tion of poultry meat products has been outstanding. Turkeys and broilers have reached commercial status as a farm enterprise since 1940. Turkey production per man-hour has increased nearly 350 percent since 1910, and broiler production per man-hour about 400 percent since 1935.

It is impossible to say exactly what will happen in the way of continued improvement of the labor efficiency of livestock production. It seems certain that for some time the trend will continue to concentrate much of the livestock production in what might be considered livestock factories rather than as secondary or even primary enterprises on general farms. That would mean greater efficiency of the labor spent on livestock.

Development and Application

R. L. Green and N. L. LeRay

PEOPLE develop and apply technology in agriculture in a way that reminds us of a slow-motion game of leapfrog, in which the time between advancing leaps is months or years or decades.

Geography fixes somewhat the intervals between jumps because of the stages of producing, processing, and marketing crops. In a broader way, the influences of people's moral codes, labor practices, and ways of life limit their initiative in developing and adapting new techniques.

The acceptance of new ideas, a complicated process, involves a series of thoughts and actions that often extend over considerable periods of time. An example: The average timespan between the time an Iowa farmer learns about hybrid seed corn and the time he accepts it for continued use is 7 years.

George M. Beal and Joe M. Bohlen, of Iowa State University, said the stages in learning about new ideas and adopting them are awareness, interest, evaluation, trial, and adoption.

They classified people on the basis of the sequence in which they adopt or reject new practices as innovators, the first to adopt new ideas; early adopters, those who are among the first to use approved practices in a community, but not the first to try new ideas; the early majority, the ones who must be sure an idea will work before they adopt it; the majority, most of the people in a community who adopt proved methods; and those who do not adopt a new practice even after it has been adopted by most neighbors.

Age, education, social-economic status, and activities in progressive organizations are among the factors that influence the sequence. The more education a farmer has, the greater the likelihood that he will adopt new ideas. Younger farmers are more favorable toward new ideas than older ones. Farmers who belong to farm organizations and cooperatives often are early adopters of new practices.

The differences that make for uneven development and application of technological advances for a commodity include:

Variations in the topography, soils, and climate in areas of production.

Variations in the cultural requirements of crops.

Variations of different production stages in susceptibility to technological advance.

Variations between adapted varieties throughout the area of production.

Variations in the economic feasibility of technological change within the area of production. Feasibility is often determined by ultimate form of a commodity for consumption and the availability and cost of labor.

Variations in the culture of people working with a commodity.

Variations in the prior combina-

tions of these factors, as reflected in present development and adaptation of technological advances. As long as labor is available and cheap, technological change seldom occurs.

Differences exist even in specific operations in the same section, and they in turn affect other enterprises. Some growers of snap beans, for example, have reduced their labor requirements by adopting a mechanical harvester, while others still harvest beans by hand. The reduction in labor required by bean growers in New York by the use of mechanical beanpickers reduced the demand for migrant labor in the community to the point that orchardists found it hard to get workers for harvesting cherries.

The same problem developed in northern Colorado, where increased mechanization cut the need for seasonal workers for sugar beets in spring. The sugar companies recruited fewer workers from southern Texas. Producers of beans, cherries, and other crops in northern Colorado subsequently had labor shortages. They lacked the organization and funds for a recruitment program of their own and could offer workers only short periods of employment.

Cotton is an example of leapfrogging in crop production. Before the invention of the cotton gin, production of cotton was limited by the capacity of hand labor to separate the seed from the fiber. After adoption of the gin, the production was limited by the availability of labor to harvest the crop in a relatively short time to avoid weather damage. Many inventors tried to develop a mechanical harvester, but none was satisfactory until plant breeders developed varieties adapted to mechanical harvesting. Mechanical cotton harvesters since have become quite common. Now considerable time and effort are being expended to develop chemical and mechanical ways to control weeds in cotton fields.

Mechanical harvesters contributed to the shift of cotton production from the Southeast toward the Southwest. The Southern Piedmont, where cotton was king, is a region of rolling countryside and fields separated by water courses and steep slopes. Fields therefore are small—a point of little consequence when the crop was planted and cultivated with horse- or mule-drawn equipment and harvested by hand, but it is not efficient to grow cotton on small fields with plows and cultivators drawn by tractors. The mechanical cotton harvester contributed to an increase in the size of fields and hastened the discontinuation of the cotton enterprise on small farms.

Much of the rolling Piedmont, which once was covered with small fields of cotton, is now planted to grain, hay, and pasture to support livestock enterprises. In some places broilers have become king.

In the Southwest, on the other hand, sections once too dry for cotton are being irrigated, and the air is filled with sounds of the mechanical cotton harvester. Topography, climate, and availability of labor limited the rate of technological advance. In parts of the Southwest there is insufficient labor to handpick cotton, but the expansion of cotton acreage no longer is prohibited in labor-deficit areas by the cost of importing labor for picking cotton.

The mechanical harvester eliminated availability of labor for picking cotton as the limiting factor. Except for acreage allocations, the limiting production factor now is the labor required to thin the crop and control weeds.

This illustration should establish the fact that technological change usually is the result of a shortage of labor; it does not always displace labor. Another aspect is that industrialization of the Southeast has attracted labor from the farms and so has contributed also to the decline of cotton in the Piedmont.

Corn and small grains respond at all stages of production to the applications of technology and better practices. The labor required per acre of corn grown in the United States dropped from 32 man-hours an acre

in 1920–1924 to 25 in 1940–1944 and to 10 in 1955–1958. The average production in those periods was 27, 32, and 46 bushels an acre, respectively. The combination of increased yields and fewer man-hours per acre meant an overall decline from 119 to 23 man-hours per 100 bushels of corn between 1920 and 1958.

The average number of man-hours per milk cow in the United States declined from 142 in 1920–1924 and 1940–1944 to 116 in 1955–1958. Milk production per cow averaged 4,000, 4,653, and 6,071 pounds, respectively, in those periods, and man-hours per hundredweight of milk declined from 3.6 in 1920–1924 to 1.9 in 1955–1958.

THUS we can produce more with less labor.

The decline in labor requirements has permitted farmers to operate larger enterprises. At the same time, investments in land, machinery, and equipment have grown. The average value of assets per farm—land, service buildings, livestock, machinery, equipment, crops held for feed, and demand deposits used for production—increased from 6,094 dollars in 1940 to 33,455 dollars in 1959.

The changes created a need for skilled operators of great managerial ability. A few years ago a sharecropper with little education could earn a subsistence living from a one-horse-crop. Today skill in operating machinery plus ability to manage a business are necessary to pay the higher fixed operating costs and to provide a living wage even for the tenant farmer.

Almost every engineering advance has brought problems that become alternate factors that for a time control production.

The adaptation of the combine for harvesting rice illustrates this shifting of controls. Rice previously was harvested with a binder, shocked, and left in the field until dry enough for storage before it was threshed. In Arkansas it was found that the optimum moisture content of rice for mechanical harvesting is about 25 percent, but the moisture content must be below 15 percent for storage. The general use of combines was not practical until drying techniques, equipment, and facilities were designed, tested, and made commercially available. The transition from binder-thresher operation to combine harvesting extended over several years.

The gains in labor efficiency because of the adoption of new technology have meant a great gain in the number of people one farmworker can supply with food. Approximately 90 percent of the farm products marketed in 1960 could be produced on about 40 percent of the farms because of the new technology and the use of much seasonal agricultural labor.

TECHNOLOGICAL change and its social and economic effects cannot be disassociated from Government programs. The need for new technology and its adoption often are related closely to agricultural programs. The problems that are met by one change often are intensified by the other. For example, any technology that increases productivity of a surplus commodity will increase oversupplies unless there is a corresponding increase in domestic or foreign consumption or a reduction in acreages or number of units produced.

The benefits of new technology in agriculture have not been distributed evenly among all segments of rural society. The uneven development and adoption of technological advances in agriculture have resulted in many serious social, political, and economic problems.

Some of the effects of the adoption of technological advances can be measured with relative ease.

It is easy to determine the difference in labor requirements in machine-picking and handpicking an acre of green beans and to determine the amount of labor required to plant an acre of corn with one-row, mule-drawn equipment and with four-row tractor equipment.

It is more difficult to determine the amount and effects of the displacement of farmworkers and families.

Most of the labor rendered surplus by technological advances has found employment in industry. Some workers may join the ranks of migratory agricultural laborers during the periods of peak seasonal labor demand. Others may join the ranks of the unemployed and add to existing social and economic problems or create new problems.

Technological advances have intensified the effects of the seasonal nature of some farm enterprises. Many farmers who can meet the labor requirements of land preparation, planting, and fertilizing with family labor and small amounts of hired labor require large numbers of seasonal workers to perform specialized activities that have not become highly mechanized. Large numbers of seasonal workers therefore are needed to perform remaining seasonal tasks, such as harvesting fruit, thinning beets, and chopping cotton.

According to reports of the Bureau of Employment Security for major agricultural areas, about 1,403 thousand seasonal agricultural workers were employed in the peak month of September 1959 and only 321 thousand in February.

Migratory farmworkers are needed because the peak labor requirements for many crops cannot be supplied from local sources. This need is being met by approximately 400 thousand domestic migratory farmworkers, accompanied by about 150 thousand dependents, and by about 450 thousand workers from Mexico, the British West Indies, Canada, and Japan.

The seasonal nature of labor requirements in the San Joaquin Valley further illustrates the effect of uneven technological advances on the need for seasonal workers. In the fertile, irrigated San Joaquin Valley, which includes parts of six counties in south-central California, cotton, grapes, peaches, apricots, potatoes, oranges, figs, and olives are grown.

The number of farmworkers needed there is about 10 thousand in March and more than 100 thousand in October. Grapes in Fresno County usually are harvested between August and the end of October, and in 1958 required about 35 thousand hands at the peak of the harvest season, but almost none from the middle of March to the middle of May. The extra workers came from Mexico, Texas, New Mexico, Arizona, southern California, and other places to harvest the raisin, table, and wine grapes.

The main areas and crops that have high peak seasonal labor requirements are California, for cotton, grapes, tomatoes, potatoes, peaches, pears, apricots, citrus fruit, and miscellaneous crops; the Lower Rio Grande Valley, for citrus fruit, cotton, tomatoes, corn, and miscellaneous vegetables; the cotton areas of Texas, New Mexico, Arizona, and the Mississippi Delta; the Atlantic coast fruit and vegetable areas; the fruit, vegetable, and sugar beet sections of Michigan; and the Northwestern States, for apples, pears, cherries, peaches, sugar beets, and other fruit and vegetables.

The migratory farmworker meets the need of the employer of seasonal farm labor by being available when required for farmwork. He also meets the requirement of the farmer's community by leaving when no work is available. Thus the migratory agricultural worker does not present a major social problem for the farmer or the farmer's community.

The migrants, however, have problems of poor housing, low incomes, and the care and schooling of children.

The rate of turnover among migratory farmworkers is high. Large numbers drop out of the migrant labor force each year and are replaced by new workers. The reasons they give for leaving include steady jobs elsewhere, the low wages, and family and health problems.

Some migrants intermittently enter and leave the migrant streams. Others become established in nonfarm work.

The worker with education and training finds it relatively easy in an expanding economy to leave migratory work and to become established elsewhere. The migrant with little education or nonagricultural skills has little chance but to follow the crops. His lack of training for nonfarm work, lack of resources, and lack of management ability condemn him to his lot. Concerted efforts of public and private agencies and groups are needed to prepare this type of worker for nonfarm work or for employment in mechanized agriculture.

Many operators of small farms have not been able to adjust to the new technology or benefit from Government agricultural programs. As a result, there are areas of low-income farmers and low-income farms in good farming areas. Improved off-farm technology and communications have created a desire for an improvement in level of living, but opportunities for such improvement have not become available.

Other operators of small farms have become part-time farmers who may regard their nonfarm jobs as temporary activities and plan to become full-time farm operators as soon as they can accumulate additional capital. Others consider part-time farming as a transitional step from full-time farm operation to full-time nonfarm work and will leave the farm when they acquire the skills necessary for a well-paying nonfarm job. For others the combination of farm and nonfarm work is a permanent way of life.

A report, "Development of Agricultural Human Resources" issued in 1955 by the Department of Agriculture, summarized the situation of many of approximately 1.5 million low-income farm families: "What they are up against in innumerable cases is lack of enough good land, lack of equipment, lack of credit facilities, and often lack of the management information and skill which might open wider opportunity to them."

Thus the central problem of low-income farm families is lack of resources and lack of opportunity.

The social-economic problems faced by many rural people are not entirely a product of technological advance in agriculture. In the past the surplus farm population was needed by nonfarm sectors of the economy. In many nonfarm sectors of the Nation, however, production has increased at a higher rate than employment because of mechanization. New jobs for unskilled labor were not readily available in 1960 for surplus farm or nonfarm populations as in the past.

UNEVEN DEVELOPMENT and application of technology in agriculture will continue the motions of leapfrog.

Production factors peculiar to a crop or geographical area will accelerate development and application of technology segment by segment. Intermittently field production capacity will exceed harvesting capabilities, harvesting capabilities will exceed storage or processing facilities, labor requirements will be unequal to available labor, and market demands will be different from supplies. Development and advancement are regulated by the inevitable laws of supply and demand; improvements in one area tend to create a train of events which will leave behind or overrun segments incapable of an accelerated pace.

Economic checks and balances may be expected to maintain a long-range equality of development and application of technology between various phases of agriculture for maximum benefit to all segments of the American economy.

IN SUMMARY: The social-economic problems that many rural people face are not entirely a product of technologic advances in agriculture. In many nonfarm sectors, production has increased at a higher rate than employment because of mechanization. Methods of solving the future problems of adjustment are available in our national capacity to produce wealth.