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ECOLOGY AND LAND USE

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WHAT IS ECOLOGICAL THINKING?

Some years ago a farmer in New York State was complaining to a friend that there were no longer any ducks on the big marsh at the lower end of his farm.

"Herb," he said, "you're a biologist, can't you tell me why I haven't any ducks anymore? There used to be three or four broods come off that marsh every summer."

"Well, John, I don't know. It might be for any one of a dozen reasons. Let's walk down that way and take a look."

But it was not settled in one afternoon. Herb made several visits to the marsh at different seasons of the year until, bit by bit, he pieced his observations together to make a complete picture. Then the biologist met his friend again.

"The ducks are gone," he said, "because the boys are trapping all the skunks."

"Why, what in thunder have the skunks got to do with the ducks?" John retorted, "I'd think trapping the skunks was all to the good, if you ask me."

"Maybe so," continued Herb, "but the situation looks like this. Skunks dig snapping turtle eggs out of the sand where they're laid, and eat them. When the fur prices went up and the boys started trapping skunks the turtles had a chance to multiply. But there wasn't enough food down there for them and they began to feed on the ducklings. Ducks won't nest where they are molested that way, and so they have gone somewhere else. If you want those ducks back you'll have to quit trapping the skunks. Their hides aren't worth much now anyway."

John was not convinced, but the ducks had been the pride of the whole family, so he decided to try the biologist's suggestion. Today there are as many ducks as ever. For when trapping ceased, the skunk population increased with a resultant drop in the number of snapping turtles; the turtles no longer exerted pressure on the ducks, which returned to nest at the pond; and something like the previous set of relationships was established.

The biologist had attempted in this instance to deal with all the factors affecting a given situation, instead of considering a single factor to the exclusion of others that might have an equally important influence. This is an example of ecological thinking.—Edward H. Graham.

ECOLOGY AND LAND USE

BY EDWARD H. GRAHAM [1]

Ecology is not so much a special branch of biology—in the sense that genetics or the physiology of nutrition are special branches—as a way of regarding animal and plant life.—A. G. Tansley.

AULUS, the Roman, spoke proudly when he announced that at last they knew malaria was caused by the night air. Then, like other intelligent Romans of his day, he ordered all the doors and windows of his home tightly closed from sundown to sunrise to exclude the "pestilence that walketh by night." Little did the Romans realize that 1,500 years would pass before the truth would be known about malaria—that the disease is carried by the *Anopheles* mosquito. Yet of all the plagues of human history malaria probably has taken the heaviest toll of human lives. For twenty-five hundred years it has persisted throughout many parts of the world. Before the rise of Rome it was recognized as the most deadly enemy of the Athenian Empire, and if she had conquered malaria, Athens would have ruled the world. Ancient Rome lost more soldiers to malaria than to her enemies.

The Roman authorities tried diligently to discover the cause of this plague, and came near the solution, for they found a relationship between the disease and the night air, and closing their homes at night was correct procedure. But the next step in man's knowledge of this malady was delayed 15 centuries until someone began to look for further relationships. Even then, long, patient experiment was necessary to learn the baffling fact that infective transmission requires a certain interval of time, that only a few of more than 100 species of mosquitoes can transmit malaria from one person to another, and that of these it is the female alone which carries the disease.

What we know now about malaria we have learned by attempting to deal with all factors affecting the situation, instead of considering a single factor to the exclusion of others that might have an equally important influence. This is an example of ecological thinking.

Some day we shall look back tolerantly upon the time when bounties were paid for hawks and owls, while men lamented the presence of mice and snakes, upon which such predatory birds, if unmolested, effect some measure of control. Shall we not knowingly shake our heads when we recall the widespread efforts of those who so enthusiastically stocked with game habitats unfit to support it, and planted fish in streams and ponds where there was no likelihood of their survival? Game laws not ecologically sound will seem absurd, for the relationship between animals and their environment will be better understood. Even now we know that high populations of deer in the Northeastern States have been possible because food was supplied by second growth browse that sprang up where virgin forests were cut away, and that as this browse matures into forest trees it will no longer be good deer food, and the deer will starve. When that happens the most stringent protective laws will be unable to preserve the animals unless management methods based upon a knowledge of existing relationships are first applied to the land.

In the program of the Soil Conservation Service a fundamental concept is that of a coordinated approach on the part of several technical fields toward the solution of a common problem—soil erosion. This concept is based on the relationship of the land owner to his environment—the farm which he operates and the market which absorbs his production. A sound agricultural program will result in a balanced condition where crops and soil, rainfall and run-off, birds and insects, yield and market, and all other components of the farm as a habitat, are in adjustment. In this light, prevention of soil erosion on agricultural land, like every conservation endeavor, is fundamentally an ecological problem.

That farming involves many ecological patterns is illustrated in the following example: For a long time agriculturists advised against the use of a permanent ground cover of herbaceous vegetation in southern California pear, avocado, and citrus orchards. It was

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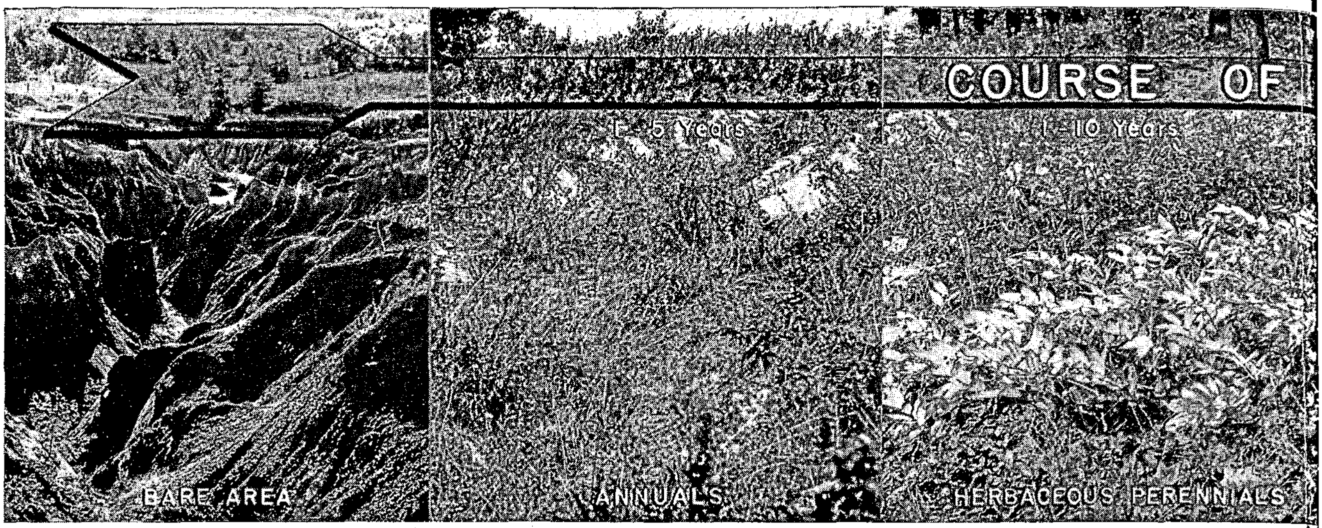


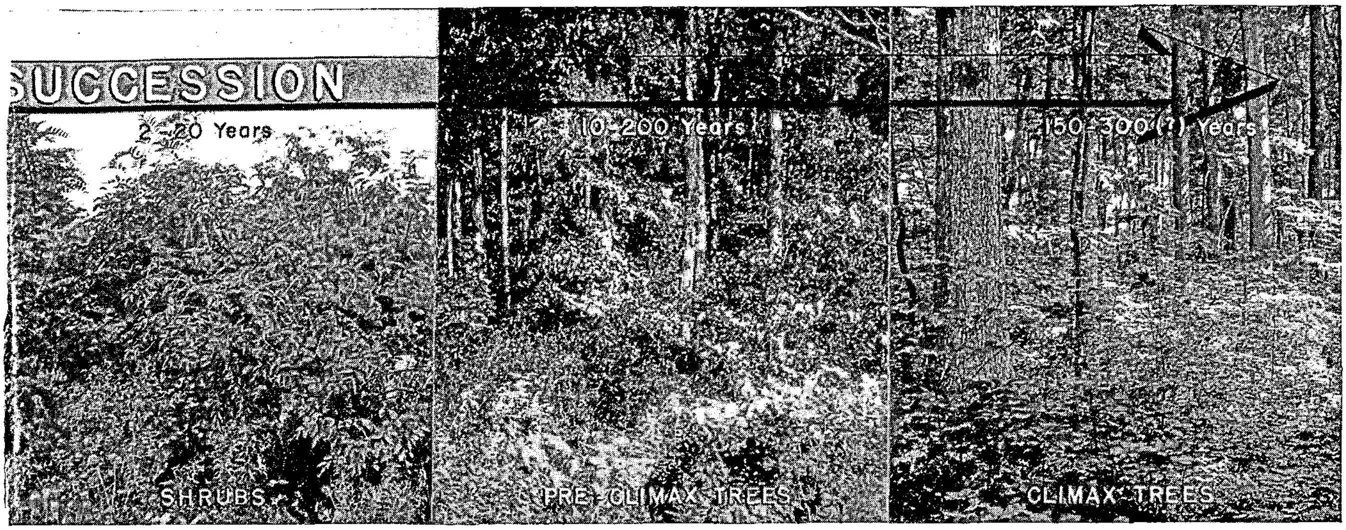
believed that a ground cover of vegetation sheltered field mice and other rodents which ate the bark and roots of trees, provided protection to injurious scale insects, increased irrigation costs by absorbing water, and, through competition for nutrients, reduced fruit yields. However, orchards maintained for a great many years in permanent cover of herbaceous perennial legumes and grasses have demonstrated that yields are not reduced under this practice. On the contrary, packing house records show yields from these orchards to be much higher than the average; they also bring better than average prices. Furthermore, operation and irrigation costs are low. Irrigation is accomplished by flooding from furrows constructed across the slope, the water being spread by the dense plant cover which, by providing infiltration into the soil in place of rapid run-off, actually conserves water.

Flood irrigation in itself is an effective aid in controlling gophers and other small rodents, and the cover of herbaceous vegetation supplies food for mice that no longer are forced to feed on the trees. The ground cover harbors predaceous insects and ground nesting birds that help naturally to combat insect pests. Permanent cover likewise obviates annual seeding, practically eliminates cultivation costs, prevents interference with feeder roots of the trees located near the surface of the ground, and prevents soil erosion. Thus the invaluable soil resource is permanently protected, and harmonious relationships are established among the biological components of the orchard community which it is to man's advantage to understand and maintain.

In farm woodlands man profits by knowing something of ecology. The snowshoe hare of our Lake States forests is often blindly charged with intolerable injury to young trees. This is especially true on clean-cut or burned-over areas where natural reproduction results in very thick stands. Now the hare is a highly cyclic species, with "highs" of large populations occurring at 10-year intervals. When the hare population is at its peak the animals eat, girdle, or prune the young trees until the stand is so open that they may be easily seen by predatory mammals, owls, and hawks. The hares must then retreat to thicker stands for protection. They may return at intervals of a few years whenever the trees have again thickened enough to form protective cover, and may thin out the stand recurrently until the bark becomes too thick to be palatable. Instead of being an unmitigated evil, however, the opening of the stand in each case permits the remaining trees to recover from their stunted condition, helps to reduce the fire hazard, and minimizes insect damage.

In northern Minnesota the value of the thinning operations of the snowshoe hare is set at a high figure. Furthermore, foresters have learned that in this region plantations of trees show a much higher percentage of survival if the plantings are thin, in which case they do not provide escape cover under which the snowshoe hares can work, and that there is minimum damage if plantings are correlated with "lows", in the population cycle of the hare.

Small forest animals, such as shrews, moles, mice, and chipmunks, have long been listed on the debit side of the forester's ledger, because they eat seeds and damage tree seedlings. Yet, recent studies show that small animals inhabiting the forest floor eat an astonishing number of insects, many of them larval forms of species highly destructive to mature trees.



The insect-destroying values of these mammals may be even higher than the values of insectivorous birds, for the number of such animals per acre is greater than the number of birds, and, unlike most birds, the mammals are resident and usually active throughout the year. It is conceivable that, without forest animals, we might have no forest at all.

The older forest plantations of continental Europe, planted to pure stands of spruce or pine, once were lauded for the neat appearance of row after row of similar trees. Today we know that soils are depleted under a uniform type of forest cover, and that disease is prevalent because it can spread more easily than in mixed stands. In such European forests insect damage is so widespread that bird boxes are being installed in an attempt to restore artificially some semblance of the biological balance which was lost by man's failure to think ecologically.

To the ecologist there is real significance in the adage that man must learn to work with nature, not against her. But the ways of nature are not easy to learn. The following example illustrates this: If a coyote is observed to kill a lamb a fact is established, namely, that coyotes kill lambs. Since lambs are desirable, the obvious conclusion seems to be that coyotes must be destroyed if lambs are to survive. This is the simplest deduction—but it does not represent ecological thinking. The ecologist wants to know how the destruction of coyotes affects other things. Unfortunately, much more money and effort have been spent in destroying coyotes than in attempting to learn the place they occupy in the biological complex of which they are a part. Nevertheless, we have learned enough about their food habits to know that they live on rabbits and various small rodents to a substantially greater extent than on lambs.

Of rabbits and rodents that live throughout the range of the coyote another isolated fact is apparent—rabbits and rodents eat grass. This simple relationship seems also to interfere with an activity of man, for cattle and sheep likewise eat grass. The obvious conclusion is that rabbits and rodents should be destroyed to preserve food for livestock.

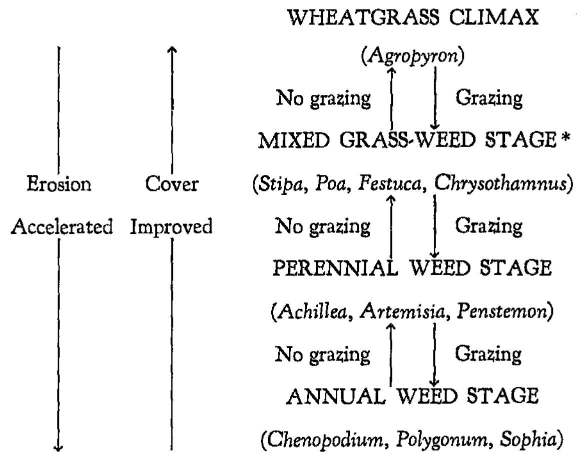
But it is apparent that the destruction of coyotes and the simultaneous destruction of rodents, on which coyotes naturally prey, is illogical. For if man did not reduce the number of rodents by poisoning, the coyotes, finding their natural food more abundant, might feed more upon rodents, and less upon lambs. There would then be less need to kill coyotes. Also the rodents thus naturally reduced in numbers, would compete less with livestock for food, and man could put to better profit much money he now spends in rodent and predator control.

Of course, practical management of wild animals in relation to range land is not as simple as the writing of the preceding paragraph, but a consideration of the interrelationships stated is a simple example of ecological thinking. From this knowledge the ecologist wants to go forward—to learn more about other relationships between coyotes, rodents, man's domesticated animals, and the vegetation of the range, until he discovers what factors, if any, must be modified to attain the biological balance that will provide the maximum return from the land consistent with its best use and long-time productivity. It may well be that regulation of livestock grazing to the carrying capacity of the range may prove to be the management measure that will keep both rodents and their predators under control. Proper grazing is a way of working with nature and may upset the desired balance less than any other kind of disturbance man might introduce. Ecologists might profitably be employed to learn more about these relationships.

Today we hear more and more about ecology. We hear that conservation of resources is attainable only if founded upon ecological principles; that many subjects, such as geography, are properly taught only when treated as human ecology; and that the tumultuous unrest of the world today exists because man has held more to political than ecological tenets. Such ideas are based on the conventional definition of ecology—the science of the relation of living things to their environment. The concept of ecology as a science, however, connotes a language of unfamiliar technical terms and a knowledge available only to the specialist. But in a broad sense, ecology is much more a process of thought than a science, and as such is useful to a great many persons. To think ecologically requires only a knowledge of facts and an ability to relate them correctly. Anyone can utilize this type of reasoning, although to arrive at a solution in specialized fields a trained ecologist may be required to interpret accurately the facts and place them in their proper relation to each other.

The ecologist finds practical as well as theoretical usefulness in the concept called succession. This concept contends that primeval vegetation undisturbed by man, whether it be forest, grassland, or desert, is in essential equilibrium with the climate. Such vegetation is considered climax for the region and will perpetuate itself. If the climax vegetation is removed from an area, it is not reestablished until several different plant communities have successively occupied the area, each more like the climax type than the preceding. For instance, if a virgin hemlock-hardwood forest is destroyed by lumbering, it is not a stand of young hemlock and hardwoods that immediately begins to replace the cut-off trees. Instead there first springs up a growth of annuals, usually widespread weeds. A few years later this is succeeded by a cover of herbaceous perennials. Still later shrubs invade the area and finally, after many years, trees such as cherry, aspen, and birch appear. In the course of a long time, these trees are gradually replaced by climax species of hemlock and hardwood, to produce eventually the type of forest originally on the land. Of course, many kinds of disturbance, as fire, cultivation, and erosion, may modify this succession, and man's activity ever tends to prevent its progress; but it is an ecological law that the vegetation of a disturbed area attempts incessantly to return to its original climax composition that is in equilibrium with the climate of the area.

Anyone familiar with the stages through which a given succession must progress in reproducing the climax type, can tell from the plant cover of a disturbed area how far it has developed toward duplication of the original vegetation. Likewise, if he watches an area over a period of years, he can determine whether it is progressing toward the climax or retrogressing toward a lower stage in succession, as it does under misuse and erosion. Man is only beginning to learn how to apply this principle to his daily activities, although a generation ago ecologists learned that in the wheatgrass grazing land of central Utah the species of plants increasing on the range tell one of two stories. If plants appearing on the range belong to a stage lower in succession than the predominant vegetation, the range is deteriorating, a condition brought about by misuse, as overgrazing; if invading plants belong to a higher successional stage, then the range is improving. The situation may be diagrammed:

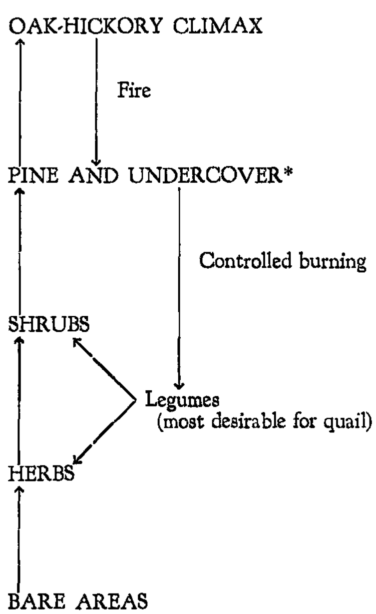


* Because the variety of palatable plants makes this stage the most desirable for grazing all classes of stock, the range manager will attempt, by proper stocking, to maintain the range in this condition.

No amount of money spent on weed control when the range is in the annual weed stage, or even in the perennial weed stage, can successfully eliminate weeds. The only economic way to control weeds is to remove the cause of their appearance, in this case overgrazing. When grazing pressure is relieved, the natural process of plant succession will inevitably replace the weeds with more desirable plant species—and at no cost to man.

More recent studies of the vegetation of abandoned fields in western Nebraska indicate that it is possible to determine, from the plants growing there, exactly how many years ago a particular field was last cultivated. Consequently, an ecological knowledge of plant communities and succession makes it possible not only to understand something of the past history of a parcel of land, but to predict its future as well, which, in the last analysis, is one of the greatest tests of the usefulness of any human discipline.

That man, by proper management, can maintain native vegetation in a condition suitable to his needs, that he can "arrest" succession, is a comparatively new thought. It would seem to be valuable in range and pasture management, forestry, and nearly every agricultural practice dealing with plants except the cultivation of annual crops. The biologist has been quick to utilize this principle. For example, game managers in the Southeast have learned how to maintain beneath open stands of longleaf pine a heavy undergrowth of native leguminous plants invaluable as food for the bobwhite quail. This is done by carefully controlled, light, periodic burning of the forest floor. Such a practice also aids in maintaining the forest of longleaf pine, for burning encourages reproduction of this species, and the resulting heavy herbaceous vegetation may well provide better grazing, although little attention has yet been given by ecologists to these further relationships. The result of burning as a quail-management practice may be diagrammed as follows:



*The stage commonly dominant for the "Southern Pine" region, due to recurrent, uncontrolled, heavy burning, even prior to the advent of white men.

In any program aimed at the proper use of land, ecological thinking is a prerequisite. Interrelationships of plants, animals, and man with the physical environment, the trend of plant succession and how to make use of it, and attention to many minor axioms of ecology must be considered, else man pushes a wagon with the brakes on. The attempt of the Soil Conservation Service to apply use-capabilities to types of land is of interest in this regard. This scheme recognizes a relationship between several factors such as soil type, degree of slope, vegetative cover, erosion, and the best adapted land use. To maintain some semblance of balance between use and conservation of land, it is generally true that disturbance of the soil must decrease as the slope of the land increases. Therefore, on the steepest and most erodible slopes a protected permanent cover of vegetation, as forest or prairie sod, must be preserved. On slopes less easily disturbed, carefully managed pasture may prove a wise land use. Still gentler slopes may be cultivated with careful application of soil-conserving practices, including, perhaps, long periods in grass rotation, while constant disturbance may be safe on the most level and least erodible areas. The designation of specific land-use capabilities for various types of land according to a consideration of all their physical properties represents a concrete application of ecological thinking.

Another matter in which the ecologist is interested is what happens when non-native plants or animals are introduced into a region. In older countries, such as England, some sort of biological balance has been attained, but in newer countries the consequences of introductions are not easily predicted and may present extremely complicated biological interactions. For example, some zealous gardener, who wanted to make Hawaii even more beautiful than it was, introduced there an ornamental tropical American shrub, *Lantana camara*. In its home this plant "knows its place" but, as we shall see, in Hawaii it took full advantage of its new association.

Some time before the introduction of this shrub, turtle doves from China had been brought to Hawaii, and Indian mynah birds also were introduced. Unlike natives, these two birds fed heavily upon Lantana fruits. The aggressiveness the plant displayed in its new habitat plus the capacity of the exotic birds to distribute the seeds combined to make the plant a serious pest in parts of the islands devoted to grazing. But there is even more to the story. Before the mynahs were introduced, the Hawaiian grasslands and young sugarcane plantations had been severely damaged by armyworm caterpillars. When the mynahs came, however, they helped to keep the armyworms under control. Meanwhile someone got the idea that certain foreign insects would check the spread of Lantana by eating the seeds. Consequently, insects were introduced. As predicted, they destroyed so much seed that the

Lantana began to decrease. Then the mynahs, deprived of Lantana seeds for food, likewise began to decrease. This resulted in a recurrence of armyworm outbreaks. Furthermore, many of the places now vacated by the Lantana shrub became occupied by other introduced shrubs, even more difficult to eradicate than Lantana. Here is a lesson about the reckless introduction of exotics, for the result in this instance was an ecologically unbalanced situation becoming for man a long difficult task in bringing about some sort of desirable stabilization.

In the United States much damage has been caused by exotics, such as the chestnut blight, Hessian fly, cotton boll weevil, and weeds, most of which are Eurasian plants. Of course, native species may also cause trouble, as do the grasshoppers of the Great Plains. In defense of introductions, one might argue that many of the cultivated crops of the United States and nearly all of our domesticated animals are non-native species. For the most part they survive, however, only when tended carefully by man. This discussion is not intended as a statement to the effect that introductions are necessarily harmful, but rather to emphasize the fact that great care must be exercised in tampering with the ecology of an area, and that it is imperative for his well-being that man think ecologically as well as in terms of simple cause and effect relationships.

We live in an environment of many facets related not as single pieces, but as a mosaic, the pattern of which is not appreciated at first glance but must be seen in different lights to disclose its true design and its real worth. Thus it is easy for man to look to immediate gain, forgetful of the long-time advantage. But to achieve a lasting economy he must consider all the implications of his operations on the land. Might it not have been possible to prevent the passage of homestead laws that once encouraged families to live on land incapable of supporting them? Might the Great Plains have been spared the devastation that resulted from wholesale plowing of the sod with no regard for consequences? Could drainage that exposed land worth less than the cost of drainage operations, and many other activities we now regret, have been avoided? Is what we plan today equally unwise, or are we prepared to consider all the interrelationships our actions might involve, and act upon that knowledge? It is not an easy responsibility. Ecological thinking is one discipline to aid man in dealing with the world in which he lives, and one to which, in the future, he must be forced more and more to give attention.