape but as a much-needed focus for conservation work, and he issues a plea to his fellow ecologists to join him in offering their best guesses about the requisites for land health. The need for action, he says, is urgent, and conservation workers cannot wait until ecologists have all the answers. Leopold also presents here his strongest assertion that land-owners, particularly farmers, ought to shoulder affirmative duties to promote the common good. He ends the essay with a subject that he often addressed in unpublished manuscripts but never really dealt with in print—the need to stabilize "human density" and the possibility that natural forces might keep human numbers in check if social forces do not.

AUGUSTE COMTE, and later Herbert Spencer, pointed out that there is a natural sequence in the development of the sciences, and that this sequence represents a gradient from the simple toward the complex. Spencer's sequence was: physics—chemistry—biology—psychology—sociology.

According to this sequence, ecology, the sociology of the biota, will be the last science to achieve the stage of predictable reactions. This expectation presents a peculiar dilemma, because there is urgent need of predictable ecology at this moment. The reason is that our new physical and chemical tools are so powerful and so widely used that they threaten to disrupt the capacity for self-renewal in the biota. This capacity I will call land-health.

The symptoms of disorganization, or land sickness, are well known. They include abnormal erosion, abnormal intensity of floods, decline of yields in crops and forests, decline of carrying capacity in pastures and ranges, outbreak of some species as pests and the disappearance of others without visible cause, a general tendency toward the shortening of species lists and of food chains, and a world-wide dominance of plant and animal weeds. With hardly a single exception, these phenomena of disorganization are only superficially understood.

George P. Marsh, in *The Earth as Modified by Human Action* (1874), was one of the first to sense that soil, water, plants, and ani-

imals are organized collectively in such a way as to present the possibility of disorganization. His case histories describe many degrees of biotic sickness in many geographic regions. They are probably the ultimate source of the biotic ideas now known as conservation.

One might offer an ironic definition of conservation as follows: Conservation is a series of ecological predictions made by beginners because ecologists have failed to offer any.

Need I stop to prove this? The names of Theodore Roosevelt, Gifford Pinchot, William T. Hornaday, Hugh H. Bennett, and Jay N. Darling seem to spring out of recent American history with an emphatic reply. This paper is, in substance, a plea for ecological prediction by ecologists, whether or no the time is ripe. If we wait for our turn in the Spencerian sequence, there will not be enough healthy land left even to define health. We are, in short, land-doc-tors forced by circumstance to reverse the logical order of our service to society. No matter how imperfect our present ability, it is likely to contribute something to social wisdom which would otherwise be lacking.

Conditions Requisite for Land-Health

I have no illusion that the thousands of ecological questions raised by modern land-use can all be assessed by ecologists. What I mean by "prediction" is a shrewd guess on just one basic question: What are the probable conditions requisite for the perpetuation of the biotic self-renewal or land-health? This would define a goal for conservationists to strive toward. They now have no basic goal bracketing all component groups. Each group has its own goal, and it is common knowledge that these conflict and nullify each other to a large degree.

I will record my own guess first as a figure of speech. The biotic clock may continue ticking if we:

1. Cease throwing away its parts.

2. Handle it gently.
3. Recognize that its importance transcends economics.
4. Don't let too many people tinker with it.

The Integrity of the Parts

Paleontology teaches us that most land was stable, at least in terms of time scales applicable to human affairs, up to the point at which fauna, flora, soil, or waters were radically modified for human use. Disorganization seldom preceded the wholesale conversion of land with modern tools. It is necessary to suppose, therefore, that a high degree of interdependence exists between the capacity for self-renewal and the integrity of the native communities.

To cite a case: Evolution made few changes in the species list of Europe and America since the last glaciation, nor have the soil or water systems changed materially. Communities were pushed around by climatic cycles, but they did not disappear, and their membership remained intact. The big changes in fauna, flora, soil, and water have all occurred in the last few centuries. We must assume, therefore, that some causal connection exists between the integrity of the native communities and their ability for self-renewal. To assume otherwise is to assume that we understand the biotic mechanisms. The absurdity of such an assumption hardly needs comment, especially to ecologists.

There are, of course, practical limits of both time and space which curtail the degree to which the species list can be returned in settled regions. No one debates the removal of the buffalo or the pigeon from the cornbelt. But we are today extinguishing many species, or relegating them to national parks, on grounds that are ecologically false. Thus the timber wolf, already extinguished over most of the West, is at the point of being extinguished in the Lake States, with official sanction and in fact subsidy, because he eats deer. The assumption is that rifles can trim the deer herd, but

the fact is that in Wisconsin and Michigan at least, the deer herd is trimming us. Not only are deer nullifying the reforestation program, but they are tending to eliminate at least three tree species from the future forest: white cedar, hemlock, and yew. The proportion of white pine is being lowered in many localities. The effect of excess deer on lesser vegetation, on other animals, and ultimately on soil, is not known, but it may be large. It has been suggested that the snowshoe hare, under the impact of overbrowsing by deer, ceases to exhibit cyclic population behavior, and that the ruffed grouse is injuriously affected through depletion of its food and cover plants.

Here then is a chain reaction of unknown length threatening the integrity of the fauna and flora over great areas, and arising from a single error in prediction: that human predation by rifle is the biotic equivalent of wolf predation.

This is one of hundreds of land-use errors, made by laymen-administrators in the name of conservation, and all based on the assumption that we are at liberty to prune the species list of members considered "useless," harmful, or unprofitable.

That we must alter the distribution and abundance of species before we understand the consequences of doing so is taken for granted. These modifications are reversible, and hence not very dangerous. But extirpation is never reversible. It is already too late to restore the wolf to the western deer ranges because the indigenous races are extinct.

Closely related to the needless pruning of species lists is the question of their needless enlargement by the importation of exotics. Space forbids my covering this. I will only say that the idea of preference for natives hardly exists in fish management, agronomy, and horticulture, and has only a tenuous hold in game management, forestry, and range management. Soil management is just discovering that there is a soil fauna and a soil flora.

Violence in Land-Use

All land must be converted, either in its plant successions, topography, or water relations, before it can support an industrial economy. My guess here is that the less violent these conversions, the more likely they are to be durable, and the less likely they are to exhibit unforeseen repercussions.

A veritable epidemic of violence prevails at the present moment in the field of water management. Flood-control dams, hydro electric dams, channelization and dyking of rivers, watershed authorities, drainages, lake outlet controls, and impoundments are running riot, all in the name of development and conservation. I am not wise enough to know which of these conversions are ecologically sound, but the most superficial observer can see that:

1. Most of them deal with symptoms, not with organic causes.
2. Their promoters are innocent of (or oblivious to) the principle that violence is risky.
3. Many of them involve irreversible changes in the organization of the biota.
4. Collectively, their use of economic arguments is naive. In one case, economic advantage is held to supersede all opposing considerations; in the next "intangible" benefit is held to supersede all economics.
5. In all of them, control of nature by concrete and steel is held to be inherently superior to natural or biotic controls.
6. In all of them, the economic products of violence are held to be more valuable than natural products.

The philosophy of violence extends far beyond water management. The reckless use of new poisons in agronomy, horticulture, wildlife control, fish management, forestry, and soil fumigation is well known. Poisons for public health are no novelty. Poisons to offset pollution in lakes and rivers are no novelty. Again I am not wise enough to say which of these violent treatments are sound, but it is obvious that the same doubts arise: They deal with symp-

toms; their promoters are innocent of probable repercussions; they involve many irreversible changes; because they are quicker than biotic controls, they are assumed to be superior to them.

Esthetics

The biota is beautiful collectively and in all its parts, but only a few of its parts are useful in the sense of yielding a profit to the private landowner. Healthy land is the only permanently profitable land, but if the biota must be whole to be healthy, and if most of its parts yield no salable products, then we cannot justify ecological conservation on economic grounds alone. To attempt to do so is sure to yield a lop-sided, and probably unhealthy, biotic organization.

Herein lies the tragedy of modern land-use education. We have spent several generations teaching the farmer that he is not obligated to do anything on or to his land that is not profitable to him as an individual. We can thank his neglect and inertia, and perhaps the hollow sound of our own voice, for the survival of such useless plants and animals, and such natural soils and waters, as remain alive today.

We have rationalized this fallacy by relegating the conservation of the merely beautiful to the state. We can thank this subterfuge for our national parks, forests, and a sprinkling of wilderness areas, but we can also thank it for a million farmers who year-by-year grow richer at the bank, poorer in soil, and bankrupt in spiritual relationships to things of the land.

The divorcement of things practical from things beautiful, and the relegation of either to specialized groups or institutions, has always been lethal to social progress, and now it threatens the land-base on which the social structure rests. The fallacy has its roots in an imperfect view of growth. All sciences, arts, and philosophies are converging lines; what seems separate today is fused tomorrow. Tomorrow we shall find out that no land unnecessarily mutilated is

useful (if, indeed, it is still there). The true problem of agriculture, and all other land-use, is to achieve both utility and beauty, and thus permanence. A farmer has the same obligation to help, within reason, to preserve the biotic integrity of his community as he has, within reason, to preserve the culture which rests on it. As a member of the community, he is the ultimate beneficiary of both.

Human Density

The trend of animal ecology shows, with increasing clarity, that all animal behavior-patterns, as well as most environmental and social relationships, are conditioned and controlled by density. It seems improbable that man is any exception to this rule.

It is almost trite to say that the ecological state called civilization became possible at a certain minimum density-threshold. It seems equally probable that above a certain maximum density its benefits begin to cancel out, and its mechanisms become unstable. Improvements in organization may raise that maximum, but they can hardly abolish it.

I have studied animal populations for twenty years, and I have yet to find a species devoid of maximum density controls. In some species the control mechanism inheres within the species, and operates by eviction and resultant vulnerability to predation (quail, muskrat). In others the control is external (deer), and consists of predation, or starvation if that fails. In all species one is impressed by one common character: If one means of reduction fails, another takes over.

It is possible to interpret the impending disorganization of land as taking over the reducing job after we foiled the normal mechanism by industrialization, medicine, and other devices. There is a striking parallelism between the present world-wide strife, and the social status of an overpopulated muskrat marsh just prior to catastrophe.

In any event it is unthinkable that we shall stabilize our land without a corresponding stabilization of our density. It is notorious that many of the “undeveloped” regions are already overpopulated.

Conclusion

These then are my personal guesses as to the conditions requisite for land-health. Some of them step beyond “science” in the narrow sense, because everything really important steps beyond it. I do not claim that my guesses are objective. They are admittedly wishful. Objectivity is possible only in matters too small to be important, or in matters too large to do anything about.