Biotic Land-Use

This previously unpublished essay, written around 1942, is a milestone in Leopold's growing grasp of land health and its practical implications. In it, Leopold explores how and why ecology should guide land-use practices. He criticizes practices aimed only at particular goals such as crop production, game management, and control of floods and erosion. Good land use, Leopold tells us, requires a single, coordinated goal. Here, Leopold terms that goal "stability," which he uses synonymously with "the health of the land as a whole." Science is never likely to "write a formula" for land stability, he predicts. Lacking that, the best measures of stability are soil fertility, retention of native fauna and flora, and efficient recycling of nutrients. Leopold may have written this essay to introduce a book or some other never-completed study of land-use practices.

MANAGEMENT is conserving particular plants or animals by keeping the land favorable.

Biotic land-use is conserving land by keeping the plants and animals favorable.

The biotic idea is thus an *extension* of the idea of management, and it asserts the *converse* of the management theorem.

Both stem from ecology. The biotic idea merely translates ecology for purposes of guiding land-use.

The term "land" includes soils, water systems, and wild and tame plants and animals.

Conservation is the attempt to understand the interactions of these components of land, and to guide their collective behavior under human dominance.

Land-use problems are of two orders.

We hear most about those problems which hinge on questions of supply and demand. Timber famine, agricultural adjustment, and attempts to husband the supply of water and game are familiar examples. This order is, for present purposes, not very important, because it deals with visible forces which are amenable to social controls. Solutions are possible, and ways and means are known.

We hear least about another order which is very important because ways and means are not known, or are ineffective. It consists of dislocations of land which present no visible cause. Thus some species irrupt as weeds or pests, while others disappear, both without visible reason.

It also includes dislocations of land for which a cause is visible, but for which the social controls so far used are inadequate. Thus we know, at least superficially, what causes soil erosion and floods, but the present program can hardly be called a cure.

There are intermediate land problems. Thus forestry and range management, if applied, can raise wood and grass; agronomy can raise crops; these problems are of the first order. But the restoration of full soil health and productivity is another matter, and falls in the second order.

Thus we see that the *basic* problem in land-use, the problem which directly underlies the second order and indirectly the first, is the stability of the land mechanism.

Stability is characteristic of new land. Undisturbed communities change their composition and their internal economy only in geological time. Within the time-scale of human affairs, they are stable.

Another characteristic of new land is diversity. The biotic community is diverse in composition, complex in organization, and tends to become more so.

When the technologies are applied to land they achieve, each within its own field, various degrees of success. There is a tacit assumption that the sum of their successes equals stable land. It is assumed that if good agronomy, erosion control, flood control, pasture management, forestry, and wildlife management be simultaneously applied to a given area, stability will follow. It is admitted that this assumption is conditional upon something which technicians in khaki call "coordination." Planners in tweeds call it "integration."

Many efforts have been made to define and implement coordination, but I recall no effort to examine the validity of its basic premise. Is it true that, given good coordination, the sum of the technologies equals stable land?

It is common knowledge that the technologies are partially competitive. "Good" agronomy means a coverless countryside devoid of all but the least exacting wild species. It means widespread drainage with possible derangement of water systems; it means the extinction of marsh and bog communities. "Good" pasture management relegates woods to the poorest slopes. "Good" forestry, until very recently, meant artificial monotypes which excluded wildlife and sometimes sickened the soil itself. "Good" game management, in Europe at least, abolishes the predators, which is in turn presumably accountable for irruptions of rodents. Can good coordination iron out these conflicts? Perhaps, but it seems safe to say that there are no instances in which it has yet done so.

The technologies are usually applied too late, and they are seldom all applied with equal intelligence to an entire land unit. We have no evidence on what they could do if perfectly balanced and timed. Our only guide is their collective performance, so far, on those land units where the largest number of them have been applied, for the longest time, with the most earnest attempt at coordination. In America, most such attempts are so far governmental rather than private. I will cite two as examples.

In southwestern Wisconsin erosion control, flood control, pasture renovation, crop rotation, nitrification by legumes, woodlot improvement, and wildlife management have been applied for a decade. Each has scored its own success in spots, and the disorganization of the land has doubtless been reduced in its velocity. But this region still displays flashy streams, loss of topsoil, silting of reservoirs, migration of plowland from upland to marshes and flood-channels, irruption of white grubs and weed pests, exaggerated drouth damage, falling water table, and scarcity of upland game. The momentum of erosion started during the wheat era and the dairy boom is certainly reduced, probably not arrested, certainly not reversed. It seems doubtful whether the sum of the technologies will stabilize this land.

Again: In the Southwest, erosion control, range management, stock water development, reclamation by irrigation and pumping, and mountain forestry have been applied during a period varying from ten to forty years. Each has scored its own success in spots, notably national forestry and range management on the headwaters. But they do not add up to stable land. All came too late, after erosion due to early overgrazing had gained momentum. The result: silted reservoirs, tearing out of valleys, widespread drainage of already dry soils by gullies, wholesale conversion of grass to chaparral, wholesale replacement of palatable by unpalatable range plants, irruption of rodent pests, loss of vulnerable and predacious wild species, falling water tables, dust storms. This land was set on a hair-trigger, and it seems doubtful whether the sum of the technologies will ever reclaim it. The disease will run its course and end up in new, and lower, levels of productivity.

These are only two instances. As evidence in the court of land science, both are defective in that technology came too late. But a glance at world experience indicates that technology *usually* comes too late. It seems academic, therefore, to say (as I myself have done) that the technologies are preventatives, not cures, and that applied in time, they will successfully preserve for land its normal stability of organization, or health. It seems more realistic to conclude that conservation, at bottom, is not to be accomplished by any mere mustering of technologies. Conservation calls for something which the technologies, individually and collectively, now lack.

What do they now lack? At this point I perforce depart from scientific logic, for we are beyond the range of scientific evidence. What I offer is opinion, or, if you prefer, judgment.

They lack, firstly, a collective purpose: stabilization of land as a whole. Until the technologies accept as their common purpose the health of the land as a whole, “coordination” is mere window-dressing, and each will continue in part to cancel the other. The acceptance of this common purpose does not call for the surrender of their separate purposes (soil, timber, game, etc.) except as these conflict with the common one.

They lack, secondly, a collective yardstick for appraising ways and means to stabilization or land-health. Each technology has its own yardsticks, usually yields or profits. But only commercial land-uses have any profits, and some of the most important land-uses have only spiritual and esthetic yields. The collective criterion of good land-use must be something deeper and more important than either profit or yield. What?

Among the ordinary yardsticks, I can think of but one which is obviously a common denominator of success in all technologies: soil fertility. That the maintenance of at least the original fertility is essential to land-health is now a truism, and needs no further discussion.

What else? What, in the evolutionary history of this flowering earth, is most closely associated with stability? The answer, to my mind, is clear: diversity of fauna and flora.

It seems improbable that science can ever analyze stability and write a formula for it. The best we can do is to recognize and cultivate the general conditions which seem to be conducive to it. Stability and diversity are associated. Both are the end-result of evolution to date. To what extent are they interdependent? Can we retain stability in used land without retaining diversity also?

There are two ways to explore this question: Examine the performance of lands where diversity has been lost, and examine the land mechanism itself for leads.

Northwestern Europe is the only part of the globe presenting an intensively used landscape which seems to have remained stable despite the loss of diversity in its fauna and flora. That its farm soils remain fertile is well known, and this alone is an achievement of world-wide importance. Part of its forest soils are sick, but the reason is now known and in process of correction. Its water systems, despite ruthless artificialization, still produce many fish, few floods, and little silt. Pest-like irruptions of plants and animals occur, but the pest problem, save for rabbits and forest insects, is perhaps less serious than with us. The non-game fauna has lost its large carnivores, but the game fauna, save for large mammals, is intact. The flora shows severe shrinkages and possibly some early and unrecorded extinctions. The migratory game birds are in a bad way, and are maintained only by replenishment from the Asiatic reservoir. The small bird fauna is warped in its composition, and some migratory species are threatened, but this is chargeable to the Latin nations where they winter.

By and large, this part of Europe has not lost its stability. Man himself is here far less stable than his land. That the present human dislocations are, at bottom, the expression of an ever-artificialized ecological mechanism is probable, but beyond the scope of this paper.

The question in hand is whether other parts of the globe can remain stable without the deliberate retention of diversity. All I can say is that I doubt it. Land is unequally sensitive. All other parts of the globe are either undeveloped (the tropics, the arctics), in process of dislocation (most of United States, South Africa, Australia, China), or already relapsed into a retrograded stability (Mediterranean countries).

What leads can we derive from the land mechanism itself?

No “language” adequate for portraying it exists in any science or art, save only ecology. A language is imperative, for if we are to guide land-use we must talk sense to farmer and economist, pioneer and poet, stockman and philosopher, lumberjack and geographer, engineer and historian.

The ecological concept is, I think, translatable into common speech.

A rock decays and forms soil. In the soil grows an oak, which bears an acorn, which feeds a squirrel, which feeds an Indian, who lays him down in his last sleep to grow another oak.

This sequence of stages in the transmission of food is a food chain. It is a fixed route or channel, established by evolution. Each link is adapted to extract food from the preceding link and hand it on to the succeeding one. The links form a circuit.

The chain is not a closed circuit. Squirrels do not get all the acorns, nor do Indians get all the squirrels; some return directly to the soil. The food channel leaks at every link; only part of the food reaches its terminus.

Food is likewise sidetracked into branch chains. Thus the squirrel drops a crumb of his acorn, which feeds a quail, which feeds a horned owl, which feeds a parasite. This chain branches like a tree.

The owl eats not only quail, but also rabbit, which is a link in another chain: soil—sumac—rabbit—tularemia. The rabbit eats a hundred other shrubs and herbs. Each animal and plant is the intersection of as many chains as there are species in its dietary. The whole system is cross-connected.

Nor is food the only link which connects them. The oak grows not only acorns, it grows fuel, browse, hollow dens, leaves, and shade on which many species depend for food and cover or other services. The chains are not only food chains, they are chains of dependency for a maze of services, competitions, piracies, and cooperations. This maze is complex; no living man can blueprint the biotic organization of a single acre, yet the organization is clearly there, else the member species would disappear. They do not disappear. Fossil bones and pollens tell us that our fauna and flora remained virtually intact since the ice age, which is 200 centuries.

Soil, the repository of food between its successive trips through the chains, tends to wash downhill, but this downhill movement is slow, and in healthy land is offset by the decomposition of rocks. Some animals likewise accomplish an uphill movement of food.

Stability is the continuity of this organized circulatory system. Land is stable when its food chains are so organized as to be able to circulate the same food an indefinite number of times.

Stability implies not only characteristic kinds, but also characteristic numbers of each species in the food chains. Thus the characteristic number of the aboriginal Indian was small; more Indians would have killed each other or their hunting ground, less would have been blotted out by some blizzard, drouth, or epidemic.

We have now modified both the species-composition of the food chains and the characteristic numbers of their constituent species. Chains now begin with corn and alfalfa instead of oaks and bluestem. The food, instead of flowing into elk, deer, and Indians, flows into cows, hogs, and poultry; farmers, flappers, and freshmen. The remaining wildlife eats tame as well as wild plants.

These substitutions are, perforce, accompanied by readjustments. To every tinkering with every link in every food chain, the whole land mechanism responds with a readjustment. We do not understand or see them, for they usually occur without perceptible dislocations. We are unconscious of them, unless and until the end-effects turn out to be bad.

Along with the deliberate and beneficial substitutions come many accidental ones (Japanese beetle, creeping Jenny, Canada thistle, chestnut blight, blister rust), most of which are bad, some ruinous. Some sober ecologists predict that a few generalized plants and animals will ultimately usurp the whole globe.

The modified land mechanism, thus converted for human use, is often unstable—i.e., it can no longer recirculate the same food an indefinite number of times. Erosion, floods, pests, loss of species, and other land-troubles without visible cause are the expressions of this instability. Would the deliberate retention of both fertility and diversity reduce instability? I think it would. But I admit in the same breath that I can't prove it, nor disprove it. If the trouble is in the plant and animal pipelines, I think it would help to keep them more nearly intact. This is only a probability based on evolution, but it is the only help in sight.

The retention of fertility is already an accepted criterion of good land-use, in theory. It needs only conversion into practice.

There remains the question: Is there room, within the existing technologies, and without the disruption of our land economy, to retain more diversity of fauna and flora? Is it possible, by deliberate social effort, to reduce the frequency and violence of changes in the land mechanism, and still use the land?

At this point I digress to refute the notion, unhappily cultivated by ecologists, that the land mechanism has a kind of Dresden china delicacy, and falls to pieces at a loud noise. The whole history of civilization shows land to be tough. Lands differ in their toughness, but even the most sensitive took several generations of violence to spoil. The pioneer has always striven for violent, not gentle, conversion to human use, and most of the technologies, especially agriculture and engineering, are still uninhibited in this respect. In fact, wildlife management, and to some extent forestry, are the only technologies conscious of "naturalism" in land-use.

Return now to our question: Could the frequency and violence of land changes be reduced by deliberate social effort? Can changes already made be tempered in violence? Can the technologies agree on stabilization as their collective purpose, and on fertility and diversity as their yardsticks of progress? Do we ourselves, as a group, believe what we cannot prove: that retaining the diversity of our fauna and flora is conducive to stable land? These are the questions now to be discussed.