Development of Natural Resources:

The Coming Technological Revolution on the Land

H. H. Bennett, *Chief, Soil Conservation Service,*
U. S. Department of Agriculture, Washington, D. C.

PRODUCTIVE LAND IS UNLIKE ANY other natural resource. It is characterized by the element of life placed by Nature in the thin mantle of fruitful soil occurring over a limited portion of the earth's surface. It is this life-producing quality that makes some lands productive, and it is the absence of this quality that makes some barren.

Productive land is further differentiated from other natural resources in that it must be maintained and used simultaneously; that is, it must be kept intact while in use. All other natural resources, with very few exceptions, must be taken from the earth—separated from it—in order to be used by man. The exceptions are certain forms of wildlife and those natural areas which, because of their aesthetic values, are kept in their original state.

Productive land is much more limited than commonly has been supposed. It occurs only on the surface of the earth, and only on part of this surface. It is not permanent. Once the fertile topsoil is washed or blown away, it cannot be restored or replaced in any practical way for generations. And what is left—subsoil—usually is far less productive, or sterile, and less stable. There are no undiscovered reserves of productive land of any substantial area.

We cannot dig deeper into the earth and find new productive soil. We cannot pump it from wells, plant it with seeds, or dig it from mines. We must keep what we have or do without. Assorted residues of sand and gravel left stranded along streamways are of small value.

Productive land is the only natural resource without which we cannot live. We are completely dependent on it for the food we eat, except fish. We also depend on it for a very large share of our clothing and shelter. We cannot get enough to feed ourselves or provide our clothing from the oceans. On any large scale, hydroponics would be utterly impractical. We might conceivably turn sometime to some form of synthetic food, as pills, plus a roughage, but this appears to be a fantastic extreme, still far away, and likely, if it ever comes, it will be decidedly unpopular.

There is no doubt about the need for protecting productive land. Year after year, for generations, man has been steadily engaged in ruining millions and million of acres of this basic resource. Every hard rain falling on unprotected, cultivated, or overgrazed sloping land washes additional tons of soil downslope, downstream, into the rivers, reservoirs, and oceans. There is no practical way of bringing this back. And every hard wind, blowing across bare, dry soil, whether sloping or level, adds to the damage. Wind lifts the fine soil particles into the air and often develops huge dust storms that destructively scatter the substance of the land. What is left behind, frequently, is infertile, shifting sand that smothers out vegetation on neighboring good land.

When the world was younger and our population much smaller, we could, perhaps, stand such waste, but that time is past. It is not defeatism to say that the world is fast maturing and must assume now a mature responsibility for its resources. It is not limiting the horizons of the future to say that land exploitation must stop. It is simply a matter of common sense and self-preservation. Besides saving soil and water—the two go together—soil conservation results in increased yields per acre. It is also easier and cheaper to farm on the contour than up and down hill.

Today, throughout our world, there are left only about 4,000,000,000 acres of immediately arable land, the productivity of a great deal of which is only fair to medium. Some of it is poor. Yet we must count on all of it to feed a population reported to be in excess of 2,000,000,000, and still increasing.

The United States is somewhat better off, from the standpoint of productive land, than most nations. Even though we have ruined more good land in less time than any other nation in recorded history, we had the advantage of an unprecedented supply to begin with. Now we have little margin left, but we still have enough productive land if we take care of it. We cannot hope to maintain our present standard of living if we lose much more; eventually, if the losses should continue, the Nation would suffer even more seriously.

There are about 460,000,000 acres of really good, high-class cropland left in the United States. This includes, in addition to that now in crops, about 100,000,000 acres that need drainage, irrigation, clearing, or other improvements. All but about 70,000,000 of these 460,000,000 acres of high-grade land is subject to erosion if it is not protected. We have no reason for complacence.

Address given before the Engineering and Human Affairs Conference at the Princeton University Bicentennial Conference, Princeton, New Jersey, October 2, 1946.

Our record shows that we have ruined, for further practical cultivation, about one-fifth of our original area of tillable land. A third of what remains has already been badly damaged, another third is highly vulnerable, and the erosion process is still going on.

How did we get into this predicament? Why was this allowed to happen? Why didn't you hear about it sooner? There are a number of reasons, but probably the following are the main ones:

First, we began losing land to erosion when the world was still young. Those were the days when there was always more land—a great deal more—just over the hill or across the ocean. People came to regard land as limitless and inexhaustible. This deceptive idea persisted as time went by, and it was probably not until the United States was settled all the way to the Pacific Coast that people began to have any real doubts about the myth of land plenty.

Second, the apparent abundance of good land for so many generations gave rise to a careless and prodigal attitude. There was nothing of any compelling nature to cause a landowner to take care of his land or have concern about maintaining its productivity. New land somewhere could almost always be had.

Third, in modern times, the leaders of thought and nations—and nearly everybody else—too often have had little or no personal knowledge or understanding of the land. They have been trained in law, finance, philosophy, administration, military science, economics, education, or some field other than agriculture, and especially that part of agriculture having to do with maintenance of the base, meaning the land. With few exceptions they have had neither the incentive nor the training to look at the landscape around them and understand what was happening. The ancient and unchallenged myth of land plenty came down to them too, through the ages, and was accepted as truth.

Fourth, too much of the land traditionally has been in the hands of the untutored and the inept. In very recent years and in a very few countries, this situation has been changing, fortunately, for the better. However, over most of the world, land is still being used by men with little specialized or adequate training for the job. Too many land users have operated on a trial-and-error basis and have been influenced predominantly by habits handed down from the past, whether good or bad. Some have placed greater faith in superstition than in science. Under the names of peasant, farmer, rustic, and country fellow, these individuals have been synonymous, for generations, with all that is naïve, uneducated, and backward. Possessed frequently of such virtues as thrift and diligence, they have nevertheless often assumed a scornful attitude toward education and the educated, and too often the farm has been the last resort to which men, unsuccessful in other fields, have turned. In short, the most precious natural resource on earth in too many places has habitually been in the charge of those who have had no greater qualifications for the trusteeship than the coincidence of inheritance or birth on the land.

Fifth, too few farms have produced surplus capital for the owner over a period of years. On the contrary, the farm often has been no better than a marginal or subsistence enterprise. Even in the United States, the farmer rarely has had the personal resources to undertake research or seek out technological improvements. He has generally been almost wholly dependent on outside help, from government or private corporation, to provide him with improvements in machinery, materials, and methods.

Sixth, our agricultural scientists failed completely, over bygone years, to recognize land for what it is—an impermanent and complex resource. They considered soil permanent and synonymous with land. As a result of this mistake, both agriculture and the land suffered. Soil is but one part of land. For all practical purposes, land must be regarded in terms of all its component parts of soil, slope, climate, and susceptibility to erosion. The early scientists largely ignored erosion, paid little attention to slope, called the weather inevitable, and took soil samples right and left. In the main, however, agricultural science was not greatly concerned about the land. In large degree it was more interested in the health and breeding of livestock; improvement in strains of grasses, legumes, grains, and fibers; and modernization of machinery and equipment. All of this was beneficial, but it did neglect the capital stock of agriculture and the source of production—the land itself.

Seventh, in agriculture as in other enterprises we often wait until we are sick before we call the doctor. There is an element of human nature about this, and it has operated on the land. We did not practice preventive medicine, and now we must try to cure a malady—erosion—that has gotten into our system and weakened us.

So much for history. There is little to be gained by a review of past shortcomings except as it will help us avoid similar pitfalls in the future. Today we are profiting from the lessons of the past. We know now:

(1) That productive land is neither limitless nor inexhaustible. On the contrary, we have learned that the area of productive land is steadily shrinking before the onslaught of erosion.

(2) That land must be expertly cared for if it is to be maintained in a productive state.

(3) That productive land must assume an ever more prominent position in the thinking of the people and their leaders. As the source of food for all people, rural and urban, it must have the regular, intelligent consideration that such indispensable wealth merits.

(4) That, since society as a whole depends absolutely on the produce of the land for its present and future existence, society as a whole must share in the responsibility and cost of maintaining land in a productive state. The individual land-

owner or operator has neither the resources nor the ability to carry the burden alone, and he has control only for a lifetime.

(5) That science must inevitably devote an increasing share of its attention to the problems of maintaining the substance and improving the yield of productive land.

(6) That action is imperative. Time is running out between the impending pincers of an increasing population and a dwindling area of productive land.

(7) That the technological key to future consideration of land development is scientific analysis of each parcel of land of any important extent to determine: (a) the type of production for which it is best suited physically and economically, as between row crops, forage, trees, grain, or wildlife; and (b) the conservation measures, such as terracing, strip cropping, and contouring, necessary to maintain it in a permanently productive state under maximum use.

(8) That practical treatment must be based on this analysis —the character of the land and its needs.

Lands vary widely from place to place and even on parts of the same farm or field. Every variation in the combination of soil, slope, climate, and susceptibility to erosion means a variation in the use and treatment necessary to keep the land permanently productive. Thus, engineering measures are used to supplement agronomic and fertility measures wherever necessary, and vice versa, according to need, adaptability, and economic limitations.

This is the basic principle underlying the new land technology developed in the United States during the past 14 years by the Soil Conservation Service (first called Soil Erosion Service). It is being applied to an ever-increasing area of land by American farmers, acting with the assistance of Service technicians. By the middle of 1947 more than 100,000,000 acres in all parts of the United States will be farmed in this modern conservation way; that is, each of the 100,000,000 acres or more will be used according to its individual capabilities and will be treated according to its conservation needs.

In the United States, land technology is spreading through a new democratic device known as the soil conservation district. The district is a subdivision of State government, brought into being by a process of referendum among the landowners and operators involved. In practical application it is a legal organization of landowners and operators within a designated area for the purpose of developing and carrying forward a mutually desirable program of soil and water conservation. Its principal advantages are in the encouragement of local initiative and in the greater strength that comes with organized numbers—farmers and ranchers working together.

In soil conservation districts the farmers themselves decide what they want to do to improve their land and water resources and how they want to go about doing it. Then they proceed along this course, working together, and utilizing all the available facilities and services they can command. In almost every instance, districts are obtaining technical guidance from the Soil Conservation Service.

On August 15 there were more than 1,670 districts in the United States, voluntarily voted into existence by the farmers themselves. These districts encompassed more than 900,000,000 acres and approximately 4,000,000 farms. Farmers are continuing to organize districts at the rate of approximately 25 per month.

Although democratic soil conservation districts are being employed in the United States to further the application of land technology, other nations may choose to utilize other means. A number, however, including the Union of South Africa, Mexico, and parts of Australia, have adopted the soil conservation district method.

In the long run, the overwhelming urge of mankind for survival will dictate that every remaining productive acre be handled in such a way that it will continue to produce indefinitely. In the meantime, other factors are combining to speed up the application of technology to the land. From the standpoint of the individual and the nation alike, the development and application of soil and water conservation technology (the tool of soil conservation science) is good business. It results in greater yields and greater returns per acre for the capital and labor expended. Moreover, it maintains or improves the basic strength and self-sufficiency of individual and nation. It probably can prevent at least half the potential famines of the future.

By increasing the per-acre, per-farm, and per-nation supply of food and fiber, conservation technology can provide the basis for an improved standard of living and simultaneously reduce the hunger and discontent among peoples which so frequently leads to discord, dictatorships, and war.

For these and other reasons, the application of land technology is certain to spread around the world, either voluntarily or by decree. By the year 1996 this world journey probably will be well advanced. By that year or before, it will have accomplished changes in agriculture tantamount to a beneficial revolution on the land.

Almost certainly, productive land will have become a major factor in national and international deliberations. In all probability there would have been better international relationships if we had worked together more on ways and means of keeping land productive.

Production in the agricultural areas of the world will be more diversified; there will be pronounced increases in the acreages devoted to livestock and trees.

Agricultural production will be restored or improved in millions of communities throughout the world, solving in large measure some of the most difficult problems of food distribution and human nutrition now confronting mankind.

The nutritive value of food produced on land rich in the constituents of plant nutrition undoubtedly will be greater than that from impoverished land, which has been stripped of its topsoil by erosion, with everything the topsoil contains: available elements of nutrition, both minor and major, all that man puts into the topsoil, and everything else. With so much eroded land around the earth, is there any wonder that malnutrition and famine are so widespread?

Development of land and water resources for agriculture, as by drainage or irrigation, will be governed primarily by factual, technological elements of land use and land maintenance rather than by promotional, exploitive, or political standards.

Also, people will learn that it is easier on machine, horse, and man to farm according to conservation standards than to follow haphazard methods not fitted to the land. Less fuel and time, for example, are required to operate a machine on the level, on the contour, than up and down slopes, and there is less wear on the machine.

The heavy costs of erosion, now running to approximately $3,844,000,000 a year in the United States alone, will be sharply cut.

Farming will become an expert profession; the inexpert and inept will be forced off the land. It is not impossible that the prospective farmer of the future will be required to satisfy society that he is qualified by training and experience to take on the trusteeship of a piece of productive land.

Most important, man will have learned the true value of his most precious natural resource. Tragically, throughout history, the land has been the most neglected.

On this job of safeguarding the land, thousands of farmers, in addition to various local, state, and federal agencies, are vigorously pushing ahead with the work. Each individual so engaged is a part of the biggest job, I think, in engineering and human affairs ever undertaken anywhere.

Do Certain Drinking Waters Favor Dental Caries?

Henry Klein, *Division of Public Health Methods, U. S. Public Health Service, Bethesda, Maryland*

IT IS NOW GENERALLY RECOGNIZED that children who consume drinking waters containing from 1 to 2 ppm of fluoride (F) during the first decade of life have a lower experience with dental caries than do comparable children consuming nonfluoride waters.[1] It is the purpose of the present note to describe findings which suggest that drinking waters may contain deleterious factors which *favor* attack by dental decay.

During the winter and spring of 1946, with the cooperation of Dr. J. M. Wisan, chief of the Division of Dental Health, New Jersey Department of Health, and with the assistance of Dr. John F. Cody, senior assistant dental surgeon, U. S. Public Health Service, a total of more than 3,000 school children were examined in five communities of southern New Jersey. In three of these communities the water supplies contain from 1.4 to 2.2 ppm of fluorine, while the remaining two communities have water supplies which are considered fluorine-free. (The water analyses were made by Dr. Elias Elvove, senior chemist, U. S. Public Health Service.)

Of the approximately 3,000 children, 1,307 were born in localities outside the five communities studied, but had migrated at various ages into the several communities where the examinations were made. Those migrating into the fluorine communities and consuming the fluorine waters continuously since first arrival totaled 882, while those migrating into the nonfluorine communities and consuming the nonfluoride waters continuously totaled 425. What effect do these two types of drinking water have on the caries attack rate of the migrants?

TABLE 1

NUMBER OF DECAYED, MISSING, AND FILLED (DMF) TEETH PER 100 PERSON-YEARS OF AGE FOR MIGRANTS INTO FLUORIDE AND NONFLUORIDE AREAS OF NEW JERSEY*

Age (years) at time of survey	Area in New Jersey	Duration of exposure (years)		
		0–4	5–9	10–14
5–9	Fluoride	8.6	5.5	†
	Nonfluoride	19.3	20.3	†
10–14	Fluoride	36.7	22.2	15.5
	Nonfluoride	37.6	44.3	57.5
15–19	Fluoride	56.6	43.5	33.3
	Nonfluoride	49.6	61.1	70.0

* Data based on observation of 1,307 migrants of both sexes of specified ages and of specified duration of continuous exposure to the city water in the specified areas.

† No observations.

The caries attack rate for the present study is defined as the number of teeth of the permanent (second) dentition showing evidence of past or present attack by dental caries (decayed, missing, or filled) per 100 person-

[1] "Fluorine in Dental Public Health": Symposium-Conference of the New York Institute of Clinical Oral Pathology, October 30, 1944, New York City.