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AMERICAN FORESTRY has derived most of the biological base for its operations from the experience of botanists, zoologists and soil scientists. The first borrowings were from the Old World. Americans had nowhere else to turn if they were to get their young profession off the ground. Very little was known about the commonest American trees, and still less about the hazards connected with their use and culture. Not only did American forestry borrow facts from contemporary experts but, more important for its future, it borrowed most of its theory from the same sources.

Accepted facts commonly turn out to be merely assumptions, or if they are sound they prove useless when transported to new contexts. Ideas, on the other hand, are amazingly persistent and influential. They can be transported. When related ones are pinned together to form general theories, or conceptual frames of reference, they can last a long time and make or break the lives of many people. A common characteristic of such conceptual structures is that they outlive their usefulness, and become dams against the progress of human ingenuity. American forestry has had considerable experience with its general frame of reference, and I choose to hang this discussion on it rather than upon a simple recital of biological problems. It will be useful to look first at the origins of the theory. Then I shall try to interpret later developments that will have grown from it.

First Concepts in American Forestry

American forestry came to consciousness around the beginning of the present century with several influential ideas in its conceptual frame. At the risk of some over-simplification these can be grouped into four elements. First, American foresters had convinced themselves that useable wood in America was getting scarce and was bound to get more so in the foreseeable future. Second, they had a vision of a "forest primeval" which they believed their forefathers had found here at the time of early settlement. It was a sort of biological datum plane for much of their thought. Third, they believed that this old productive forest had been devastated by destructive exploitation. And

fourth, they conceived that their mission in life was to stop the devastation, protect what was left, and rehabilitate as much as possible in order to alleviate the incipient famine.

Wood had been scarce in many parts of western Europe for a long time. Forest economies in those regions had been adjusted to the scarcity by carefully nurtured production, and by various subsidies that were socially justifiable in the total internal economies of the nations. When early American foresters were bringing European techniques to this country—techniques that had been developed over a century or more to deal with an economy of scarcity, it was inevitable that the idea itself should come with the methods of coping with it. Common observation in our eastern landscapes, together with other elements in the conceptual scheme, made it easy for Americans to accept the whole European program, including the idea of scarcity.

The impending shortage of wood led to the assumption that land, labor, and capital could be used intensively to produce wood profitably. This assumption was used to justify the heavy emphasis laid upon silviculture and management in the training of foresters. It also justified much of the weight given to forest protection in American institutions. All of these are fields in which the study of forest biology had promise of development.

Time has always been the forester's problem child. The growth of trees being a slow process, he has had to make long-term biological predictions based on the assumption that a planned and orderly production of trees would continue for many decades or even hundreds of years. He rationalized his predictions by borrowing a conceptual apparatus invented by the ecologists, notably by the American plant ecologists. This was the conception of vegetational development, *in situ*, over time periods long enough to cover the life spans of several to many generations of plants. For foresters, because trees are long-lived, the time periods could run to several centuries or even millenia. An integral part of the conception was that the developmental process was an orderly one which for any given region was predictable. It would eventually result in a

AMERICAN

AMERICAN FOREST BIOLOGY

kind of balance or equilibrium between vegetation and site which would then perpetuate itself. This biologically balanced forest was believed to have achieved great richness and productivity in pre-settlement time. It was the "forest primeval." This whole ecological conception was indeed an elegant one. It lent an aura of scientific precision to definitions of the forester's aims and methods.

A more important prediction the forester had to make in his conflict with time was that people would want his trees after the long period it took to produce them—want them badly enough to pay the price needed for their production. He justified this in part by recourse to the threatened scarcity, and in part by what seems to have been a simple article of faith. Because wood was going to be very scarce, and people would always want it and have to have it, they would, perforce, have to gear their demands to the supply and pay the price.

The Puritan settlers of eastern America in the 17th and 18th centuries were land-hungry. Their idea of what to do with their new land was to *use* it—to the hilt. The vegetation they found on it, including the forests, was a nuisance, to be got out of the way as quickly as possible to make room for the production of needed housing, crops, livestock, and profits. Although their notions of personal sin and depravity were extraordinarily acute, they seemed not to apply them to what they did to the landscape. In short, their exploitation of the land and all its resources gave them, in itself, no sense of sin. This characteristic was deep-laid in Puritan philosophy, and gave an honorable precedent to much that has happened since in Americans' exploitive use of their natural resources.

The Puritans did consider it morally wrong, on the other hand, to be personally unsuccessful in the use of resources. We still have a good deal of this idea, too, in our makeup. A curious reversal of the first of these attitudes began to appear in the latter half of the 19th century. In that period it gradually became wrong to exploit the land and forests. From small and isolated beginnings this notion grew into the conservation movement of our time. It is not impossible that some of the roots of the movement, much of which was in

the eastern states, were in efforts to rationalize the old stigma attached to personal failure. Large numbers of people were experiencing such failure in the eastern states during this period, with the decline of agriculture and trade in New England and disaster to the South in the aftermath of the Civil War. It is possible that they looked for scapegoats wherever they could find them, and a large number found them in the so-called devastators of the land.

By the turn of the century there were very few of our forests that had not been modified by the hand of the invading white man. The conventional wisdom of the time emphasized the destructive nature of man, and portrayed him as a ruthless vandal in his treatment of the woods. The ecologists were on hand with their picture of the ancient stable forest, to show what a priceless heritage he had destroyed—a heritage that could not be replaced until many centuries had elapsed, if then. Most of the existing forests were regarded as pale reflections of what the land had produced in the past and might produce in future with careful management and protection.

In light of the foregoing concepts the mission of the American forester became clear. He had methods which he believed would work or could be made to work. He believed he had economic, social, and scientific justification. But he had something more than this. Like nearly everybody else, he was against sin, and he found a ready target in the newly defined but widely recognized sin against the land and the forests. From this conflict he got the sense of moral rectitude that pervaded American forestry and supplied its missionary zeal.

The Theory Proves Inadequate

American forestry during the past 60 years has experienced a series of traumatic shocks to its whole conceptual apparatus. First, it has gradually begun to know that the threatened scarcity upon which much of its theory was based was not realistic. Our foresters have always been oriented almost exclusively toward their resource—the forest itself. This has had some tragic consequences because no forest has value until human beings feel a need for it. Therefore people have been as much a part of the equation as the trees. In spite of greatly increased numbers, with a vastly enlarged range not only of wants and desires but also of the means to get them, people are using very little more wood than they did 60 years ago. During this period they have been extraordinarily inventive, not only producing a technological explosion, but far-reaching innovations in social and economic institu-

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tions as well. Our foresters, prepossessed as they were with the physical resource—the woods, made their long-term prognostications within a frame of reference that virtually excluded the largest single biological factor in the forest system—the cunning brain and contriving hand of man. The scarcity they thought they saw approaching was mainly in lumber of qualities that were then demanded by the trade. They seemed unaware of the simple fact that those demands were governed by peoples' value judgements, and that people changed their values at will. People had been doing it for centuries, reaching a crescendo of change in the industrial revolution of the 18th and 19th centuries.

Another shock has come with the collapse of the basic assumptions that shored up the American forester's ecological theory. The concept of the age-old stable primeval forest has all but disappeared. Accumulating evidence points in one direction, and indicates that most of the forests seen by the first settlers in America were in their first generation after one or another kind of major disturbance—fire, insect pests and diseases, or windthrow. It is becoming apparent that the old forests were scarcely different from the present ones, and that the latter form a far better datum plane for planning than the assumed balanced forest of the theory.

Because Western Europeans could not be blamed for the catastrophic events, most of the validity dropped away from another element of the forester's conceptual structure—that man (European man, at least) was the arch enemy of forest productivity. It seems that the way was opening for erasure of much of our sense of sin against the land, and for reinstating the old Puritan ethic that enabled full use of the land for whatever purpose seemed most profitable.

Still another shock has risen from the appearance, on a large scale, of amenity values in forests and forest land. This might have been predicted if foresters had been paying more heed to the social and economic forces that were in play around their woods. The amenity values had been appearing in many parts of the country during the latter half of the 19th century. It is probable that our early foresters, if they considered them at all, wrote them off as passing fancies that made no contribution to the serious business of their war against famine.

Our forestry, early in its development, found itself severely limited in what it could do with its talents. This was felt particularly in the areas in which the biology of the forests played a large role. The foresters found that they had to devote themselves almost entirely to measurement, protection, logging, and sales.

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Although the terms of their mission included regeneration by silvicultural means, and management practices to upgrade the quality of the forests, the hard facts of life soon threw doubt on the capacity of these enterprises to attract investment capital. They were possible only where some form of subsidy was available. The social justification of this subsidy began to fade when scarcity was disappearing over the planning horizon. The failure of capital to move, without subsidy, into silviculture, management, and their hand maiden—silvics, left the primarily biological aspects of American forestry without much material support. The only biological areas that could draw such support were in forest pathology and entomology, which were protective of immediately valuable growing stock.

Prevention and control of fire could also be supported. But the biological implications of fire got short shrift for many years. Fire had no real place in the ecological frame of reference that the foresters had adopted, for in the grand design of long-term forest development all such disturbances were either disregarded entirely or admitted as infrequent aberrant happenings. Within this frame it was easy to label fire as an unmitigated evil, and to give its elimination high priority.

Status of American Forest Biology and Suggested Future Development

What, then, are the present status and probable future of American forest biology? I cannot divorce this question from a similar one regarding American forestry in general. I do not consider the wreckage of initial aims and concepts merely as irreparable damage. Rather it is a release. The forester is no longer so limited in his choice of fields for the application of his talents.

Perhaps the most important element in this release is, paradoxically for many, the admission of the immediate wants and desires of people into forest calculations. It represents a vast opportunity that American foresters have never had. To utilize this opportunity however, requires that our forestry construct a new frame of reference, in which the focal point is not the physical resource but the human mind, from which all forest values come. Because the human mind is inventive, fickle, and essentially unpredictable, any frame of reference built around it must have a large element of flexibility. The flexibility must apply not only to the physical resource, but also to the time it takes to produce it.

What kinds of demands can we expect people to make? Crooked trees can be just as valuable as straight ones. Clear openings in forested lands may have higher values than if they were covered with trees. Continued technological innovation can make little trees as valuable as big ones. Species that have never had value can turn into the most valuable of all. And if we make paper out of annual crops grown on good agricultural land of which we seem to have a plethora, huge acreages of forest will have none of the traditional values except those of wilderness. Serious famine has never forced us to produce wood culturally on a large scale in America. It is possible that we never will have to, and that over large areas the forest

will become a nuisance as it was to the early settlers on the eastern seaboard. It is already acquiring this character in some parts of New England.

Our forests are, like the demands made on them, atomized. They are a hodgepodge of types, age classes, and form classes. Our studies of their history show that they have always been so. The only order we can see in them, in any given landscape, comes from their relations to site. When we come down to cases the individual species appear to be reacting far more to physical site factors than to each other in supposedly necessary community relationships. The fact that the species are as productive and persistent as they are and have been is mute evidence that they have immense built-in adjustability not only to local site variation but also to violent disturbance by external forces including man.

Thus both the demand for forests and forest products by people, and the supply in the forests, are extremely variable in kind, quality, and quantity. Both have massive elements of uncertainty, which is part of their very fabric. The forests have a flexibility which matches that of human demand provided we can learn how to control and use it. What the demands for biological knowledge will be as we attack these complex problems is difficult and probably impossible to predict. I shall venture a proposal, which carries with it the proviso that it is more likely to be wrong than right.

I think that the variability and fragmentation in human demands and in the forest suggest that the forester's knowledge and treatment of the woods will likewise have to be much more varied and fragmented than they have been in the past. This leads me to our more neglected field—silvics and its allied problems in site relations. It deals directly with the fundamental units—the individual species—that will be most useful in coping with the uncertainties of a constantly changing man-forest system. Modern agriculture, horticulture, and animal husbandry are living examples of what can be done when people study species intensively. European foresters began doing this long ago, and have never neglected it. The present status of our silvics, like everything else in the field, has been conditioned by the old conceptual structure.

In accepting the ecological theory of the early 1900's our foresters failed to see a fundamental flaw in its structure. Ecology as we know it was first developed in western Europe, primarily in the field of plant geography which had a maze of unsolved problems. It was thought that physiological experiments with species of plants would produce a working knowledge of their requirements and limitations. This knowledge could then be correlated with measurements of site factors, and a means of explaining distribution would be at hand. But the proponents of the idea seemed not to have sensed the magnitude of the research that would be necessary before it could be productive. Ecologists at the turn of the century began, rightly, to despair of accomplishing enough of it to be effective in the foreseeable future.

The theory set up by American ecologists attempted to avoid a large part of the burdensome research proposed by the physiologists. The latter had insisted

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that the basic unit of study was the individual plant species. Our ecologists thought they could make more progress by using larger units composed of many species. They called these units by various names: communities, associations, or formations. Foresters called them forest types. They were worked into the general theory of vegetational development and became stages in natural successions. Beating their drum for this proposal the ecologists now proceeded to beat the head in. They ruled that the species was defunct as a unit of study, and that only the community was acceptable. This idea has had a dire effect upon the American forest biology of the past 60 years. It led both the botanists and the foresters to by-pass most of the field of silvics. Just at the time when they would otherwise have been making intensive studies of the native, untried forest trees, they found no place for them in their frame of reference.

Every kind of tree has built-in parameters of tolerance on gradients of moisture, light, nutrients, temperature, and factors of physical disturbance. The individual tree in which the tolerances are expressed is only one unit in a large population, and in this population the parameters commonly change regionally. Thus species are apt to behave differently with respect to site from one region to another. Studies of structural variation and behavior patterns among and within tree species can be approached through the disciplines of physiology, morphology, and genetics; but progress in all of these with respect to the common American trees is in its infancy. This is a field in which practical lumbermen, mill operators, and manufacturers of wood products commonly have more useful knowledge than technically trained foresters do. The collection and codification of this miscellaneous knowledge might well be a starting point for the definition of many research problems in silvics.

By way of summary, I think the largest single need in American forest biology is the study of man's relation to forest land. Our foresters need to understand much more than most of them do about purely human motives and aspirations with respect to the land. They ought to become genuinely knowledgeable and respectful of people's economic, social, and aesthetic institutions. Felt needs defined in these areas are the only ones in which foresters or anyone else can find sale for their goods and services. Secondly, I would place the study, in depth, of the behavior of trees as species and individuals. Out of this study can come flexibility in technical knowledge and management practice. It would enable foresters to take up more efficiently the varied options that are now open to them in their new frame of reference. ■