LOSSES IN AGRICULTURE

Agriculture Handbook No. 291

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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Agricultural Research Service

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Errata for Agriculture Handbook No. 291

"Losses in Agriculture"

Page 5: The second line of footnote 1, table 2, should read "--- the loss in quantity and value are based on the quantity and average prices ---"

The seventh line of footnote 2, table 2, should read "--- would be available for additional production with no ---"

Page 120: In the second column of table 59, the fourth entry should be 3,812,406 instead of 3,312,906 and the first total should be 14,771,687 instead of 14,272,187.

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PERSONNEL INVOLVED IN PREPARATION OF THIS HANDBOOK

This handbook was prepared under the general guidance of a committee appointed by the Administrator of the Agricultural Research Service in 1962. The committee included representatives of agencies concerned with losses in agriculture. The members were:

H. R. Adams, Soil Conservation Service
M. E. Bailey, Statistical Reporting Service
C. E. Burkhead, Statistical Reporting Service
H. T. Cook, C. D. Van Houweling, and R. J. Anderson, Agricultural Research Service
James Vermeer, Economic Research Service
R. C. Wilson, Forest Service
E. L. LeClerg, Agricultural Research Service, *chairman*

A working group (coordinators), consisting of representatives from each of the agencies, assisted the chairman of the committee in the details of securing the estimates of losses and text material. The members were:

Agricultural Research Service

Proctor Campbell, Utilization Research and Development Division
Walter M. Carleton, Agricultural Engineering Research Division
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The chairman was responsible for calculating losses in quantity and value for each kind of loss reported. In addition, he assembled the various tables and reviewed the text material submitted by the various agencies in support of their estimates.

FOREWORD

The Department of Agriculture from time to time receives requests for information on the losses incurred in the production, processing, transportation, and marketing of farm and forest products. To answer these requests, the Department issued in June 1954, ARS-20-1, "Losses in Agriculture: A Preliminary Appraisal for Review." Estimates in that publication, which for the most part represented average annual losses for the period 1942-51, have been reviewed and brought up to date for this handbook.

The estimates in this handbook are based on average prices for the period 1951-60. Some of the estimates are based on surveys or actual records; most, however, represent the best judgment of Department specialists.

Dollar values were placed on the losses because the monetary value of the losses is the only common measure that could be used. The dollar values represent losses to the public — not to farmers. No consideration was given to lower prices that might have resulted from the larger volume of products that would have been available had these losses not occurred.

The higher estimates for losses in this bulletin, as compared with those in the previous report, are the result of several factors including (1) higher prices for farm products; (2) greater volume of production and, therefore, greater opportunity for losses; (3) larger number of losses reported; and (4) a better basis for estimating losses.

George W. Irving, Jr., Administrator
Agricultural Research Service

PRECAUTIONS

Pesticides are poisonous to man and animals. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the labels.

Keep pesticides in closed, well-labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and pets cannot reach them.

Avoid repeated or prolonged contact of pesticide with your skin. Avoid spilling it on your skin, and keep it out of your eyes, nose, and mouth. If you spill any on your skin, wash it off with soap and water.

After handling a pesticide, do not eat or smoke until you have washed you hands and face. Wash your hands and face immediately after applying pesticide.

When handling pesticides, wear clean, dry clothing. If you spill pesticide on your clothing, launder the clothing before wearing it again.

Do not inhale pesticide dusts or mists.

To protect fish and wildlife, do not contaminate lakes, streams, or ponds with pesticide. Do not clean spraying equipment or dump excess spray material near such water.

To minimize losses of honey bees and other pollinating insects, apply insecticide, when possible, during hours when the insects are not visiting the plants. Avoid drift of insecticide into bee yards.

Also avoid drift of pesticide to nearby crops or livestock.

Empty containers are particularly hazardous. Burn empty bags and cardboard containers in the open or bury them. Crush and bury bottles or cans.

CONTENTS

	Page
Chapter 1.—Introduction	1
Economic effects of losses	1
Procedures	1
Meaning of estimates	2
Chapter 2.—Diseases of crop and ornamental plants	3
Field crops	4
Alfalfa and all other hay plants	14
Forage plants grown for seed	15
Pasture and rangeland plants	16
Fruit and nut crops	17
Vegetable crops	23
Ornamental plants and shade trees	31
Crop losses from air pollutants	34
Chapter 3.—Nematode damage to crop plants	36
Field and forage crops	36
Fruit crops	38
Vegetable crops	38
Chapter 4.—Injurious crop insects	40
Field crops	41
Forage and seed crops and rangelands	45
Turf	46
Fruit and nut crops	46
Vegetable crops	49
Landscape flowers and ornamentals	53
Horticultural specialties	53
Loss to honey bee industry	54
Chapter 5.—Weeds	55
Field crops	55
Forage-seed and grazing crops	58
Fruit and nut crops	60
Vegetable crops	62
Chapter 6.—Inefficient farm operations and fire	66
Excessive pesticide application	66
Improper fertilizer placement	66
Improper planting	66
Improper root pruning	66
Chapter 7.—Harvesting and storage losses	67
Harvesting losses	67
Storage losses	69
Chapter 8.—Livestock and poultry losses	72
Infectious diseases	72
Noninfectious diseases and nutritional disorders	72
Internal parasites of livestock and poultry	78
Insect pests of livestock and poultry	81
Chapter 9.—Marketing and processing losses	85
Marketing fruits and vegetables	85
Fruits and vegetables in retail stores	89
Processing crops	89
Marketing and processing poultry and poultry products	93
Meat and poultry condemnations	94
Chapter 10.—Forest resources and forest products losses	95
Fire losses	95
Insect losses	95
Disease losses	97
Other losses	97
Chapter 11.—Soil and water losses	98
Erosion, water, and unfavorable soil conditions	98
Weeds in aquatic and noncrop areas	103
Chapter 12.—Cost of controlling losses and of inspection and quarantine services	105
Animal-disease eradication programs	105
Animal inspection and quarantine programs	106
Cooperative plant pest control programs	107
Controlling erosion in 17 Western States	107
Controlling fire, insects, and disease in forests	108
Controlling insects affecting crops, man, animals, and households	109
Controlling insects in stored products	109
Controlling nematodes	110
Controlling plant diseases	110
Plant quarantine and regulatory measures	111
Controlling weeds	111
Chapter 13.—Summary	119

LOSSES IN AGRICULTURE

Chapter 1.—Introduction

Losses in agriculture are of two types: (1) reduction in quantity or quality during production, handling, and processing of farm and forest products; and (2) deterioration in land that affects production immediately or over a period of years. Another source of loss represents the labor and materials required to control such factors as pests, soil erosion, and water loss.

This handbook provides information on the extent of some of these losses. It does not include losses in production and productive efficiency caused by differences in the utilization of the land, such as growing less productive crops than might have been grown, or avoiding a crop because of possible loss from some pest. It does, however, include estimates of losses resulting from failure to use recommended production practices or techniques.

Information on losses can be used in planning and administering agricultural research and control programs. Certain kinds of loss data can be used to direct extension activities to problems of greatest economic importance. In addition, information on sources of losses is of value to farmers, processors, and marketers of agricultural products. Manufacturers and distributors of agricultural chemicals base their programs, in part at least, on losses in crop commodities and livestock and poultry.

ECONOMIC EFFECTS OF LOSSES

Losses in agricultural production have two kinds of economic effects: (1) they increase the cost of production; and (2) they reduce the quantity and, in some instances, the quality of products available to consumers. From another viewpoint, consumer needs could be more fully satisfied and better nutrition provided with the same resources and expenditures if the causes of loss were not present.

The possibility of profitably reducing or eliminating agricultural losses is influenced by technological developments. Technological developments may affect either the cost of production or the value of the product. The discovery of more effective or lower cost agricultural chemicals and of more efficient methods of application, for example, may make possible either larger production of higher quality goods at little or no increase in cost to farmers or the same production with the use of fewer resources and at a lower cost. On the other hand, the discovery of new or improved uses for products may increase their total value with little or no change in resources used or in production costs.

Some methods of reducing or eliminating losses may not increase operating costs. For example, while development of a more effective agricultural chemical may require substantial funds for research, the new chemical may be no more expensive to manufacture and apply than those previously used.

Some losses may be difficult to reduce or eliminate. For example, it may be impossible to find ways of completely eliminating losses to crops and livestock caused by some pests. And, even if it were possible, the cost of control might be high in relation to the increase in quantity or quality of the product.

PROCEDURES

Nature of estimates

Estimates of losses are included in this handbook, whether or not they arise from causes that are preventable with present technical knowledge. However, complete estimates of all losses could not be obtained. The loss estimates are limited to the more economically important factors.

Computation of losses

The losses during production of crops and animals are expressed as annual production lost in terms of (1) quantity and (2) value. Estimates of losses in quantity (bushels, tons, etc.) indicate the extent to which national production of each product would have increased had the cause of the loss been eliminated. Estimates of losses in value are based on average prices received by farmers. Estimates of losses in quality are included in estimates of losses in value.

The losses shown in the tables are based in most instances on national annual averages, chiefly for 1951–60. Because of wide variations in some kinds of losses from year to year, it was considered desirable to use an average for the 10 years rather than data for a single year. In some instances, lack of information on which to base estimates for the 10-year period made it necessary to use a shorter and more recent period. These data are footnoted in the tables.

Losses were computed as follows:

Losses During Production. — Percentage losses from potential production were estimated for losses to crops caused by insects, diseases, nematodes, and weeds; and during harvesting operations; and for losses to livestock and poultry caused by insects and diseases. The procedure used is a modification of that reported in the Plant Disease Reporter.[1] Since more than one causal factor may affect a crop or an animal species at the same time, an average potential was estimated assuming all known losses were eliminated. The loss caused by each factor was then taken as the product of the average potential and the estimated percentage loss.

Estimates of losses in quality of commodities produced (crops and farm animals) are included in the computation of losses in value.

Losses Following Production. — Losses to crops and other commodities in storage on farms, in transit, during processing, and in marketing channels were also measured in terms of quantity, quality, and value lost. However, the appropriate quantities and values were multiplied directly by the estimated loss percentages to obtain the two measures of average annual losses.

How estimates were obtained

Estimates of losses were based on surveys and records where possible. However, surveys and records were not available for many losses, and estimates are based on judgment of specialists in the different natural science fields. But even the information that these specialists had available was limited; consequently, the accuracy or reliability of the estimates differs greatly.

Each member of the working group assembled the estimates obtained from specialists within his agency. Most of the estimates are applicable to national data on production and resources.

Adding percentage loss estimates from different causes affecting the same product so as to avoid duplication or overestimating presented a special problem. It was assumed that percentage loss estimates could be added when they were low and from closely related causes, such as diseases affecting the same crop.

The Statistical Reporting Service supplied most of the data on quantity and farm value of production and other basic data to which percentage loss estimates were applied to obtain national estimates of losses.

MEANING OF ESTIMATES

In interpreting the estimates of losses in this handbook, it is essential to recognize the assumptions on which they are based.

The estimates indicate not only preventable reductions in production but also, in some cases, those not avoidable with present technical knowledge.

The estimates evaluate the annual production at the prevailing average farm prices from 1951 to 1960. This does not necessarily mean that the farmers' cash income would have been increased to that extent if the losses had not been incurred. Increased supplies generally decrease prices sufficiently so that total farm income from a large crop may be smaller than from a small one, unless demand for the product increases simultaneously. The losses given must, therefore, be interpreted as losses to the public rather than to farmers.

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[1] CHESTER, K. STARR. PLANT DISEASE LOSSES: THEIR APPRAISAL AND INTERPRETATION. U.S. Dept. Agr., Agr. Res. Serv. Plant Disease Reporter, Supplement 193 (1950): 191-362.

Chapter 2.—Diseases of Crop and Ornamental Plants[1]

Plant diseases are commonly defined by plant pathologists as deviations from normal growth or structure of the plants. Diseases may be due to pathogens or parasites (fungi, bacteria, viruses, nematodes,[2] and higher plants) or to nonparasitic causes (weather, nutritional deficiencies or excesses, and toxic substances including air pollutants).

The interrelation of weather, diseases, insects, and nematodes in causing plant losses makes it difficult to assign losses accurately to one cause or the other. For example, the poor growth associated with yellowing of the leaves of barley and other cereals was formerly believed to be due to excessive soil water, drought, storage of nitrogen, or low-temperature injury. Now barley yellow dwarf virus, transmitted by several species of aphids, is known to be responsible for much of this type of damage. The virus overseasons on certain perennial grasses and volunteer and fall-planted cereal plants. The severity of the outbreak the next crop season depends on the size of the population of infectious aphids, which in turn depends largely on winter weather.

Some pathogens are disseminated by wind and rain, and for entry need moisture on the plant. Certain root diseases occur only when soil moisture is abnormally high. Weeds may provide conditions favorable for high relative humidity in the microclimate about the plant and thus aid in the development of such diseases as late blight of tomato and potato.

Diseases may affect any part of a plant (roots, stems, leaves, flowers, fruit) at any stage in its development (seed, seedling, mature plant). Diseases reduce yields (from 2 percent in tung to 52 percent in lupines) and also quality of certain crops. Diseased grains may be lightweight, discolored, and shriveled. Disease-induced poor coloration, blemishes, or rots of fruits and vegetable crops reduce their grade. Most consumers are familiar with the browning and internal discoloration found frequently in lettuce, potatoes, and sweetpotatoes. The oil content of peanuts, safflower, and soybeans may be lowered by diseases in the crop plants. Viruses may cause undesirable mottling of blossoms such as gladiolus and tulip. City dwellers have seen elms and oaks gradually disappear because of Dutch elm disease, phloem necrosis, and oak wilt.

Diseases prevent growing of certain crops in many sections. For example, tomatoes are not grown in many areas of the West because they become infected by an insect-transmitted virus that causes curly top. The bacterial disease fireblight prevents successful growing of high-quality pears in Eastern United States. Most seed crops are now produced in the arid West to avoid losses from diseases favored by rains during the growing season. Mint production has been moved from one area to another to avoid damage from verticillium wilt, caused by a fungus in the soil.

Diseases affect dependability of yield. Disease losses in a particular crop vary greatly from year to year, as illustrated by the losses caused by cereal rusts. Outbreaks of these diseases depend on the supply of rust inoculum in Southern United States and Mexico, upper air circulation to move large quantities of spores great distances, the prevailing weather, stage of plant development when the spores are deposited, and finally resistance to the races of rust prevalent in any season. In 1935, losses from stem rust were estimated at 100 million bushels of spring wheat worth approximately 50 million dollars, and there was another epidemic in 1937. Another serious one, however, did not occur until the 1950's when race 15B of stem rust first became prevalent. Because of severity of damage by this race, 75 percent of the durum and 25 percent of the hard red spring wheat acreage was lost in 1953 and 1954.

Certain diseases of plants can produce illness and death of persons and animals that eat affected products. In humid areas scabby grain may be toxic to hogs. The sclerotia of the ergot-producing fungus, which attacks the flowers of cereals and grasses, contain alkaloids that can produce convulsions and even kill animals and human beings. Ergot, however, can be beneficial for it has medicinal use, particularly in childbirth.

Disease losses affect not only the farmer but also the consumer. When diseases limit production and result in a short crop, prices usually increase. Many diseases are effectively controlled at great expense by application of chemicals. The added cost of production is re-

[1] Loss estimates for diseases transmitted by insects are included in this chapter instead of chapter 4.

[2] See chapter 3.

flected in higher prices. Reducing disease losses not only will enable the farmer to lower his production costs but will enable him to produce the food necessary in the future when the rapidly expanding U.S. population will require maximum yields on limited acreages of cropland.

The estimated average annual loss in potential value caused by plant diseases during production of crop groups and the cost of controlling plant diseases are presented in table 1.

TABLE 1.—*Estimated average annual losses in value caused by plant diseases and air pollution to various groups of crops during production and cost of controlling diseases, 1951–60*

Crop group	Average annual loss
	1,000 dollars
Field crops	1,890,836
Alfalfa and all other hay plants	614,766
Forage seed crops	23,584
Pasture and range plants	193,935
Fruit and nut crops	223,505
Vegetable crops	290,389
Ornamental plants and shade trees	14,099
All crops: Loss from air pollutants	325,000
Total	3,576,114
Cost of controlling diseases	115,800
Grand total	3,691,914

In this chapter losses attributable to pathogens such as bacteria, fungi, and viruses are emphasized; but occasional estimates of losses from diseases not caused by pathogens are included. Most of the losses from diseases are grouped by type of crop: field crops, alfalfa and all other hay plants, forage plants grown for seed, pasture and rangeland plants, fruit and nut crops, vegetable crops, and ornamental crops and shade trees. Losses are included for each crop in the various groups. Also included in this chapter is a section on crop losses caused by air pollutants.

FIELD CROPS

Estimated disease losses for 23 field crops for the period 1951-60 appear in table 2. The average annual losses to field crops caused by these diseases were estimated to be $1,890,836,000.

Barley

Annual losses in barley resulting from diseases caused by various plant pathogens during the period 1951–60 averaged 14 percent. Most diseases caused about the same reductions in yield each year.

Several items are not included in the estimated losses from diseases. The area in which barley is produced in the United States has moved north and west, partly because corn hybrids adapted to the areas where barley was formerly produced have been developed. The helminthosporium and scab diseases, which cause little damage to corn, have become so prevalent and severe on barley in those areas that it is no longer economical to produce barley. In some areas of Southern United States, barley cannot be produced because of root rots and leaf blights.

Most reduction in production was caused by two virus diseases: barley stripe mosaic and barley yellow dwarf. The barley stripe mosaic virus is transmitted through the seed and by contact of healthy plants with those harboring the virus. For many years this disease was referred to as false stripe. It reduced the yield in many commercial fields by 15 to 20 percent in the area where malting barley was produced. Since the quality of the grain was normal and at harvesttime the disease symptoms were not evident, growers were not aware of this loss.

The helminthosporium diseases are present in most areas where barley is grown. They are most severe in the warmer humid climates. *Fusarium*, or scab fungi, and species of *Helminthosporium* cause kernel blights that decrease the quality of malting barley.

The septoria leaf blotch has become very severe on malting barleys produced in the Red River Valley of North Dakota and Minnesota. It has caused only a small reduction in yield but has resulted in a much higher percentage of thin kernels. The thin kernels decrease the value of the crop since they increase the cost of producing malt.

Loose and other smut fungi cause losses in most areas where barley is produced.

Estimated average annual losses by specific barley diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Stripe mosaic	3.2
Root rots	2.8
Helminthosporium diseases	2.6
Yellow dwarf	1.6
Fusarium blight, or scab	.9
Loose smut	.9
Septoria leaf blotch	.8
Powdery mildew	.5
Rhynchosporium scald	.5
Others	.2
Total	14.0

TABLE 2.—FIELD CROPS: *Estimated average annual losses due to diseases, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Barley	Bushel	14	56,496	55,403
Beans, dry	Hundredweight	17	3,423	[3] 24,934
Castorbeans	Pound	11	3,369	184
Corn	Bushel	12	413,051	527,285
Cotton	Bale	12	1,859	300,920
Flax (seed)	Bushel	10	3,757	11,603
Hops	Pound	13	7,055	3,318
Mint [4]	do	10	406	1,474
Oats	Bushel	21	299,284	198,417
Peanuts	Pound	28	499,744	53,716
Peas, dry	Hundredweight	14	535	2,404
Rice	do	7	3,874	18,799
Rye	Bushel	3	801	928
Safflower	Ton	12	16,345	615
Sesame	Pound	11	[5] 940	[5] 121
Sorghum:				
Grain	Bushel	9	33,866	34,072
Silage and forage [6]	Ton	9	1,493	8,550
Sweet	Gallon	15	463	987
Soybeans	Bushel	14	64,251	142,835
Sugarbeets	Ton	16	2,420	27,254
Sugarcane	do	23	1,906	13,521
Tobacco	Pound	11	243,399	132,203
Wheat	Bushel	14	173,911	331,293
Total				1,890,836

[1] So far as possible, the basic data used to calculate the loss in quantity and value represent the averages for the period 1951–60 as estimated by the Statistical Reporting Service. Where data were not available, best approximations were used.

[2] Estimate is based on full production with the causes eliminated. These percentages were applied to the data of actual farm production to obtain estimates of loss of farm production in terms of quantity and value. Loss in quality is included in the loss in value. Value loss is computed upon the assumption that market outlets would be available for reduced production with no change from average farm prices. See chapter 1 for more detailed explanation of procedure.

[3] Includes blackeyes and garbanzos in California in addition to ordinary edible beans and beans grown for seed.

[4] Peppermint and spearmint.

[5] Basic data are from the 1959 Census of Agriculture.

[6] See discussion under sorghum, grain and sweet.

Beans, dry (including seed beans, blackeyes, and dry limas)

Losses in dry beans and seed beans result chiefly from root rots caused by several fungi, including *Fusarium, Rhizoctonia,* and *Sclerotinia.* In some years the bacterial blights cause severe injury in Colorado, Michigan, Nebraska, and Wyoming. Two virus diseases—New York 15 strain of common mosaic and bean yellow mosaic—cause considerable damage in some years, especially in central Washington.

Curly top is found only in States west of the Continental Divide. The causal virus is transmitted by a single species of leafhopper and it occurs only where this insect occurs. In some areas where the vectors are prevalent, such as southern Idaho, eastern Oregon, and central Washington, curly top prevents the production of susceptible varieties.

In southern Idaho, bacterial blights are normally of little consequence and anthracnose never occurs because of low rainfall. Therefore, much of the seed of dry beans and about 85 percent of all the seed beans used in the United States are produced here. As a result of using blight- and anthracnose-free seed, these diseases have become of minor importance in the United States.

The average annual increase in disease losses in the period 1951–60 (17 percent) as contrasted with losses in the previous 10-year period (11.5 percent) is due to the spread of sclerotinia wilt and fusarium root rot into new areas for these diseases. Since 1948–49, losses from sclerotinia wilt have increased considerably. Beans are now planted 20 or 22 inches apart in the rows, whereas earlier they were planted 28 inches apart. Close planting creates conditions of high relative humidity, which are ideal for the development and spread of the causal fungus. This was not the case when beans were planted 28 inches apart, and losses from sclerotinia wilt were much less.

Between 1953 and 1960, bean acreage increased considerably in the Columbia Basin of central Washington, where the soils have very low humus contents. Bean root-rotting organisms in such soils develop very rapidly because of lack of competition from nonparasitic organisms that are present in large numbers in soils with higher humus contents. Losses from fusarium root rot have increased in this area, especially in fields where good methods of crop rotation are not practiced.

Losses in dry lima beans, blackeyes, and garbanzos are caused chiefly by the root rots that affect dry and seed beans.

Estimated average annual losses caused by various bean diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Fusarium root rot	4.5
Sclerotinia wilt	3.5
Bacterial blights	2.0
Rhizoctonia root rot	2.0
Anthracnose	1.0
Bean yellow mosaic	1.0
Common bean mosaic	1.0
Curly top	1.0
Rust	1.0
Total	17.0

Castorbeans

The most destructive diseases of castorbeans are alternaria leaf spot and capsule molds. Each type of disease causes estimated annual losses of 5 percent. Alternaria leaf spot was particularly bad on the High Plains of Texas in 1952, 1959, and 1960, when losses were severe. Most of the acreage in 1961 was planted to resistant varieties, but losses on the susceptible variety B296 amounted to 50 percent in some fields. Capsule molds caused by *Alternaria* and *Botrytis* were particularly destructive in 1951 and 1958. Seedling diseases caused average annual losses of 1 percent. Capsule drop has been particularly bad in experimental plantings in the humid areas east of Texas. Some varieties in Mississippi have dropped up to 70 percent of their capsules before maturity.

Corn

Corn production in the United States is reduced each year by diseases. More than 25 diseases occur to some extent on corn; they attack the plant in various stages of growth. Leaves, stalks, ears, and roots may be affected. Not all diseases are found in all of the corn-growing areas.

Many corn diseases appear only sporadically, but sometimes losses in individual fields may exceed 30 percent. Generally, losses are due to lowered grain quality, decreased value of fodder, and decreased yield. Annual losses in the period 1951–60 averaged about 12 percent.

Stalk rots comprise the group that causes the greatest disease losses in corn. The two major stalk rots are diploida stalk rot, which is most destructive in the Corn Belt, and gibberella stalk rot, which is widely distributed but causes most of its damage in the northern and eastern parts of the United States. Sometimes associated with stalk rots are ear rots, some of which are caused by the fungi that attack stalks. Ear losses also may occur during mechanical harvesting when plants weakened by stalk rots fall to the ground. Severe epidemics of ear rots are limited to localized areas and are less important economically than stalk rots.

Two major leaf diseases of corn are known as the helminthosporium blights (northern leaf blight and southern leaf blight). Northern leaf blight is more widespread and causes more losses than southern leaf blight. Northern leaf blight may occasionally become severe locally, and losses that exceed 30 percent have been observed in scattered fields when the disease has become well established 2 or 3 weeks after silking. It has been increasing in the northern part of the Corn Belt. Southern leaf blight is more severe in the Southern States.

Stewart's leaf blight of corn, a bacterial disease, generally appears rather late in the season but can become severe in some years. It has increased in some areas in the central part of the United States, especially after mild winters.

Smut causes little damage in corn, although it is widespread. It is most prevalent in dry areas; and when the disease appears in a field around silking time, it may become severe. The heaviest damage occurs when ears become infected. In 1956, smut was unusually heavy.

Because of the use of improved hybrids and high-quality seed treated with fungicides, seedling blights are becoming less destructive.

Sometimes the minor diseases of corn may become severe in localized areas. Sporadic epidemics cause the greatest losses.

Estimated average annual losses caused by specific corn diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Stalk rots (fungus)	3.0
Helminthosporium leaf blights	2.3
Seedling blights	1.6
Root rots	1.3
Ear rots	1.2
Smut	.7
Bacterial leaf blight	.5
Physoderma brown spot	.2
Others	1.2
Total	12.0

Cotton

The pattern of cotton disease losses is constantly changing across the Cotton Belt. The changes are due to differences in environment from year to year, changed cultural practices, increased fertilization, and use of excessive irrigation water. For instance, losses from verticillium wilt in California are becoming less severe as the result of use of tolerant varieties. On the other hand, verticillium wilt is becoming very damaging in western Oklahoma and the High Plains of Texas, largely because most of the area is now being irrigated and heavy applications of nitrogen are used.

During the period 1951–60, annual losses from all diseases averaged 12 percent. Prevention of these losses would not necessarily increase overall cotton production, but it would provide an opportunity for improving the lot of cotton farmers by increasing efficiency of production with a correspondingly greater return per unit produced.

Seedling diseases are caused by a complex of seedborne and soilborne organisms. Losses occur across the entire Cotton Belt but are greatest in the Southeast where, on the average, seed quality is rather low. Research has shown that low-quality planting seed is affected more by adverse conditions after planting than is high-quality seed, and it is also more susceptible to the seedling disease complex. Seedling diseases still account for about 20 percent of the annual disease losses in cotton. The cost of replanting represents only a fraction of the potential losses inasmuch as replanted cotton may be severely damaged by insects and by weed competition.

Wilts cause more than 25 percent of the annual disease losses in cotton even though *Fusarium*-resistant varieties are available and control practices that reduce damage by *Verticillium* are known.

Boll rots are caused by a complex of organisms, many of which are considered to be saprophytes; but under appropriate conditions, many of these grow on the uninjured bolls and seriously damage the fiber. The upward trend in losses from boll rots has been due largely to attempts to grow greater and greater amounts of cotton on the same acreage. To do this, farmers overwatered and overfertilized the plants, and the plant growth pattern was conducive to boll rots. These practices also contribute to low seed and fiber qualities.

Estimated average annual losses caused by various cotton diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Seedling diseases	2.6
Verticillium wilt	2.3
Boll rots	2.2
Bacterial blight	1.7
Fusarium wilt	1.1
Phymatotrichum root rot	.9
Ascochyta blight	.2
Others	1.0
Total	12.0

Flax (seed)

Pasmo, rust, and wilt are the most destructive flax diseases in the United States. In 1955–56 curly top caused losses of 10 to 30 percent in the Imperial Valley of California and in Texas. In 1957 losses from aster yellows were estimated at 20 percent of the crop in the Dakotas and Minnesota. Crinkle occasionally causes small losses. Seedling blight is widely distributed and causes appreciable loss of stand in isolated fields nearly every year.

Pasmo is estimated to cause a 3-percent annual loss in yield of flax. This disease occurs in years of frequent rains and heavy dews during the period from flowering to maturity. Varieties differ in their field tolerance to the disease. Early-maturing varieties tend to escape with less damage than late-maturing ones. There were no serious epiphytotics of pasmo in the period covered by this report.

A new race of flax rust attacked the variety Dakota in Minnesota and in the Dakotas in 1950–51. Resistant varieties were quickly substituted, and losses were held to 10 percent in 1951, 5 percent in 1952, and 0 to 1 percent in subsequent years.

Losses from wilt during the period 1951–60 were estimated at 1 percent. All commercial varieties in Minnesota and in the Dakotas have a high degree of resistance. A wilt-resistant variety, New River, released in California, reduced losses in that area to 5 percent.

A number of soilborne and seedborne fungi occasionally cause seedling blights with resulting stand decimation.

Estimated average annual losses caused by specific flax diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Pasmo	3.0
Rust	2.0
Crinkle and aster yellows	2.0
Seedling blights	1.5
Wilt	1.0
Curly top	.5
Total	10.0

Hops

Virus diseases cause the most serious losses in hop yields (10 percent) in California, Idaho, Oregon, and Washington. Usually there is a reduction in yield during the last year or two the diseased hill remains in the yard, and there is a further reduction while a new cutting is being established.

Downy mildew, the most damaging and widespread fungus disease of hops in the United States, caused an estimated 3-percent reduction in average annual yield during the period 1951–60.

While verticillium wilt is not now a serious hazard of hops in the United States, a few infected plants have been found, and it may become more destructive in the future.

Mint

Verticillium wilt, which attacks both peppermint and spearmint, caused estimated annual losses in yield of 10 percent in Indiana and Michigan during the period 1951–60. It has been increasing in Oregon and Washington and caused estimated average annual losses in yield of 6 percent for 1951–60. The average annual losses for the entire mint-growing area are estimated at 8 percent.

Rust causes losses in yield in Oregon and Washington estimated at 4 percent annually. The estimated annual losses for the entire mint-growing area average 2 percent.

Oats

Oat diseases are a major factor in oat production. In the United States, losses caused by diseases are generally higher in oats than in other small grains, because most of the oat crop is spring grown in warm, humid regions usually favorable for disease development. Heavy losses are also experienced in the Deep South, where oats are fall sown and winters are mild and humid. However, only about half of the more than 30 diseases attacking oats in the United States have caused appreciable damage. Total losses from all diseases during the period 1951–60 were estimated at 21 percent.

Losses from crown rust averaged 3.7 percent for 1951–60. Resistant varieties constitute the only effective control of crown rust, and this protection is often nullified by the frequent appearance of new, virulent races of rust. In 1953, crown rust caused estimated losses of 30 percent in Iowa and losses totaling more than 100 million dollars in the three leading oat-producing States, Iowa, Minnesota, and Wisconsin.

Yellow dwarf (virus) caused average annual losses of 3.8 percent during the period 1951–60 and superseded crown rust as the most damaging oat disease. The disease is widely distributed and is of major importance throughout the principal oat-producing regions. Yellow dwarf symptoms on oats were not fully recognized until about 1956. Previously, much of the damage caused by yellow dwarf was attributed to blast, drought, heat, cold, and low fertility. In 1959 an epiphytotic of yellow dwarf caused severe damage in the heavy oat-producing North Central States, with carefully estimated losses as follows: Missouri, 37 percent; Indiana, 27.5 percent; Kansas, 25 percent; Iowa, 12 percent; and Wisconsin, 5 percent. The estimated losses from yellow dwarf in Oregon were 9.1 percent in 1957, 9.5 percent in 1958, and 14.8 percent in 1959. Severe damage also occurred in the Northeast in 1960.

Some of the 2.5-percent loss from blast reported during 1951–60 possibly should have been attributed to yellow dwarf, because blasting was not fully recognized as a symptom of yellow dwarf until about 1956. Blast and root necrosis, which ranked third and fourth in destructiveness in 1951–60, have several causes and it is difficult to arrive at accurate loss estimates. The estimates of losses for root necrosis were based to some extent on yield increases obtained from soil sterilization and seed treatment.

Stem rust of oats usually has been less severe than crown rust in the United States, partly because of the availability of new varieties resistant to stem rust. But a changing stem rust situation has tended to nullify the protection afforded by resistant varieties. The threat from new and more virulent races and subraces could result in greater losses from stem rust.

Septoria foliage blight, the sixth-ranking oat disease, caused estimated losses of 15 percent in the Iowa oat crop in 1952. It affects yield and quality of both grain and forage. Heavy infection by *Septoria* has been most frequently observed in the Northern States.

The estimated losses in yield of oats from Victoria blight (*Helminthosporium*) averaged only 0.4 percent for 1951–60. This disease caused severe losses throughout both the northern and the southern oat-producing regions in 1946, 1947, and 1948, with Iowa reporting losses of 25 percent in 1946 and 32 percent in 1947. A dramatic shift to resistant varieties has virtually eliminated Victoria blight.

Oat smuts, once major diseases, are now of relatively minor economic importance because of the widespread use of resistant varieties.

Soilborne mosaic, a virus disease of winter oats, appears to be increasing in prevalence and severity.

Losses caused by scab, helminthosporium leaf blotch, helminthosporium culm rot, bacterial diseases, blue dwarf, and nonparasitic diseases have been relatively minor nationally, although sometimes they are locally severe.

Estimated average annual losses caused by specific oat diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Yellow dwarf	3.8
Crown rust	3.7
Blast (sterility)	2.5
Root necrosis	2.4
Stem rust	2.3
Septoria foliage blight	1.8
Scab	.9
Helminthosporium leaf blotch	.7
Smuts	.6
Soilborne mosaic	.5
Bacterial stripe blight	.4
Victoria blight	.4
Blue dwarf	.3
Halo blight	.3
Helminthosporium culm rot	.2
Physiologic leaf spot	.1
Others	.1
Total	21.0

Peanuts

Principal losses from diseases in the production of peanuts are caused by cercospora leaf spot and stem rot, or southern blight. Pod rots not associated with stem rot are of major economic importance in the Virginia-Carolina area. Root rots, which may be associated with the stem rot complex, are of concern in Georgia and Texas.

Estimated average annual losses caused by various peanut diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Leaf spot	10.0
Stem rot, or southern blight	7.5
Pod rots	2.5
Root rots	2.5
Seedling death or stunting	2.5
Seed decay after planting	2.0
Collar and crown rot	1.0
Total	28.0

Peas, dry (including seed peas)

Losses from diseases of dry and seed peas are due principally to root rots caused by several organisms. With the increase in acreage in the Columbia Basin, where root rots are severe because of the low humus content of the soils, these diseases are increasing in importance. Less severe losses are caused by mosaics, ascochyta and bacterial blights, and powdery mildew.

Estimated average annual losses caused by various diseases of dry peas for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Root rots	8.0
Virus diseases	2.5
Ascochyta blight	1.0
Fusarium wilts	1.0
Powdery mildew	1.0
Bacterial blight	.5
Total	14.0

Rice

Rice is grown in Arkansas, California, Louisiana, Mississippi, Missouri, and Texas. Diseases cause appreciable losses only in the South. In California, the only major disease of rice is sterility, which is caused by unfavorable environmental conditions. Because estimates of losses are based on the entire production, losses are somewhat higher in the South than indicated in the tabulation.

Blast, the most economically important disease of rice, causes major losses in most varieties. Increased use of nitrogen fertilizer, which favors disease development, and the appearance of a number of races of the causal fungus have increased losses during recent years. Kernel smut, a major disease in some areas in certain years, sometimes causes severe losses in both yield and quality. Seedling blight and root rots also are major diseases of rice. Kernel spots, caused by several fungi, cause losses in yield and in quality.

Straighthead, a physiological disease, and sterility (spikelet or panicle blight) due to unfavorable environmental factors cause appreciable losses each year. The estimated combined losses from these causes is about 2 percent each year. Stem rot occasionally causes losses, but this disease is becoming less severe. Fungi that attack the leaf and sheath are prevalent each year in the South. The estimated combined losses from these diseases average about 0.6 percent a year.

Estimated average annual losses caused by specific rice diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Blast	1.6
Root rots	1.0
Kernel smut	.5
Seedling blight	.5
Kernel spots	.3
Brown leaf spot	.2
Narrow brown leaf spot	.2
Stem rot	.2
Straighthead	.2
Bordered sheath spot	.1
Leaf smut	.1
Others (sterility and miscellaneous minor diseases)	2.1
Total	7.0

Rye

Losses in the potential rye crop in the United States from all diseases for the period 1951–60 are estimated at 3 percent, somewhat lower than the estimate for other cereal crops. Losses are greatest (over 5 percent) in the humid areas of the Southeast, where rye is grown for pasture cover or green manure.

Rusts are the principal diseases of rye in all rye-growing areas and are estimated to cause losses of about 1 percent. Rust-induced losses occur in both grain and forage. Various leaf diseases associated with the fungi *Helminthosporium, Septoria,* and *Rhynchosporium* also are destructive in the Southeast.

Ergot causes losses of about 0.7 percent; root rots, about 0.7 percent; and anthracnose, about 0.4 percent. Stalk smut is present in only trace amounts, but occasionally it may be locally severe.

Estimated average annual losses caused by the major diseases of rye for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Rusts	1.0
Ergot	.7
Root rots	.7
Anthracnose	.4
Leaf spots	.1
Stalk smut	.1
Total	3.0

Safflower

Rust may be a particularly destructive disease of safflower grown on irrigated or subirrigated land in central California where humidity is high. Losses in this area have been as high as 25 percent. Annual losses for the entire safflower area during the period 1951–60 averaged about 5 percent.

Root rot may be destructive wherever the crop is grown on irrigated land. Average annual losses were estimated at 3 percent for the period of 1951–60.

When the weather is humid, bud rot may be a serious disease of safflower from flowering to maturity. Losses may be large, especially where the crop is grown out of its area of adaptation.

Verticillium wilt causes small losses wherever safflower is grown.

Estimated average annual losses caused by specific safflower diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Rust	5.0
Root rot	3.0
Bud rot	2.0
Leaf spot	1.0
Verticillium wilt	.5
Damping-off	.3
Curly top	.2
Total	12.0

Sesame

Sesame is grown chiefly on the High Plains of Texas. Bacterial leaf spot of sesame caused annual losses estimated at more than 5 percent during the period 1951–60. High nitrogen fertilization, together with periods of cloudy weather with high humidity, tends to increase the disease.

Rhizoctonia root rot is responsible for some loss of stand in almost every field, and the estimated loss of 2 percent for 1951–60 seems conservative.

Charcoal rot caused additional estimated annual losses of 2.5 percent. This disease attacks a number of other crops grown in the area where sesame is grown. Miscellaneous diseases caused losses of about 1.5 percent.

Sorghum, grain

Reduction in yield of grain sorghum as a result of diseases was estimated at 9 percent for the period 1951–60. Losses were heaviest in the southern sorghum-producing areas of the Plains States, where the major diseases are stalk rots and head smut. In the higher rainfall area of Eastern United States, various leaf diseases cause losses in grain sorghum production. Losses from diseases are lowest in the Northern Great Plains, Arizona, and California.

Stalk and root rots reduced yields by an estimated 4.5 percent during the period 1951–60. These diseases are typically sporadic and, therefore, it is difficult to arrive at average losses. Charcoal rot is the most destructive and may cause total loss in small areas, such as a 160-acre field, or in areas the size of a county or several counties. It occurs with greatest regularity in the Southern Great Plains.

The loose and covered kernel smuts of grain sorghum, once destructive diseases, are now controlled effectively by seed treatment. In contrast, head smut has increased markedly in recent years and is estimated to cause a loss of 1 percent. It may cause losses as high as 30 percent in south and central Texas and as high as 10 percent in irrigated sorghum in western Kansas.

During 1951–60, seed rots and seedling diseases caused estimated losses of 1 percent.

These diseases are more severe in cool, wet springs in the more northern areas when the seed is planted early. Some of the loss would be represented in the cost of 2 to 3 pounds per acre of additional seed sown in anticipation of loss in stand from diseases. With the shift to hybrid sorghums, some reduction in losses may be expected, since virtually all hybrid seed is treated with fungicides.

Leaf diseases such as helminthosporium leaf blight, bacterial blights, and rust may cause losses in the eastern and southern portions of the grain sorghum area. Anthracnose is also destructive, particularly in the Southeast. However, in the major grain sorghum-producing areas, these diseases cause so little damage that losses do not exceed 2 percent of the grain sorghum crop as a whole.

Estimated average annual losses caused by various diseases of grain sorghum for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Charcoal rot and other stalk and root rots	4.5
Head smut	1.0
Seed rots and seedling diseases	1.0
Bacterial blights	.3
Helminthosporium leaf blight	.2
Weak neck	.2
Anthracnose	.1
Loose and covered kernel smuts	.1
Others (miscellaneous leaf diseases, rust, etc.)	1.6
Total	9.0

Sorghum, sweet

Losses in sweet sorghum in the Southeast during the period 1951–60 were caused primarily by four fungus diseases: gray leaf spot, zonate leaf spot, rust, and red rot including leaf anthracnose. Gray leaf spot was a de-
Alabama, Louisiana, Mississippi, and Tennes-
structive disease of susceptible varieties in
see. Zonate leaf spot was prevalent most seasons on highly susceptible varieties in Tennessee. Rust is a serious disease annually on susceptible varieties in humid areas of Louisiana, Mississippi, and other Southern States. Losses from red rot including leaf anthracnose were reduced in the 1950's by the use of resistant varieties; it occurs on susceptible varieties in all sirup-producing States.

Bacterial stripe occurs on susceptible varieties of sweet sorghum in sirup-producing areas of the Southern States; losses are usually minor. The virus that causes mosaic of sugarcane damages sweet sorghum in Alabama, Georgia, Louisana, and Mississippi when the crops are grown in close proximity. Other fungus diseases that cause minor losses in sirup-producing areas of the South are sooty stripe, leaf blight, smut, rough spot, and pokkah boeng.

Disease losses in sweet sorghum occur regularly. They reduce growth and sugar content of the sorghum and the total yield of sirup. Losses from all diseases reduced the total annual yield an estimated 15 percent during the period 1951–60.

Estimated average annual losses caused by various diseases of sweet sorghum for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Gray leaf spot	2.8
Zonate leaf spot	2.7
Rust	1.2
Red rot including leaf anthracnose	1.1
Others	7.2
Total	15.0

Soybeans

Most of the disease losses in soybeans in the United States are caused by 12 diseases, but more than twice this number are known to attack the crop. Some newly discovered bacterial diseases apparently cause damage, but they are not well enough understood to be included in the estimates.

Use of varieties resistant to the destructive foliage disease bacterial pustule reduced losses from this disease in the southern half of the soybean-producing area during the period 1951–60, but no variety resistant to this disease and adapted to the northern production area was available.

Varieties resistant to frogeye leaf spot reduced losses from this disease, particularly in the south-central part of the soybean-producing area, where losses from it were most severe. However, a new race of the frogeye fungus has become prevalent in areas where frogeye was previously a serious problem.

The leaf disease bacterial blight is prevalent throughout the soybean-producing area in the United States, and most varieties are susceptible to it. The complex inheritance of resistance to the disease and the different races of the causal organism make the development of resistant varieties difficult.

The leaf disease downy mildew, the most widespread soybean disease in the United States, is prevalent throughout the soybean-producing area. Many races of the causal fungus are known, and no commercial variety is resistant to all of them. However, selection of improved varieties for resistance to some races and low susceptibility to others has kept losses from this disease at a moderate level.

The most destructive fungus disease of soybeans is phytophthora root and stem rot, one of the few soybean diseases that has caused total losses. The causal fungus is widespread throughout the soybean-producing area of the country, except in the extreme northern part and in the light, well-drained soils in the southern part. Damage from the disease ranges from stunting of the plants to death. Most southern varieties are tolerant or resistant to the disease.

Two diseases of soybeans, pod and stem blight and purple stain, reduce seed quality much more than they reduce yield. Both diseases are prevalent in the soybean-producing areas of the United States, but losses from them are most severe in the humid areas of the East Coast and the South.

Stem canker, a widespread disease throughout the northern half of the soybean-producing area, causes death of plants late in the growing season. No varieties resistant to the disease are known, but selection of varieties with a low incidence of the disease has helped to keep losses at a minimum.

Brown stem rot is widespread throughout the soybean-producing areas but is particularly severe where soybeans are grown continuously or rotated infrequently with nonsusceptible crops. No completely resistant variety is known, but some varieties are much more severely affected by the disease than are others.

Soybeans are affected by a number of viruses; the main one is the tobacco ringspot virus, which causes bud blight and is prevalent throughout the soybean-producing areas. Although this disease sometimes causes complete loss of yield, it occurs sporadically from year to year. Since symptoms are difficult to recognize except in the most extreme stages, losses from it might be substantially underestimated.

Estimated average annual losses caused by specific soybean diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Phytophthora rot	2.3
Bacterial blight	2.2
Downy mildew	1.6
Bacterial pustule	1.4
Pod and stem blight	1.2
Stem canker	1.1
Bud blight	.8
Brown spot	.8
Brown stem rot	.8
Purple stain	.7
Fusarium root rot	.6
Frogeye leaf spot	.1
Others	.4
Total	14.0

Sugarbeets

Diseases are serious hazards to stable production of sugarbeets and cause losses in all areas. In California and the Pacific Northwest, beet yellows and western yellows reached epidemic proportions during the period 1951–60. Curly top is responsible for losses in the sugarbeet areas west of the Rocky Mountains.

In the sugarbeet areas east of the Rocky Mountains, cercospora leaf spot and black root, both fungus diseases, reduce yield and quality.

Minor diseases such as downy mildew and rust occur in California, where they reduce yields significantly some years. Mosaic is most prevalent in California and in the Pacific Northwest, and savoy is found in the Great Lakes area.

Rhizoctonia and other root rots are responsible for severe loss of mature roots before harvest. These losses fluctuate with weather conditions and cropping practices.

Estimated average annual losses caused by various sugarbeet diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Yellows (beet yellows and western yellows)	6.0
Cercospora leaf spot	3.0
Curly top	3.0
Root rots	2.0
Black root	1.0
Minor diseases (downy mildew, rust, diseases caused by *Phoma*, savoy, and mosaic)	1.0
Total	16.0

Sugarcane

Sugarcane diseases regularly decrease growth of the crop and reduce the sucrose content and yield of sugar. The ratoon stunting disease, caused by a virus, is the most damaging disease in Florida, Louisiana, and the sirup-producing States (Alabama, Georgia and Mississippi). Mosaic, another virus disease, is prevalent in all U.S. mainland sugarcane-producing areas; losses from mosaic have been reduced by the use of resistant varieties.

Diseases caused by soil pathogens reduce yields of sugar in Hawaii and in most sugarcane-producing areas of the mainland.

Red rot, a fungus disease, causes severe losses in stands and total yield of sugar and sirup in Florida, Louisiana, and the sirup-producing States. Rind disease is prevalent in Hawaii, but it is of minor importance in other areas. Other fungus diseases that cause some losses in mainland sugarcane-producing areas are pythium root rot, phytophthora rot, pokkah boeng, and red stripe.

Estimated average annual losses by various sugarcane diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Ratoon stunting disease	13.7
Red rot	4.5
Diseases caused by soil pathogens	1.7
Mosaic	.8
Pokkah boeng	.8
Rind disease	.7
Pythium root rot	.5
Red stripe	.2
Phytophthora rot	.1
Total	23.0

Tobacco

In the period 1951–60, estimated disease losses in tobacco were 11 percent. During that period losses were sharply reduced primarily by the development and increased use of disease-resistant varieties. Development of burley varieties with resistance to wildfire and mosaic greatly reduced losses from these diseases. More recently, cigar tobaccos with resistance to wildfire and tobacco mosaic have become available. Varieties of various types of tobacco resistant to one or more stalk diseases such as blank shank, Granville wilt, and fusarium wilt have been developed.

Severe losses to the growing tobacco crop are caused primarily by four classes of diseases: root rots, leaf spots, virus diseases. and stalk diseases. Losses during curing may be severe, especially in air-cured tobacco.

Root rots reduce plant growth in all tobacco-growing areas. Black root rot is especially damaging in the burley and cigar tobacco-producing areas. Leaf spots reduce yields and in some instances affect quality. Virus diseases are prevalent in all areas. They always reduce yields and quality of cured leaf.

Though black shank appears to be more widespread than formerly, the severity of the disease in general is being controlled more effectively by use of resistant varieties and crop rotation. Many varieties resistant to black shank are also resistant to other stalk and root diseases.

Blue mold commonly occurs in seedbeds each year. It causes shortage of transplants, delay in planting, and resultant poor stands. Blue mold is sometimes a serious problem in field plantings of cigar-wrapper tobacco.

Miscellaneous tobacco diseases occasionally cause some damage. These include sore shin, southern stem rot, and damping-off of transplants. Cercospora leaf spot causes considerable damage to burley and Maryland tobaccos. Losses from brown spot have increased on flue-cured tobacco. Losses from air pollution (see discussion of this subject) have been recognized in cigar-wrapper tobacco.

Estimated average annual losses caused by various tobacco diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Leaf decay during curing	2.7
Tobacco mosaic	1.4
Wildfire	1.3
Miscellaneous stalk and root diseases	1.1
Black shank	1.0
Black root rot	.9
Brown spot	.8
Blue mold	.6
Blackfire	.3
Miscellaneous leaf diseases	.3
Frogeye	.2
Fusarium wilt	.2
Granville wilt	.2
Total	11.0

Wheat

Diseases continue to be a major hazard in wheat production in the United States and cause losses principally through reducing yield and quality of grain. Estimated annual losses from all diseases for the period 1951–60 were 14 percent. Losses were due principally to a series of epidemics, including stem rust epidemics in the spring wheat areas in the early 1950's; wheat streak mosaic outbreaks in the hard red winter wheat areas, especially in 1954 and 1959; epidemics caused by *Septoria*, principally in the eastern soft winter wheat area during several years in the decade; and the common bunt and stripe rust epidemics, which reduced the wheat crop in the Pacific Northwest.

The most destructive diseases of wheat are rusts. Stem rust caused the heaviest losses, principally due to the ravages of race 15B, which devastated the hard spring and durum regions and caused an average annual loss of over 11 percent. Losses from stem rust in 1953 and again in 1954 were estimated at more than 200 million dollars. Losses in 1952 and 1953 were estimated to be between 10 and 50 million dollars and in 1956 and 1957, between 5 and 10 million dollars.

Leaf rust is estimated to have resulted in losses of 2.5 percent. Normally, leaf rust does not cause outright crop failures such as associated with stem rust, but it is present every year in most areas where wheat is grown. Stripe rust appeared for the first time in the Plains States and was epidemic in the Pacific Northwest in 1960 where it reduced wheat production an estimated 15 to 25 percent.

Virus diseases caused losses of nearly 2 percent during the decade. The chief offender was wheat streak mosaic, with an average annual loss of 1 percent. Epidemics of wheat streak mosaic occurred in 1953, 1594, and 1959. It is estimated, for example, to have reduced yields 20 percent in Kansas in 1959. Soilborne mosaics caused estimated losses of 0.5 percent. Experimental evidence that barley yellow dwarf may damage wheat severely is accumulating but, because of the obscurity of the symptoms, estimates of losses were not made.

Septoria leaf and glume blotch was particularly destructive in the midwestern and eastern soft wheat areas. Estimates of losses ranged up to 7 percent in these areas. On a national basis this disease reduced potential yield by 1 percent. Powdery mildew (0.4-percent loss) caused small but consistent losses in these areas. Scab, which is most severe in the eastern and southern soft wheat areas, caused estimated losses of 2 percent in Kansas alone.

Root rots, foot rots, and seedling blights are known to take a heavy toll of the national wheat production potential, but reliable estimates of damage are difficult to obtain. Conservative estimates place these losses at about 2 percent. These diseases appear to be increasing in destructiveness as wheat culture becomes more intensive with larger rates of fertilizer being applied and, in many cases, with less crop rotation being practiced. Snow molds (0.1-percent loss) associated with *Fusarium* or *Typhula* take an annual toll throughout the most northern winter wheat areas, and frequently they are locally severe enough to cause crop failure, particularly in the Pacific Northwest and Intermountain areas.

National losses from the various smut (bunt) diseases were in excess of 1 percent during the period 1951–60. Common bunt, which was epidemic in the Pacific Northwest during most of the decade, reduced both the yield and quality of the crop. Introduction of more efficient seed-treatment fungicides and resistant varieties resulted in nearly complete control of this disease. At the same time, dwarf bunt continued to cause ever greater losses over a wider area, particularly in the winter wheat areas of the Pacific Northwest. Loose smut causes losses in the eastern soft winter wheat areas and the eastern parts of the hard red winter wheat and hard red spring wheat areas. Losses are rather consistent from year to year and from decade to decade.

Estimated average annual losses caused by various wheat diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Stem rust	4.0
Leaf rust	2.5
Root rots	1.0
Septoria leaf and glume blotch	1.0
Wheat streak mosaic	1.0
Loose smut	.8
Cercosporella foot rot	.6
Scab	.5
Soilborne mosaics	.5
Common bunt	.4
Powdery mildew	.4
Take-all	.2
Bacterial diseases	.1
Dwarf bunt	.1
Miscellaneous leaf and head blights	.1
Miscellaneous virus diseases	.1
Snow molds caused by *Fusarium* or *Typhula*, or both	.1
Stripe rust	.1
Others	.5
Total	14.0

ALFALFA AND ALL OTHER HAY PLANTS

Annual disease losses for hay crops are difficult to assess because losses in perennial grasses and legumes usually are cumulative. Foliar blights and root rots take their toll of plants and affect productivity of a hay crop as long as the stand is retained. Infections by crown and root rot fungi and viruses are not always immediately fatal. These pathogens frequently weaken plants so that they are unable to withstand adverse conditions such as summer drought and low winter temperature. Defoliation by leaf spot fungi reduces not only the yield of hay but also its quality, since a higher proportion of stems than leaves is harvested.

In the decade 1951-60, control measures were developed for diseases of some forage plants; however, new disease outbreaks occurred on others. Widespread use of varieties of alfalfa resistant to bacterial wilt appreciably reduced losses attributable to this disease. However, the recent recognition of Pierce's disease of grapevine, caused by alfalfa dwarf virus, in the Gulf Coast States and in the Eastern United States suggests that this virus may be prevalent in eastern alfalfa fields. During the late 1940's, the disease appeared more frequently and became increasingly destructive so that it is now considered to be one of the major leaf spots of alfalfa in North-central and Northeastern United States.

Estimated disease losses to alfalfa and all other hay plants appear in table 3. The average annual losses to these crops were estimated to be $614,766,000.

Estimated average annual losses caused by various diseases in alfalfa grown for hay for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Bacterial wilt	5.0
Crown and root rots	5.0
Virus diseases	5.0
Foliar diseases including black stem	9.0
Total	24.0

TABLE 3.—ALFALFA AND ALL OTHER HAY PLANTS: *Estimated average annual losses due to diseases, 1951–60*

Commodity	Production unit	Loss from potential production[1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Alfalfa	Ton	24	17,562	388,648
All other hay plants	do	15	9,439	[3] 226,118
Total				614,766

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Value computed at $23 per ton.

The numerous pathogens that attack true clovers and sweetclover cause losses in stand, yield, and quality of the crop. Root and crown rots are generally held responsible for making red clover behave as a biennial rather than a perennial. In most of the area where red clover is grown, root and crown rots virtually destroy stands by midsummer of the second year.

Estimated average annual losses caused by various diseases in red clover grown for hay for the period 1951-60 are as follows:

Disease	*Average annual loss (percent)*
Crown and root rots	23.0
Leaf spots and rust	6.5
Virus diseases	5.5
Total	35.0

In ladino clover, virus infection frequently builds up so that 50 percent or more of the plants in some fields are infected by the third year. Virus infection, coupled with damage from root and stolon rot fungi, frequently causes rapid depletion of the legume in pasture and hay fields. Improved varieties of clovers are available and are being grown more widely.

Attacks by crown and root rot fungi have largely eliminated stands of birdsfoot trefoil in the southernmost area of its adaptation. Stemphylium leaf spot also is widespread and may cause extensive defoliation in some years.

Perennial grasses grown for hay are generally attacked throughout the growing season by a succession of foliar pathogens. Most damage results from premature withering and drying of leaves, which reduces productivity and quality of the hay.

FORAGE PLANTS GROWN FOR SEED

Between 850 and 900 million pounds of forage seed valued at 175 to 200 million dollars is produced annually in the United States; losses due to diseases for the period 1951–60 were estimated at $23,584,000 (table 4).

Most improved varieties of commonly grown grasses and legumes adapted to the Midwest and Eastern United States are increased for seed in the West. Consequently, diseases of little or no importance where plants are grown for pasture, hay, or turf may be very destructive on improved varieties grown to maturity for seed in the West. Outbreaks of rusts on red clover, some varieties of orchardgrass, and Kentucky bluegrass have caused losses in seed production and quality. In 1960, a severe outbreak of stripe rust in Merion Kentucky bluegrass seed fields in western Oregon threatened production of seed of this grass until effective fungicide treatments were developed. Blind seed disease of perennial ryegrass sometimes recurs alarmingly when the price of seed drops and growers attempt to economize by discontinuing recommended control measures. Usually ergot does not seriously limit seed production by most grass species; however, it is omnipresent on dallisgrass in the South and is considered to be the major factor limiting commercial production of dallisgrass seed in the United States.

Virus infections in clovers, alfalfa, and other legumes are more prevalent and severe in the Pacific Northwest than had been originally anticipated. Virus infection has reduced seed production of ladino clover as much as 53 percent.

Seed yields of red and alsike clover fields are frequently reduced by attacks of crown and root rot fungi. Sclerotinia crown and stem rot is a widespread, destructive winter disease of legumes in the Southeastern States. Frequently, large patches of seedlings and older plants in crimson clover seed fields are destroyed by *Sclerotinia*.

During the period 1951–60, acreage of sweet yellow lupine grown for forage and seed in Florida dropped from 200,000 acres to less than 1,000, largely because of widespread infection by seedborne bean yellow mosaic virus.

TABLE 4.—FORAGE PLANTS GROWN FOR SEED: *Estimated average annual losses due to disease, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Alfalfa	Pound	9	17,923	4,751
Bluegrass, Kentucky [3]	do	8	1,749	525
Brome, smooth	do	8	1,054	126
Clover:				
Alsike	do	20	2,391	540
Crimson	do	12	2,490	511
Red	do	32	33,100	9,044
White (including ladino)	do	24	3,365	2,053
Fescue, tall	do	4	1,365	236
Grasses:				
Miscellaneous [4]	do	5	4,196	623
Turf [5]	do	12	1,979	607
Legumes, miscellaneous [6]	do	7	7,019	543
Lespedeza	do	14	19,174	2,134
Lupines	do	52	15,810	553
Orchardgrass	do	8	1,056	169
Ryegrass	do	6	7,726	505
Sweetclover	do	8	3,246	288
Timothy	do	4	1,620	171
Trefoil, birdsfoot	do	18	267	205
Total				23,584

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Includes Merion bluegrass.
[4] Includes wheatgrasses, Russian wildrye, bluestems, gramas, switchgrass, dropseed, buffalograss, rhodesgrass, lovegrass, redtop, reed canarygrass, bermudagrass, bahiagrass, dallisgrass, sudangrass, millets, johnsongrass, and pangola.
[5] Includes chewings fescue, red fescue, and bentgrass.
[6] Includes common vetch, hairy vetch, purple vetch, and Austrian winter peas.

Estimated average annual losses in seed production caused by various diseases in five kinds of forage plants for the period 1951–60 are as follows:

Crop and disease	*Average annual loss (percent)*
Alfalfa:	
Virus diseases	3.0
Bacterial wilt	2.0
Black stem and other foliar diseases	2.0
Crown and root rots	2.0
Total	9.0
Clover, crimson:	
Crown rot	6.5
Leaf spots	3.0
Virus diseases	2.5
Total	12.0
Clover, red:	
Crown and root rots	23.0
Virus diseases	5.5
Leaf spots and rust	3.5
Total	32.0
Clover, white (including ladino):	
Virus diseases	13.0
Crown, root, and stolon rots	10.0
Foliar diseases	1.0
Total	24.0

Crop and disease	*Average annual loss (percent)*
Lupines:	
Virus diseases	25.0
Stemphylium leaf spots	15.0
Brown spot	7.0
Anthracnose and root rots	5.0
Total	52.0

PASTURE AND RANGELAND PLANTS

Approximately 50 percent of the total land area of the United States is used for pastures or grazing. These grazing lands cover a diversity of soils and climatic conditions, which influence the type and density of cover, productive capacity, and quality of the forage. The returns from these grasslands in the form of animals and animal products depend on the particular plants or mixtures, their yield, and their resistance to heat, drought, or other hazards. Accurate data are not available on the returns from U.S. grazing lands. It has been estimated, however, that at least half of all the feed nutrients consumed by domestic livestock are provided by pastures and rangelands. In addition, such lands are of value in soil and water conservation and the maintenance of land resources.

Pasture and range grasses and legumes persist under highly competitive and often very adverse conditions. Consequently, each species and frequently each plant continuously competes with its neighbor for existence. Thus, any hazard or combination of hazards that exerts stress on desirable forage plants tends to weaken or eliminate them so that they are often replaced by less desirable species or weeds. Plant diseases are one hazard affecting pasture and rangeland species. Losses from diseases were estimated at $193,935,000 for the period 1951–60 (table 5).

More than 75 fungi, bacteria, and viruses have been identified as the causal agents of pasture grass and legume diseases. Representatives of these groups of pathogens attack plants at any stage of development from seed germination to maturity. Some organisms such as seedling blight and root rot fungi inhibit seed germination, kill seedlings, or attack and weaken older plants. Some fungus diseases such as stripe smut and certain virus infections cause chronic conditions that weaken plants. The plants fail to withstand adverse conditions that ordinarily would not seriously affect their growth and survival. Fungi inciting leaf spots often occur sporadically throughout the growing season. Abundant leaf spots cause leaves to wither and die prematurely. In addition to weakening plants and reducing their productivity, foliar diseases, when severe, reduce palatability and nutritive value of the forage. Fungi inciting head smut and ergot in grasses reduce natural reseeding on ranges. Furthermore, cattle grazing on ergot-infected grass heads are sometimes poisoned.

Losses from plant diseases in pastures and rangelands occur more frequently under humid conditions and usually are more severe. However, plant pathogens attack pasture grasses and legumes even under arid conditions, where dew provides sufficient moisture for fungus spores to germinate and infect plant tissues. Moisture from occasional showers and from melting snow provides conditions favorable for development of seed rots, seedling blights, and root rots on range grasses in Western United States. Losses from disease organisms in irrigated regions sometimes approach those in humid regions.

FRUIT AND NUT CROPS

Estimates of losses in fruit and nut crops due to diseases were restricted to those grown commercially. Limited acreages for home and farm plantings and on small estates were not considered. The average annual losses were estimated at $223,505,000 for the period 1951–60 (table 6).

Almonds

Because of their climatic requirements, almonds are grown commercially only west of the Rocky Mountains. Plantings are particularly extensive in California.

Two fungus diseases are prevalent in all almond-growing areas. The first is brown rot, which is serious on the blossoms because the fungus can materially reduce the size of the crop by blighting them. The second disease, called shot hole or coryneum blight, causes extensive gum production and kills the blossoms, twigs, and branches.

A noninfectious bud failure has increased recently enough to cause as much damage as either brown rot or shot hole, or even more.

TABLE 5.—PASTURE AND RANGELAND PLANTS: *Estimated average annual losses due to diseases, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity [3]	Value
		Percent	*1,000 units*	*1,000 dollars*
Cropland pastures	Acre	9	6,387	[4] 76,645
Forest land pastures	--do	3	7,839	[5] 15,677
Grassland pastures and range	--do	5	33,871	[6] 101,613
Total				193,935

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Basic data on quantities are from the Economic Research Service.
[4] Computed at $12 per acre.
[5] Computed at $2 per acre.
[6] Computed at $3 per acre.

TABLE 6.—FRUIT AND NUT CROPS: *Estimated average annual losses due to diseases, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Almonds	Ton	9	4	2,521
Apples	Bushel	8	9,612	17,791
Apricots	Ton	7	15	1,782
Blackberries [3]	Quart	34	[4] 11,169	[4] 1,472
Blueberries	do	14	5,520	1,842
Cherries	Ton	24	60	12,355
Cranberries	Barrel	9	107	1,298
Filberts (hazelnuts)	Ton	4	([5])	122
Grapefruit	do	2	35	1,020
Grapes	do	27	959	48,415
Lemons	do	25	163	11,137
Oranges	do	12	686	38,560
Peaches	do	14	9,891	19,805
Pears	Bushel	17	5,589	10,176
Pecans	Pound	21	40,006	9,963
Plums	Ton	10	9	1,612
Prunes, fresh	do	10	49	4,895
Raspberries	Quart	38	18,445	5,191
Strawberries	Pound	26	[6] 153,517	[6] 26,869
Tung	Ton	2	2	109
Walnuts	do	18	15	6,570
Total				223,505

[1] See table 2, footnote 1.

[2] See table 2, footnote 2.

[3] Includes both trailing (dewberries) and erect blackberries.

[4] Basic data for quantity and value are from the 1959 Census of Agriculture.

[5] Loss in quantity was estimated at about 300 tons.

[6] Basic data represent the quantity marketed and its value.

Estimated average annual losses caused by various diseases of almonds for the period 1951–60 are as follows:

Disease	*Average annual loss* [1] *(percent)*
Brown rot	2.0
Shot hole	2.0
Crown gall	1.0
Dieback	.5
Ring spot (virus)	.5
Root rots	.5
Verticillium wilt	.5
Others, including bud failure	2.0
Total	9.0

[1] Based on data from Interior Valleys and some coastal areas of California.

Apples

Apple scab, a fungus disease, is perhaps the major disease problem facing apple growers east of the Rocky Mountains. The causal fungus is widely distributed and is a threat every year. It makes the fruit worthless when infection is heavy, and even scattered infections result in misshapen, small fruit. Also it invades the leaves. Scab still accounts for about half of the total losses.

Fireblight and black rot, which account for about 25 percent of the total losses, are next in destructiveness. Other diseases such as apple blotch, bitter rot, botryosphaeria rot, cedar-apple rust, fly speck, and sooty blotch also take a toll of the fruit in the East. These fungus diseases occur more sporadically than scab, but in favorable years they can destroy appreciable quantities of the crop. Black rot, apple blotch, and bitter rot cause more damage in the southern part of the apple belt.

Most apple diseases cause little damage in the arid fruit-growing sections of the Far West; powdery mildew, however, is prevalent and is very difficult to control, especially on the Jonathan and Rome Beauty varieties. Both of these varieties are also very susceptible to fireblight and therefore many farmers do not grow them.

Estimated average annual losses caused by specific diseases of apples for the period 1951–60 are as follows:

Disease	Average annual loss[1] (percent)
Scab	3.7
Black rot	1.1
Fireblight	1.1
Bitter rot	.3
Powdery mildew	.2
Virus diseases	.2
Apple blotch	.1
Armillaria root rot	.1
Botryosphaeria rot	.1
Brook spot	.1
Cedar-apple rust	.1
Crown gall	.1
Fly speck	.1
Sooty blotch	.1
Others	.6
Total	8.0

[1] Based on data from California, Delaware, Georgia, Illinois, Kansas, Maryland, Michigan, New Hampshire, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Virginia, Washington, and West Virginia.

Apricots

Apricots, like almonds, are grown commercially only in the Far West. Most of the commercial acreage is in California, but large plantings exist also in Washington and Utah.

Two fungus diseases—brown rot and shot hole (*Coryneum*)—are universally present in these western apricot orchards. They are responsible for gum flow and blighting of the twigs and blossoms, and *Coryneum* also spots the leaves and fruit. These diseases, which are most damaging during the blossom period, represent a constant threat to the industry. Other diseases such as bacterial canker, powdery mildew, virus diseases, armillaria root rot, and crown gall also cause losses.

Estimated average annual losses caused by various diseases of apricots for the period 1951–60 are as follows:

Disease	Average annual loss[1] (percent)
Brown rot	1.7
Armillaria root rot	1.0
Virus diseases	1.0
Bacterial canker	.9
Powdery mildew	.9
Crown gall	.5
Shot hole	.4
Phytophthora canker	.3
Others	.3
Total	7.0

[1] Based on data from California and Washington.

Blueberries

Commercial blueberry culture is confined largely to special areas in Massachusetts, Michigan, New Jersey, North Carolina, and Washington. Blueberry plantings are damaged by various diseases; but mummy berry and stem canker (fungus diseases) and stunt (a virus disease) are the major commercial problems. These three diseases were responsible for about one-third of the estimated annual losses reported for the period 1951–60. About one-third was attributed to blossom and twig blight, caused by the common gray mold fungus (*Botrytis*). The remaining one-third was caused by a miscellaneous group of diseases.

Mummy berry occurs in all blueberry-growing areas. The young blossoms are infected, and the fruit is converted into a hard, inedible mass as the result of development of the causal fungus in the inner tissues. Blighting of the twigs further reduces the size of the crop. Partial control (about 75 percent) is achieved by using caustic sprays to kill the fungus on the ground and by spraying the bushes with fungicides to protect them from infection.

Stunt occurs in Michigan, New Jersey, North Carolina, and the New England States. Infected plants slowly decline in vigor, become unproductive, and eventually die.

Stem canker occurs mainly in North Carolina. The causal fungus girdles the canes and weakens the plants, which eventually die.

Blossom and twig blight occurs sporadically and is usually economically important only in rainy seasons. The causal fungus grows from the infected blossoms into the shoots and starts twig blight.

Estimated average annual losses caused by various diseases of blueberries for the period 1951–60 are as follows:

Disease	Average annual loss[1] (percent)
Blossom and twig blight	4.4
Stem canker	2.5
Mummy berry	1.3
Stem blight	1.3
Stunt	.9
Bacterial cane blight	.7
Powdery mildew	.6
Godronia blight	.5
Phyllostictina leaf spot	.5
Double spot	.3
Septoria leaf spot and canker	.3
Anthracnose	.1
Gloeocercospora leaf spot	.1
Leaf rust	.1
Mosaic	.1
Phomopsis twig blight	.1
Ring spot	.1
Stem and leaf fleck	.1
Total	14.0

[1] Based on data from Michigan, New Jersey, North Carolina, and Washington.

Brambleberries (blackberries and raspberries)

In the United States, about one-third of bramble crops are lost each year to disease. Virus diseases alone accounted for about one-third of the total estimated losses reported for the period 1951–60. Fungus-induced rots caused about one-seventh of the total. Septoria leaf spots of blackberry is a major problem in the South.

Estimated average annual losses caused by various diseases of blackberries and raspberries for the period 1951–60 are as follows:

Crop and disease	*Average annual loss (percent)*
Blackberries:[1]	
Virus diseases	9.4
Fruit rots	6.2
Anthracnose	4.1
Septoria leaf spot	4.1
Crown gall	1.1
Orange rust	.8
Verticillium wilt	.7
Double blossom	.6
Cane and leaf rust	.3
Others	6.7
Total	34.0
Raspberries:[2]	
Virus diseases	12.4
Anthracnose	7.8
Fruit rots	5.0
Crown gall	4.2
Spur blight	3.9
Verticillium wilt	2.2
Orange rust	1.1
Cane blight	.8
Leaf rusts	.6
Total	38.0

[1] Based on data from New Jersey, New York, North Carolina, Texas, and Washington.

[2] Based on data from Illinois, Maryland, New York, Ohio, Pennsylvania, and Washington.

Cherries

Commercial production of cherries is seriously reduced by both virus and fungus diseases. Sour cherry yellows and certain other virus diseases occur wherever sour cherries are grown in the United States. In fact, almost half of the yield losses due to disease during the period 1951–60 were attributed to viruses. Usually they do not kill the trees, but they reduce yields by reducing the number of fruit-bearing spurs. Leaf spot (*Coccomyces*) and brown rot, two fungus diseases, cause much trouble east of the Rocky Mountains. These two diseases accounted for one-third of the estimated annual losses attributed to disease during the period 1951–60. They are present most years.

Estimated average annual losses caused by various diseases of cherries for the period 1951–60 are as follows:

Disease	*Average annual loss[1] (percent)*
Virus diseases	10.7
Brown rot	4.2
Coccomyces leaf spot	4.0
Armillaria root rot	1.2
Powdery mildew	.2
Black knot	.1
Others	3.6
Total	24.0

[1] Based on data from the following States: California, Kansas, Maryland, Michigan, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Virginia, Washington, and West Virginia.

Citrus (lemons, grapefruit, and oranges)

Citrus trees and fruit are damaged by a number of fungus diseases; but for the most part, they can be kept under control without much effort. More than half of the estimated losses from diseases reported for the period 1951–60 were caused by wood and root rots, and fruit and leaf spots.

On the other hand, several virus diseases, but especially tristeza, menace the very existence of the citrus industry. The virus diseases occur in Florida, along the Gulf Coast, and in California and are estimated to kill up to 1 million trees each year. Trees affected with tristeza gradually lose vigor and become less productive for several years before their death. Trees of sweet orange on sour orange rootstock are killed or severely damaged when infected with the causal virus.

Estimated average annual losses caused by various diseases of lemons for the period 1951–60 are as follows:

Disease	*Average annual loss[1] (percent)*
Sieve-tube necrosis	9.9
Shellbark	6.0
Root and foot rot	4.8
Fruit rots	3.0
Psorosis	.5
Wood rot	.5
Blossom blights	.2
Twig blights	.1
Total	25.0

[1] Based on data from California.

Estimated average annual losses caused by various diseases of oranges and grapefruit for the period 1951–60 are as follows:

Disease	*Average annual loss[1]*	
	Orange (percent)	*Grapefruit (percent)*
Root and foot rot	3.2	0.4
Psorosis	2.0	.4
Exocortis	1.9	.2

Disease	Average annual loss [1] Orange (percent)	Grapefruit (percent)
Tristeza	1.9	.1
Fruit and leaf spots	1.3	.2
Wood and heart rots	1.3	.3
Blossom blight	.1	.1
"Stubborn" disease	.1	.1
Twig blight	.1	.1
Xyloporosis	.1	.1
Total	12.0	2.0

[1] Based on data from California, Florida, and Texas.

Cranberries

The main disease problem in cranberries is fruit rots. Fruit rots are caused by a number of fungi, which were responsible for estimated average annual losses in yield of 8.7 percent during the period 1951–60 according to data from Massachusetts, New Jersey, Washington, and Wisconsin. Damage is initiated at blossom time, but the rot phase does not appear until near harvest. Some rot is present every year but severity depends on weather. Twig dieback, twig blight, and other diseases each caused losses estimated at 0.1 percent.

Filberts (hazelnuts)

Filberts are grown commercially in Oregon and Washington. Bacterial blight is present in all plantings and was responsible for the estimated average annual losses of 4 percent reported for the period 1951–60. The causal organism attacks the buds, leaves, branches, and trunk of the trees. It rarely attacks nuts directly but reduces the size of the crop by killing the fruiting twigs.

Grapes

Climatic factors are so important in commercial grape production that the high-quality vinifera, or European, table grapes can be grown readily only in the Western States, where more than 90 percent of the U.S. grapes are grown.

In the East, American bunch grapes are damaged primarily by black rot and dead arm. The black rot fungus infects all the green parts of the plant and causes severe rotting of the fruit. Black rot is much more difficult to control in the Southeast than in other areas. Dead arm, which occurs also in California, kills the main branches of the vines.

The virus-induced Pierce's disease limits culture of bunch grapes in the South and often kills all vines in a planting. In certain parts of California, the causal virus has become established and precludes growing of European grapes.

Information developed during the 1950's indicates that at least one-seventh of the potential production of vinifera grapes is lost to other virus diseases. These virus diseases reduce vigor, yield, or sugar content.

Estimated average annual losses caused by various diseases of grapes for the period 1951–60 are as follows:

Disease	Average annual loss (percent)
Leaf roll	8.4
Black measles	5.0
Fanleaf, yellow mosaic, and vein banding	5.0
Summer bunch rot	2.2
Dead arm	2.0
Powdery mildew	1.8
Fruit rots	1.0
Pierce's disease	.5
Armillaria root rot	.2
Black rot	.2
Yellow vein	.2
Anthracnose	.1
Downy mildew	.1
Others	.3
Total	27.0

Peaches

East of the Rocky Mountains bacterial leaf spot is probably the most serious disease with which peach growers have to contend. The continued defoliation year after year weakens the trees and predisposes them to winter injury. In some areas bacterial leaf spot is so destructive that many high-quality varieties are not grown because of their susceptibility. Bacterial leaf spot caused about one-fifth of the total estimated losses from disease for the period 1951–60.

Brown rots, scab, and leaf curl fungus diseases are widely distributed in the United States. They caused somewhat less than half the estimated losses of peaches reported. In certain seasons they cause extensive losses, particularly in the humid East, and sometimes brown rot and leaf curl cause losses even in western orchards.

Peach canker, another fungus disease sometimes called constriction disease, appears to be getting more troublesome in some peach-growing areas in the Midwest and the East.

The virus diseases phony and peach mosaic seem to be under control. Phony was brought under control by following an eradication program involving the removal of infected trees. Also contributing to the success of this program was use of organic insecticides, which control the insect vectors.

Estimated average annual losses caused by various diseases of peaches for the period 1951–60 are as follows:

Disease	Average annual loss [1] (percent)
Brown rots	4.5
Bacterial leaf spot	2.8
Scab	1.2
Leaf curl	.8
Mosaic	.7
Peach canker (constriction disease)	.6
Crown gall	.5
Miscellaneous virus diseases	.5
Phony peach mosaic	.5
Coryneum blight	.3
Crown or root rot	.3
Armillaria root rot	.2
Bacterial canker	.2
Powdery mildew	.1
Rust	.1
Others	.7
Total	14.0

[1] Based on data from Alabama, California, Delaware, Georgia, Illinois, Kansas, Maryland, Michigan, New Hampshire, New York, North Carolina, Pennsylvania, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, Virginia, Washington, and West Virginia.

Pears

Except in a few isolated areas, the destructive fireblight (bacterial pear blight) has restricted commercial production of high-quality pears almost exclusively to the Pacific Coast States. In the arid climate of those States, pear growing can be profitable even though none of the orchards are entirely free from fireblight. In fact, this disease accounts for about one-sixth of the losses reported in table 6.

Pear decline, a serious disorder of pear trees, occurs in the pear-growing areas on the Pacific Coast, where it has killed many thousands of trees. Symptoms are of two general types: (1) quick wilting and sudden death of trees, often within a week; and (2) slow decline characterized by cessation of growth, failure to set fruit, and progressive weakening of trees, eventually ending in death, usually in 1 or 2 years. The cause of pear decline was recently determined to be a virus, carried by the pear psyllid. About three-quarters of the estimated losses in pear yields (in California, Oregon, and Washington) reported for the period 1951–60 can be traced to pear decline.

Estimated average annual losses caused by the various diseases of pears for the period 1951–60 are as follows:

Disease	Average annual loss [1] (percent)
Pear decline	12.2
Fireblight	2.7
Leaf blight	.8
Scab	.4
Leaf spot	.1
Powdery mildew	.1
Sooty blotch	.1
Stony pit	.1
Others	.5
Total	17.0

[1] Based on data from California, Georgia, Illinois, Kansas, Michigan, New Hampshire, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, and Washington.

Pecans

The commercial pecan industry is in the South from South Carolina through Georgia and Florida and westward to Texas, Oklahoma, and Arizona. Scab is present throughout this region and is probably the most damaging disease that affects the crop. Scab caused about half of the total estimated losses reported for the period 1951–60. It is especially damaging on susceptible varieties, but fortunately only one-tenth of the acreage is planted to these varieties. Leaf spots due to various fungi, crown gall, and nutritional troubles all reduce the size of the crop. Bunch, a ruinous disease of undetermined etiology, has spread rapidly in the Mississippi Delta area in the last few years.

Estimated average annual losses caused by various diseases of pecans for the period 1951–60 are as follows:

Disease	Average annual loss [1] (percent)
Scab	9.8
Brown leaf spot	4.0
Downy spot	3.0
Leaf blotch	2.0
Pink mold	1.0
Powdery mildew	1.0
Crown gall	.1
Nursery blight	.1
Total	21.0

[1] Based on data from Arizona, Georgia, Oklahoma, South Carolina, and Texas.

Plums and fresh prunes

Brown rot is the most destructive fungus disease of plums and prunes. It caused about half of the estimated losses in yield reported for the period 1951–60.

In the Southeastern States bacterial leaf spot is probably more severe on plums and prunes than on peaches. Fortunately, it has not been found on these fruit crops in the Far West.

Estimated average annual losses caused by the various diseases of plums and fresh prunes for the period 1951–60 are as follows:

Disease	Average annual loss [1] (percent)
Brown rot	4.6
Plum pocket	1.9
Bacterial leaf spot	1.3
Black knot	1.0
Armillaria root rot	.4
Leaf spot	.3
Others	.5
Total	10.0

[1] Based on data from Alabama, California, Georgia, Kansas, Maryland, New York, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Virginia, Washington, and West Virginia.

Strawberries

Strawberry fruit rots, principally gray mold, account for more than half the estimated losses in yield reported for the period 1951–60. Losses vary greatly from year to year. Experimental data from spray tests indicate that losses are considerably higher than previously reported.

Losses from virus diseases, which account for one-fifth of the total losses, were markedly reduced during the period 1951–60 as the result of propagation and certification of virus-free stocks. With the development of virus-free stocks, a basis for comparison with the almost universally infected commercial plants was available. Such comparisons indicated much greater losses than previously reported.

Losses from red stele were low for 1951–60 because of the development and use of resistant varieties of high commercial quality. Verticillium wilt, a major disease in the California area until recently, is now almost completely controlled.

Estimated average annual losses caused by various diseases of strawberries for the period 1951–60 are as follows:

Disease	Average annual loss (percent)
Fruit rots	15.0
Virus diseases	5.0
Leaf diseases	2.0
Verticillium wilt	2.0
Powdery mildew	.5
Red stele	.5
Others	1.0
Total	26.0

Tung trees

Tung trees are cultivated commercially in a narrow belt approximately 100 miles wide along the Gulf of Mexico from eastern Texas to Florida. In general, this crop has been free of fungus diseases. Recently, losses from mycosphaerella leaf spot (1.8 percent) increased slightly. Clitocybe root rot caused estimated average annual losses of about 0.3 percent during the period 1951–60.

Walnuts

Bacterial blight, which is destructive in the extensive commercial plantings of walnuts in California and Oregon, caused estimated average annual losses of about 15 percent during the period 1951–60. The disease primarily affects the nuts, but it may also spot leaves and blight blossom clusters early in the spring. Black line, a disease of undetermined etiology, caused estimated losses of about 3 percent annually.

VEGETABLE CROPS

The estimates of disease losses in vegetable crops (table 7) include only those for the important commercial crops on which reasonably accurate data are available. No attempt was made to estimate losses in home gardens and other noncommercial plantings. The estimated annual losses caused by vegetable diseases for the period 1951–60 averaged $290,389,000.

Artichokes

The gray mold fungus causes the greatest disease losses in artichokes. It decays the older bud scales, the growing buds, and the stem and lateral branches. Average annual losses were estimated at 3 percent for the period 1951–60.

Curly dwarf, a virus disease, has recently caused some losses (1 percent), chiefly in California where most of the crop is grown. It stunts growth and causes the plants to die prematurely; the result is a reduction in yield (number of heads). Root and stem rots also cause estimated average annual losses of 1 percent.

Asparagus

Most disease losses in asparagus are caused by rust; average annual losses were estimated at 7 percent for the period 1951–60. The rust fungus injures the stems that develop after the cutting season is over and causes the needle-like branches to fall. This injury to the top growth reduces storage of food reserves in the fleshy roots and consequently reduces vigor and yield of the plants the next year. The marketable portions of the plants, however, are not infected. Rust occurs throughout the United States, but is most severe in humid regions. Stalk wilt and root decay also cause some losses in asparagus (about 1 percent each).

Beans, green lima

Downy mildew, root rots, stem anthracnose, and seed decay cause more losses in lima beans than do other diseases. Root rots and seed decay cause more damage to the large-seeded limas than to other types. Losses are due to reduced yield and quality.

In years when downy mildew is severe in Delaware and New Jersey, it causes considerable loss. Wherever lima beans are grown in the East under humid and other conditions favorable for anthracnose, this disease causes some loss. Bacterial blights cause less damage in lima beans than they do in snap beans.

Estimated average annual losses caused by specific diseases of lima beans for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Downy mildew	4.0
Root rots	2.0
Stem anthracnose	2.0
Seed decay	1.0
Seed pitting	.5
Bacterial blights	.3
Bacterial spot	.2
Total	10.0

Beans, green snap

Losses in snap beans are caused principally by fusarium root rot, rhizoctonia root rot, sclerotinia wilt, and virus-induced diseases including mosaics and curly top. Seed decay caused by soil fungi can result in considerable damage in certain seasons.

In humid areas and where hail occurs, the bacterial blights can be damaging. Rust is

TABLE 7.—VEGETABLES: *Estimated average annual losses due to diseases, 1951–60*

Commodity	Production unit	Loss from potential production [1] Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Artichokes	Hundredweight	5	18	162
Asparagus	do	9	347	4,073
Beans:				
Green lima	do	10	262	1,922
Green snap	do	20	2,586	17,651
Beets, table	do	3	115	145
Broccoli	do	2	46	369
Cabbage	do	8	2,229	3,973
Cantaloups	do	16	2,070	9,126
Carrots	do	8	1,284	3,845
Cauliflower	do	8	233	1,476
Celery	do	17	2,955	10,866
Corn, sweet	do	8	1,041	1,034
Cowpeas	Bushel	8	1,634	6,786
Cucumbers:				
Fresh market	Hundredweight	18	808	4,110
Greenhouse	do	8	2	42
Pickling	Bushel	11	1,645	2,261
Eggplant	Hundredweight	12	64	327
Escarole (endive)	do	6	46	214
Kale	do	8	16	70
Lettuce, field-grown	do	12	4,278	17,274
Melons, honeydew and honeyball	do	14	229	1,119
Mushrooms	do	16	243	6,813
Onions	do	20	5,379	13,901
Peas, green	do	23	2,656	11,976
Peppers, green sweet	do	14	450	3,752
Potatoes	do	19	45,052	89,527
Shallots	do	21	35	245
Spinach	do	20	1,009	3,753
Sweetpotatoes	do	18	2,173	8,932
Tomatoes:				
Fresh market	do	21	4,536	31,800
Greenhouse	do	20	[3] 124	[3] 4,038
Plant bed	Crate	8	----	[3] 522
Processing	Ton	22	916	23,868
Watermelons	do	10	3,125	4,417
Total				290,389

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Based on data from the 1959 Census of Agriculture.

common in the coastal sections in the South and recently has been of concern along the Atlantic Seaboard. The curly top virus causes little or no damage where snap beans are grown for market or processing but prevents their production in many western areas such as southern Idaho, eastern Oregon, and central Washington. The losses are due not only to reduced yield, but also to decreased pod quality because of decay and spotting.

Estimated average annual losses caused by various diseases of snap beans for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Fusarium root rot	6.0
Mosaics	3.0
Rhizoctonia root rot	3.0
Bacterial blights	2.0
Sclerotinia wilt	2.0
Curly top	1.0
Powdery mildew	1.0
Rust	1.0
Anthracnose	.5
Southern blight	.5
Total	20.0

Beets, table

Table beets are not generally injured greatly by diseases. Most losses are caused by seedling diseases, downy mildew, leaf spots, and boron deficiency (black spot). Black-root fungi cause damping-off of seedlings wherever beets are grown. Downy mildew is confined almost entirely to the Pacific Coast. Cercospora leaf spot is common east of the Continental Divide but does not cause severe losses. Boron deficiency is probably the most damaging disease of beets grown for canning in the Northern States. Losses are due not only to reduced yield but also to decreased quality because of root necrosis.

Estimated average annual losses caused by various diseases of table beets for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Downy mildew	1.0
Black spot (boron deficiency)	1.0
Black root	.5
Leaf spots	.5
Total	3.0

Broccoli

Downy mildew causes the greatest losses in broccoli; average annual losses for the period 1951–60 were estimated at 1 percent. The downy mildew fungus causes numerous black spots of different sizes, which reduce the quality of this crop wherever it is grown. Other diseases cause additional losses of 1 percent.

Cabbage

The diseases responsible for most losses in cabbage are fusarium yellows, blackleg, clubroot, watery soft rot, black rot, mosaic, and downy mildew. The losses are due to reduced yield, reduced size, and decay of the heads. Yellows caused by a soilborne *Fusarium* may occur wherever cabbage is grown. Blackleg is present in all parts of the Temperate Zone where susceptible crops are grown intensively. Clubroot is widespread in Northern United States, and watery soft rot may be destructive wherever cabbage is grown. Black rot occurs chiefly in humid areas. Mosaic occurs throughout the United States, but downy mildew is most prevalent in the coastal regions.

Estimated average annual losses caused by various cabbage diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Fusarium yellows	2.5
Clubroot	1.5
Blackleg	1.0
Watery soft rot	1.0
Black rot	.5
Others, including downy and powdery mildews, rhizoctonia root rot, and mosaic	1.5
Total	8.0

Cantaloups

Losses in cantaloups are caused chiefly by crown blight, leaf diseases, and virus diseases. The most damaging leaf diseases are downy and powdery mildews; anthracnose and alternaria leaf spots also cause some losses. Diseases caused by watermelon mosaic virus, squash mosaic virus, cucumber mosaic virus, and curly top virus are responsible for severe damage in the West. A disease caused by tobacco ring spot virus is serious in Texas. Minor losses are caused by bacterial wilt.

Losses from many of the diseases affecting cantaloups are regional. Crown blight is a major disease in the West, especially the Southwest. Downy mildew as a major disease is confined largely to the Atlantic Seaboard and the Gulf States. Anthracnose, alternaria leaf spot, and bacterial wilt are destructive only in humid areas east of the Continental Divide. On the other hand, powdery mildew is most destructive in Arizona and California. Mosaics are much more damaging in Arizona, California, Florida, Texas, and Washington than in the Central and Eastern States. Curly top is confined to areas west of the Continental Divide, where the insect vector, the beet leafhopper, occurs. The losses are due not only to a reduced yield but also to decreased quality because of fruit blemishes.

Estimated average annual losses caused by specific cantaloup diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Crown blight	4.0
Virus diseases	3.5
Powdery mildew	3.0
Downy mildew	2.5
Alternaria leaf spot	1.0
Anthracnose	1.0
Gummy stem blight	.5
Fusarium wilt	.3
Bacterial wilt	.2
Total	16.0

Carrots

Most of the disease losses in carrots during the period 1951–60 were caused by bacterial blight (estimated at 2 percent annually), alternaria and cercospora leaf blights (2 percent), and yellows caused by the aster yellow virus (2 percent). Losses caused by other diseases were also estimated at 2 percent, making a total of 8 percent.

Bacterial blight occurs chiefly in California and other Southwestern States. It occurs on both roots and seeds. Alternaria and cercospora blights, which attack the foliage, occur wherever carrots are grown. Aster yellows is restricted to Western United States. It not only reduces yield but also decreases the value of roots because of their atypical shapes and sizes.

Cauliflower

The diseases responsible for the greatest cauliflower losses are clubroot, black rot, blackleg, downy mildew, and mosaic. Annual losses estimated at 1 percent were caused by each of these during the period 1951–60, as compared with losses of 3 percent caused by miscellaneous other diseases.

Clubroot is widespread in the humid regions and blackleg is very widespread. Downy mildew is most prevalent in coastal areas and mosaic may occur throughout the United States. Losses are due to reduced yield, head discoloration, and curd damage.

Celery

Celery is subject to losses caused by leaf blights, fusarium yellows (wilt), virus diseases, and nonparasitic disorders. The major leaf diseases are early and late blights, but bacterial leaf spot caused some losses. Cucumber mosaic and western aster yellows each caused annual losses estimated at 2.5 percent during the period 1951–60. The major nonparasitic diseases are blackheart (caused by sudden saturation of the soil with water) and cracked stem (due to boron deficiency in the soil).

Most of the major diseases of celery occur wherever the crop is grown. Western aster yellows, which is limited to Western States, is damaging chiefly in California. Losses are due to reduced yield. In addition, blemishes and bitterness caused by some diseases reduce quality.

Estimated average annual losses caused by various celery diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Early blight	4.0
Late blight	4.0
Cucumber mosaic	2.5
Western aster yellows	2.5
Bacterial leaf spot	1.0
Blackheart	1.0
Cracked stem	1.0
Fusarium yellows	1.0
Total	17.0

Corn, sweet

The principal diseases that damage sweet corn are bacterial wilt and helminthosporium leaf blights.

Bacterial wilt occurs throughout the Corn Belt and in the Eastern United States. Smut, leaf blights, and seedling diseases occur in all corn-growing areas. In Florida, where corn acreages have increased, losses from leaf blights are severe if fungicides are not applied regularly. Smut also has been severe in Florida. Seedling diseases are more severe in cold and humid areas.

Estimated average annual losses caused by the various diseases of sweet corn for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Bacterial wilt	4.0
Helminthosporium leaf blights	2.5
Seedling diseases	1.0
Others, including smut	.5
Total	8.0

Cowpeas, edible

Throughout the growing areas the greatest losses in cowpeas during the period 1951–60 were due to fusarium wilt (estimated at 4 percent annually) and cladosporium leaf and pod spot (2 percent). Charcoal rot and mosaics each caused estimated losses of 1 percent. These losses were due not only to reduced yield but also to decreased pod quality because of blemishes and deformation.

Cucumbers, fresh market

Disease losses in cucumbers grown for fresh market are caused chiefly by downy mildew, anthracnose, angular leaf spot, and cucumber mosaic. Less severe losses are caused by various other diseases, of which scab is an example.

Loss from downy mildew is probably greatest, although the disease is confined to the Atlantic Coast. Anthracnose and angular leaf spot are widespread in humid regions east of the Continental Divide, and virus diseases are a major cause of losses in many cucumber-growing areas. Scab is troublesome chiefly in the northern tier of States from Minnesota to Maine, but it occurs on fall cucumbers in North Carolina and causes minor losses in Maryland and New Jersey. The losses are due not only to reduced yield but also to decreased quality because of blemished and deformed fruit.

Estimated average annual losses caused by various diseases of cucumbers grown for fresh market for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Anthracnose	3.5
Downy mildew	3.5
Angular leaf spot	2.0
Cucumber mosaic	2.0
Powdery mildew	1.5
Alternaria blight	1.0
Cercospora leaf spot	1.0
Tobacco ringspot	1.0
Watermelon mosaic	1.0
Scab	.5
Fusarium wilt	.3
Pythium fruit rot	.3
Bacterial wilt	.2
Diplodia fruit rot	.2
Total	18.0

Cucumbers, greenhouse

The principal disease losses in cucumbers in the greenhouse are caused by powdery mildew and cucumber mosaic. Occasionally there are minor losses from bacterial wilt and fusarium foot rot. All these diseases may occur and reduce yields wherever the crop is grown.

Estimated average annual losses caused by specific diseases of greenhouse cucumbers for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Powdery mildew	6.5
Cucumber mosaic	1.0
Bacterial wilt	.3
Fusarium foot rot	.2
Total	8.0

Cucumbers, pickling

The major disease losses in cucumbers grown for pickling are caused by cucumber mosaic, tobacco ringspot, scab, and angular leaf spot.

About 60 percent of the pickling cucumbers are grown in the North Central States, particularly Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. Another 25 percent are grown in Alabama, Georgia, Maryland, Mississippi, North Carolina, and South Carolina. California, Colorado, and Oregon produce most of the western crop. The relative severity of the various diseases is determined by the location. Mosaic is especially prevalent in the North Central States. Bacterial wilt, also common there, is rarely found in the South. Scab is most damaging in the northern tier of States from Minnesota to Maine. The losses are due not only to reduced yield but also to decreased quality because of fruit blemishes and deformation. Angular leaf spot is damaging some years in all production areas east of the Rocky Mountains. Tobacco ringspot causes losses from Texas northward into Wisconsin.

Estimated average annual losses caused by specific diseases of cucumbers grown for pickling for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Cucumber mosaic	2.5
Scab	2.5
Tobacco ringspot	2.0
Angular leaf spot	1.5
Alternaria leaf spot	.5
Anthracnose	.5
Downy mildew	.5
Powdery mildew	.5
Bacterial wilt	.2
Cercospora leaf spot	.2
Pythium fruit rot	.1
Total	11.0

Eggplant

The major diseases of eggplant are fruit rots and leaf diseases, which occur wherever the crop is grown but are most damaging in the South. Verticillium wilt causes some losses in the North. The losses are due to reduced yield and quality.

Estimated average annual losses caused by various eggplant diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Phomopsis blight	6.0
Cercospora leaf spot	2.0
Sclerotinia stem rot	1.5
Colletotrichum fruit rot	1.0
Verticillium wilt	1.0
Yellows	.5
Total	12.0

Escarole (endive)

Disease losses in escarole during the period 1951–60 were caused by stem and leaf spots (estimated at 2 percent annually), bacterial soft rot (2 percent), aster yellows (1 percent), and miscellaneous diseases (1 percent). All these diseases occur in Florida, where most of the crop is grown. Losses are due not only to reduced yield but also to decreased quality because of discoloration.

Kale

Blackleg, black rots, clubroot, downy mildew, and fusarium yellows—all are diseases of kale, a commercial crop only in Virginia. They each caused average annual losses estimated at 1 percent during the period 1951–60. In addition, miscellaneous diseases caused losses of 3 percent. The diseases reduced both yield and quality by stunting the plants and injuring the edible leaves.

Lettuce, field-grown

Field-grown lettuce is damaged severely by lettuce mosaic, a virus disease. Downy mildew, which withers the leaves, is another cause of heavy losses. Big vein and tipburn, the latter a nonparasitic disease, often damage lettuce. Bottom and sclerotinia rots decay stems and leaves.

Mosaic and downy mildew are widespread, particularly in the western growing areas, but aster yellows is found chiefly in the Northeastern States. Tipburn and bottom and sclerotinia rots occur wherever lettuce is grown. The greatest losses from disease are due to decreased quality caused by discoloration, deformities, and off-flavor.

Estimated average annual losses caused by various diseases of field-grown lettuce for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Mosaic	4.0
Downy mildew	3.0
Tipburn	1.5
Big vein	1.0
Aster yellows	1.0
Damping-off	.5
Others, including bottom and sclerotinia rots	1.0
Total	12.0

Melons, honeydew and honeyball

Honeydew and honeyball melons are damaged by crown blight, which caused average annual losses estimated at 6 percent during the period 1951–60. Severe losses are also caused by powdery mildew (4 percent). Stunting of the plants and reduced yields result from infection by the watermelon mosaic virus, curcurbit latent virus, cucumber mosaic virus, and squash virus (4 percent). All these diseases are present in Arizona and California, where nearly all the crop is grown. The losses are due not only to reduced yield but also to decreased quality because of blemishes and deformity of fruit.

Mushrooms

Losses in mushrooms, which occur wherever the crop is grown, are caused chiefly by pathogenic fungi and bacteria that deform and blemish the mushrooms and by weedmolds that compete with the mushrooms for nutrients in the compost. The weedmolds that cause most damage are olive green mold, mat, lipstick, and truffle. Bubbles and brown spot are the principal diseases caused by pathogens. Ocasionally these diseases cause almost total loss.

Estimated average annual losses caused by different diseases or molds of mushrooms for the period 1951–60 are as follows:

Disease or mold	*Average annual loss (percent)*
Bubbles	4.0
Brown spot	2.7
Olive green mold	2.0
Bacterial blotch	1.0
Green mold	1.0
Lipstick mold	1.0
Mat	.8
Truffle	.8
Mummy	.2
Red spot	.2
Bacterial pit	.1
Mildew	.1
Soft mildew	.1
Others	2.0
Total	16.0

Onions

Downy mildew, fusarium root rots, neck rot, ping root, purple blotch, and smudge cause more losses in onions than do other diseases. They reduce yields because the bulbs of infected plants remain undersized and rot.

Smudge occurs only on white onions. Downy mildew is most destructive in California, Louisiana, Michigan, New York, and Oregon. In unusually cool seasons it may become severe in the Midwest, Colorado, and Texas. Neck rot is most severe in upper North-central and Northeastern United States. Pink root is prevalent in the Rio Grande Valley and Central California. Fusarium root rots and purple blotch are present wherever onions are grown intensively.

Estimated average annual losses caused by the various diseases of onions for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Fusarium root rots	4.0
Neck rot	4.0
Pink root	3.0
Purple blotch	3.0
Downy mildew	1.0
Smudge	1.0
Others	4.0
Total	20.0

Peas, green

The greatest disease losses in green peas are caused by several root rots, all general in occurrence throughout the various pea-growing areas. Severe losses are often caused by five viruses that infect peas, particularly in the Pacific Northwest. Of less importance are wilts, and ascochyta and bacterial blights. The losses are due primarily to reduced yield.

Estimated average annual losses caused by the various diseases of green peas for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Root rots	10.0
Virus diseases	6.0
Ascochyta blight	2.0
Fusarium wilts	2.0
Bacterial blight	1.0
Powdery mildew	1.0
Others	1.0
Total	23.0

Peppers, green sweet

Disease losses in peppers are due principally to leaf spots, fruit spots and rots, and mosaics. Anthracnose fruit rot is also of economic importance, but it causes less damage than the leaf spots.

Leaf spots and fruit rots occur wherever peppers are grown in humid areas. Virus diseases are present in all pepper-growing sections. Fusarium wilt is most prevalent in the Southwest. Losses are due not only to reduced yield but also to decreased quality because of blemished, deformed fruit.

Estimated average annual losses caused by the various diseases of green sweet peppers for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Bacterial spot	6.0
Anthracnose	2.0
Fusarium wilt	1.5
Cercospora leaf spot	1.0
Phytophthora blight	1.0
Tobacco mosaic	1.0
Cucumber mosaic	.5
Potato mosaic caused by virus Y	.5
Tobacco etch mosaic	.5
Total	14.0

Potatoes

Potatoes in the field are severely injured by diseases. Late blight is manifested by foliage injury and tuber rot. It is a major cause of losses in many of the large producing areas in the Central and Atlantic States, and at times in some sections of California. Verticillium wilt is another major cause of losses, particularly in the West. Leaf roll, a virus disease, ranks with late blight and verticillium wilt as a cause of losses in potatoes; it reduces both yield and quality.

Less severe but important losses result from scab, early blight, rhizoctonia black scurf, fusarium wilt, blackleg, and ring rot. Most of these diseases may occur wherever potatoes are grown, but they are particularly prevalent in the North Atlantic, North Central, and Pacific Coast States. Since viruses are carried in seed tubers, virus diseases occur wherever potatoes are grown. Losses result not only from decreased yield and quality of tubers, but also from increased costs of production because of the necessity for planting certified seed and for keeping the plants comparatively free from infection.

Estimated average annual losses caused by various potato diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Late blight	4.0
Leaf roll	3.0
Verticillium wilt	2.7
Scab	1.5
Early blight	1.0
Latent mosaic	1.0
Mild mosaic	1.0
Rhizoctonia black scurf	1.0
Rugose mosaic	1.0
Blackleg	.5
Fusarium wilt	.5
Ring rot	.5
Spindle tuber	.2
Bacterial brown rot	.1
Others	1.0
Total	19.0

Shallots

Greatest losses in shallots are caused by yellow dwarf, a virus disease. Other losses are caused by the same diseases that occur on onions, largely in Louisiana, where the crop is grown.

Estimated average annual losses caused by various diseases of shallots for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Yellow dwarf	4.0
Pink root	3.0

Disease	*Average annual loss (percent)*
Downy mildew	2.0
Fusarium root rots	2.0
Neck rot	2.0
Purple blotch	2.0
Smudge	2.0
Others	4.0
Total	21.0

Spinach

Downy mildew, which damages the leaves, is a major cause of losses wherever susceptible varieties of spinach are grown, particularly in humid coastal areas. White rust is epidemic in Arkansas, Oklahoma, Texas, and Virginia but has not caused losses elsewhere. Damping-off is damaging to seedling plants in all plantings. Fusarium wilt causes losses in Texas and Virginia. Spinach blight is particularly severe on fall and winter crops. Curly top, which causes heavy losses west of the Continental Divide, limits production in some areas; occasionally the disease appears also in southwestern Texas. Malva yellows causes severe losses in California. Losses are due not only to reduced yield but also to decreased quality because of blemished leaves and petioles.

Estimated average annual losses caused by specific spinach diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Downy mildew	5.0
White rust	5.0
Damping-off	3.0
Malva yellows	2.0
Curly top	1.5
Anthracnose	1.0
Fusarium wilt	1.0
Spinach blight	1.0
Cercospora leaf spot	.5
Total	20.0

Sweetpotatoes

Field losses in sweetpotatoes are due primarily to stem rot and black rot. Stem rot causes losses in yield by killing from 10 to 50 percent of the crop of susceptible dry-flesh varieties in some areas. Black rot reduces yield in all areas where sweetpotatoes are grown. Yellow dwarf reduces yields; it is especially prevalent in California, Georgia, and New Jersey. Roots affected by internal cork are inedible, but it causes greater losses as a storage disease than as a field disease. Leaf spot, scurf, and soil rot all reduce yields and lower eating quality throughout the sweetpotato-growing areas.

Estimated average annual losses caused by specific sweetpotato diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Stem rot	7.0
Black rot	5.0
Yellow dwarf	2.0
Internal cork	1.5
Leaf spot	1.5
Scurf	.5
Soil rot (pox)	.5
Total	18.0

Tomatoes, fresh market

The diseases that cause the most severe losses in fresh market tomatoes are leaf spots, virus diseases, and fruit rots. The most important wilt is verticillium wilt, which affects the fresh market tomato crop to some extent in southern Florida and certain areas in the Midwest and the Middle Atlantic States. Defoliation associated with leaf spots reduces yields and exposes fruit to sunscald. Some leaf spots occur only on the foliage and stems, but other pathogens that infect leaves also cause rot of fruit. Septoria leaf spot and gray leaf spot are the chief diseases that affect only the leaves. Leaf mold causes minor losses. Early and late blights cause both leaf spotting and fruit rot; but late blight, always a major threat to tomatoes, is most injurious as a fruit rot. Most of these diseases are widespread in humid areas east of the Continental Divide. Leaf mold, however, occurs chiefly in the South Atlantic States, and gray leaf spot has spread from the South into the North Central and Middle Atlantic States. Bacterial wilt causes minor losses in Florida. Some fruit rots (anthracnose, soil rot, and buckeye rot) are caused by fungi that do not seriously affect the leaves, and they cause only minor losses to the fresh market crop.

Viruses infect tomatoes wherever they are grown. The tobacco mosaic virus causes some reduction in yield in most fields, but other viruses cause only minor losses east of the Rocky Mountains except in southwest Texas, where some losses occur most years.

Blossom-end rot, a nonparasitic disorder due to high temperatures and lack of soil moisture, causes some injury throughout the United States.

Estimated average annual losses caused by the specific diseases of fresh market tomatoes for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Tobacco mosaic	5.0
Gray leaf spot	3.0

Disease	Average annual loss (percent)
Verticillium wilt	3.0
Bacterial spot	1.0
Blossom-end rot	1.0
Curly top	1.0
Early blight (alternaria leaf spot)	1.0
Fusarium wilt	1.0
Bacterial wilt	.5
Late blight	.5
Leaf mold	.5
Septoria leaf spot	.5
Others	3.0
Total	21.0

Tomatoes, greenhouse

Leaf mold and tobacco mosaic continue to be the primary causes of fruit-production losses to greenhouse tomato growers. Blotchy ripening, gray wall, or internal browning of fruit may cause severe losses.

Estimated average annual losses caused by various diseases of greenhouse tomatoes for the period 1951–60 are as follows:

Disease	Average annual loss (percent)
Leaf mold	8.0
Tobacco mosaic	7.0
Tobacco streak	1.0
Others	4.0
Total	20.0

Tomatoes, transplant

Diseases were estimated to have caused total losses of 8 percent each year to the southern plant-bed tomato industry during the period 1951–60. Alternaria leaf spot (3 percent) and bacterial spot (2.5 percent) caused the greatest losses, mostly in Georgia. Rhizoctonia canker and alternaria stem canker caused estimated losses of 1 percent each, and late blight caused losses of 0.5 percent.

Tomatoes, processing

Diseases causing the most severe losses in tomatoes for processing are anthracnose in the East and verticillium wilt in the West. Some losses due to verticillium wilt occur in the Middle Atlantic States. Virus diseases and nonparasitic disorders are just as prevalent on tomatoes for processing as on fresh market tomatoes.

Estimated average annual losses caused by the various diseases of processing tomatoes for the period 1951–60 are as follows:

Disease	Average annual loss (percent)
Anthracnose	4.0
Verticillium wilt	4.0
Curly top	3.0
Fusarium wilt	2.0
Gray leaf spot	2.0
Bacterial spot	1.0
Tobacco mosaic	1.0
Others	5.0
Total	22.0

Watermelons

The anthracnose fungus, which can cause defoliation of vines and fruit rot, is the most damaging disease of watermelons. It is widespread in humid areas east of the Continental Divide. Downy mildew is severe in the Atlantic and Gulf States; watermelon mosaic in the South, particularly the Southwest; and tobacco ring spot in Oklahoma and Texas. Fusarium wilt causes considerable damage wherever the crop is grown. Some years gummy stem blight is severe in the South.

Estimated average annual losses caused by specific watermelon diseases for the period 1951–60 are as follows:

Disease	Average annual loss (percent)
Anthracnose	5.0
Fusarium wilt	2.0
Gummy stem blight	1.0
Watermelon mosaic	1.0
Downy mildew	.5
Tobacco ring spot	.5
Total	10.0

ORNAMENTAL PLANTS AND SHADE TREES

Estimates of disease losses in ornamental plants and shade trees (table 8) were limited to commercial plantings. Except for shade trees, the estimates do not include losses in home gardens and landscaping. The average annual reduction due to diseases for the period 1951–60 was estimated at $14,099,000. Important disease losses in home garden plantings are mentioned even though the percentage of loss is not reported.

Carnations

Continuous greenhouse culture of carnations, becoming a general practice, reduces the danger of losses from alternaria blight and rhizoctonia stem rot. Under greenhouse culture these two diseases cause losses in yield by reducing plant stands, and losses in flower quality and size by reducing foliar surface. In wet seasons alternaria blight builds up on plants maintained outside. Considerable losses caused by nonblooming for months occur when such diseased plants are used later for greenhouse forcing.

TABLE 8.—ORNAMENTAL CROPS AND SHADE TREES: *Estimated average annual losses due to diseases, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity [3]	Value [4]
		Percent	*1,000 units*	*1,000 dollars*
Carnations	Number	11	1,290	108
Chrysanthemums	do	11	30,374	2,669
Foliage plants	do	22		8,425
Geraniums	do	5	3,907	983
Gladiolus (corms)	do	20		625
Lilies	do	15	702	986
Roses	do	12	95	133
Shade and ornamental trees [5]	do	1	76	170
Total				14,099

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Number of plants or trees from the 1959 Census of Agriculture.
[4] Based on wholesale prices from the 1959 Census of Agriculture.
[5] Deciduous shade and flowering trees.

Average annual losses from these two diseases were estimated at 4 percent of the carnation crop for the period 1951–60.

Wilts, caused by *Fusarium* and bacteria, cause estimated annual losses of about 5 percent of the crop. These wilts kill plants in all stages of growth. Losses are twofold: Total bench space is not used efficiently and total flower production is decreased. The cost of maintaining disease-free propagating stock also reduces profits to carnation growers. Fusarium stem rot, a disease distinct from fusarium wilt, caused losses estimated at 2 percent.

Virus diseases have not proved to be a source of significant losses in commercial carnation varieties.

Chrysanthemums

Losses caused by chrysanthemum viruses to the greenhouse crop decreased during the 10-year period 1951–60. At the beginning of the period, viruses threatened to wipe out the industry. Plants infected with viruses such as stunt are a total loss, for they produce no flowers and are of no value for further propagation. Verticillium wilt kills the leaves progressively up the stem and thereby lowers the quality of the flowers and reduces the number of salable ones. Chrysanthemum diseases lead to increased costs per cutting, because of the specialized techniques required to produce disease-free stock. Disinfection and soil sterilization to control diseases caused by soilborne agents such as the wilts increase costs of production.

Bacterial wilt is associated with a brown to black soft rot of stems under warm, humid conditions. Under cooler and drier conditions the causal bacterium may remain inactive and unnoticed. Thus, infected plants may move in commercial trade and develop conspicuous symptoms when planted in warm, humid areas. Ascochyta blight, a disease of chrysanthemum flowers, stems, and leaves, is caused by a fungus active over a wide range of temperatures and adapted to survive and to develop over most of the United States. Botrytis blight destroys flowers, leaves, and stems of growing plants. Stemphylium ray speck disfigures flowers in field and packing houses during warm, wet weather.

Estimated average annual losses caused by chrysanthemum diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Ascochyta blight	2.0
Bacterial wilt	2.0
Botrytis blight	2.0
Stunt (virus)	2.0
Leaf spots	1.0
Stemphylium ray speck	1.0
Verticillium wilt	1.0
Total	11.0

In garden mums, leaf-spotting fungi defoliate the plants and reduce both the number and size of flowers, and the plants are killed by wilts. Losses caused by viruses are high in the garden crop wherever mums are grown.

Foliage plants

Damping-off of cuttings of foliage plants and root and stem rots caused by species of *Pythium, Phytophthora,* and *Rhizoctonia* deplete stands. Bacterial soft rots of the leaves and stem of aroids such as caladiums cause heavy losses in foliage-plant nurseries.

A few leaf spots may make foliage plants unsalable. Several fungi disfigure leaves of foliage plants and cause considerable damage if they are not controlled by sprays. Labor and spray materials to control foliar diseases add to the growers' expenses.

Estimated average annual losses caused by diseases in foliage plants for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Damping-off	7.0
Bacterial soft rot	6.0
Stem rots	6.0
Leaf spots	3.0
Total	22.0

Geraniums

During cutting, geraniums (*Pelargonium*) are subject to losses from krinkle virus and other diseases; during greenhouse culture, to losses from bacterial leaf spot and rots caused by *Pythium;* and in garden plantings, to losses from verticillium wilt, virus yellows, and other diseases. Geranium losses from these diseases amounted to an estimated 5 percent annually during the period 1951–60. Losses are caused by killing plants or lowering their vigor, by rotting cuttings, and by reducing flower quality. Yields of salable plants are lowered.

Gladiolus

During the period 1951–60 the gladiolus industry experienced heavy losses due to diseases. Large expenditures were involved in postharvest and preplanting sorting and chemical treatment of corms, in quick drying corms after harvest, in rotation of fields, and particularly in replacement of stock. In spite of using the best available control measures, growers may lose from 5 to 40 percent of susceptible varieties. Fusarium corm rot causes the greatest loss in warm soils; it is outranked by stromatinia dry rot and botrytis blight in cooler areas. Cucumber mosaic and virus-induced stunt are gaining recognition as causes of cull plants.

Botrytis blight affects all parts of the gladiolus plant, and losses are severe in cool, moist weather. Botrytis causes corm rot in the Northern States when weather is wet at harvesttime and it causes damaging leaf spot in all growing areas during wet weather.

Curvularia blight losses are most severe in young stock grown from seed or cormels. Losses are caused by defoliation of plants and rotting of corms.

Fusarium corm rot occurs in the field and in storage wherever gladiolus are grown. A large number of plants die in warm soils in spite of the best available control measures.

Stromatinia dry rot of gladiolus corms, associated with neck rot in plants in the field, results in premature yellowing and death of tops and mummification of corms. In cool, moist climates, losses are as high as from botrytis blight.

Losses from stemphylium leaf spot occur from Florida to New York at medium temperatures following cool periods. Varieties differ in susceptibility and hence the losses depend on the variety grown. Leaf surface is reduced and plant vitality is lowered, and lower quality flowers and smaller corms result.

Cucumber mosaic is manifest by white streaks in leaves, stripe breaks in flowers, and short stems. In Northeastern States some infected cultivars are completely destroyed and eliminated each year by cucumber mosaic virus.

Infection by the stunt virus makes spikes, plants, and leaves short. Infected plants are a complete loss because they are too short for the cut-flower market.

Estimated average annual losses caused by specific gladiolus diseases for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Fusarium corm rot	5.0
Stromatinia dry rot	5.0
Botrytis blight	3.0
Cucumber mosaic	2.0
Curvularia blight	2.0
Stunt (virus)	2.0
Stemphylium leaf spot	1.0
Total	20.0

Lilies

In the Southeast, where bulbs are produced for greenhouse finishing as cut blooms, production has been sharply limited by necrotic fleck, a virus complex transmitted by aphids. Fleck-diseased plants are unsalable because they are dwarfed and foliage is curled. Flowers are unsalable because they are subnormal in size, fail to open fully, and are distorted and streaked. The affected plants produce undersized bulbs that cannot be sold. Spray costs for controlling aphids are high, and the frequent replacement of planting stock from uncontaminated areas is expensive. The Creole cultivar has practically disappeared because of fleck.

In the Northwest, where bulbs are grown for the Easter potted plant trade, scorch, due to nutritional imbalance, causes tipburn of leaves of the cultivar Croft. Scorch reduces bulb yields. A root-rot complex, involving fungi, nematodes, and symphyllids, causes serious losses to Croft. The roots are killed, plants stunted, leaves scorched, and buds blasted.

The bulb yields of Easter and garden lilies are reduced by botrytis blight and fusarium rot. Flowers of the more susceptible lilies, such as Madonna and Testaceum cultivars, are completely ruined. Botrytis blight is more prevalent in cool, moist weather, whereas fusarium rot causes losses in warm, moist soils. The flowering stems are stunted and hence unsalable. Bulbs are rotted and yields reduced. Scales from diseased bulbs are unsalable for further propagation.

Estimated average annual losses caused by specific diseases in lilies for the period 1951–60 are as follows:

Disease	*Average annual loss (percent)*
Botrytis blight	4.0
Fusarium rot	4.0
Necrotic fleck (virus complex)	4.0
Scorch	3.0
Total	15.0

Roses

Black spot occurs wherever roses are grown in humid areas and causes greater losses than any other rose disease. It causes defoliation and subsequent dieback and killing, predisposes the plants to winter killing, and reduces flower production. Losses are extremely high in home gardens. In commercial plantings the disease is controlled at great expense for spray material and labor costs. Rose black spot caused average annual losses during the period 1951–60 estimated at 8 percent.

Rose powdery mildew, a common disease in humid areas, is especially prevalent in greenhouses. Despite consistent spray programs, yield is reduced by the disease or by the phytotoxic effects of the necessary spray. The leaves and buds are distorted and the badly affected flowers are valueless. Affected buds often do not open. Estimated average annual losses of 4 percent are attributable to this disease.

Shade and ornamental trees

Over 1,000 species and varieties of native and introduced shade and ornamental trees are grown in home grounds, on farmsteads, in parks, and along streets and highways. No species is immune from disease. A conservative estimate of trees killed annually by diseases would be 1 percent. Some disease-producing organisms kill the trees, some weaken them so that they are unsafe, and others kill the tops and reduce growth. Examples of killing diseases and the regions in which they are present are: Dutch elm disease, the most destructive shade tree disease in the Northeast and Midwest; elm phloem necrosis and oak wilt in the Midwest; mimosa wilt in the Southeast; and cankerstain of London planetree in the Middle Atlantic States. There are hundreds of canker diseases, wood rots, leaf diseases, and root diseases of shade and ornamental trees. The total losses from these diseases in terms of reduced growth and impaired esthetic value cannot be estimated accurately on the basis of available information.

No definite information is available on the total cost of protecting shade trees from diseases and of replacing those killed or structurally weakened. A conservative estimate of the average cost of removing one large dead tree and replacing it with a small tree is $20 to $50. Recently the low bid for tree removal in one eastern city was $113 per tree. In one large midwestern city the budget for shade tree care, mostly control of Dutch elm disease, was $750,000 in 1961. Bond issues for $2,500,000 were passed by one midwestern city for Dutch elm disease control. Losses from shade tree diseases are continuous, but in a given locality may increase greatly for a few years when an epidemic such as Dutch elm disease strikes.

CROP LOSSES FROM AIR POLLUTANTS

Plant damage from air pollution was recognized during the past century. The classical example of damage resulting from such acid fumes as sulfur dioxide, chlorine, and fluorides emanating from industrial plants is well known. During the 1950's a form of air pollution resulting from photochemical reactions in the atmosphere was recognized in widely separated parts of the United States. Two important toxicants identified from these reactions are ozone and peroxyacetyl nitrate. These compounds result when hydrocarbons and nitrogen oxides from automobile exhausts and other combustion sources react in the presence of sunlight. Photochemical air pollution has been identified as causing plant injury in 25 States and the District of Columbia. With increasing population and industrialization the potential agricultural damage from this source will undoubtedly increase.

Losses due to various forms of air pollution are difficult to estimate, and only limited reliable data are available. Losses are relatively easy to estimate when pollution is severe enough to cause chlorosis or necrosis of leaves of plants such as lettuce, spinach, and tobacco; to injure flowers and ornamental crops such as orchids enough to reduce their value or make them unsalable; or to kill the plants. Plant growth, however, is reduced without visible injury. Under such conditions damage to crops is difficult to assay but can be demonstrated by measurements of growth rates, leaf area, fresh and dry weights, size and quality of fruit, and yields. Accumulation of fluorides in forages and vegetable crops may prevent their use as feed and food.

In southern California, visible damage to crops from photochemical air pollution was estimated at over 3 million dollars in 1953 and over 8 million dollars in 1958. More recently crop losses in California probably reached 10 million dollars. In Connecticut losses to the cigar wrapper tobacco crop were estimated at 3 to 5 million dollars in 1955 and 1959. Most of the loss in 1959 occurred on a single weekend in mid-July. In 1959 truck crops in New Jersey were damaged by air pollutants. Damage to vegetation in urban and suburban areas, where it is known that plants are more likely to be affected, has not been estimated. Estimates of annual losses to agricultural crops from air pollutants due to growth suppression, delayed maturity, reduction in quality, reduction in yields, and other factors range from 150 million dollars to 500 million dollars for the period 1951–60, but an average of 325 million dollars was used in calculating the total losses due to plant diseases.

Chapter 3.—Nematode Damage to Crop Plants

The gross effects of heavy infection by plant-parasitic nematodes are malformation of the plant parts attacked and interference with their normal growth and function. Nematode damage is often extended by bacteria and fungi that invade the damaged tissue and cause general rotting. If enough of the root system on a plant is damaged, growth of the plant is limited, and it shows signs of malnutrition and lack of water. Thus, nematode damage often reduces growth and yield.

In addition to reducing yield, nematode damage may also reduce the quality of produce. Root-knot nematodes cause conspicuous galls on beets, carrots, and potato tubers. The damaged vegetables are discarded as culls at harvest. The wheat nematode causes galls to form instead of wheat grains; the galls mixed with the wheat reduce its grade. Fruit from citrus trees heavily infected by citrus nematodes is smaller than fruit from normal noninfected trees. The same is often true of fruit from other nematode-infected crop plants.

Some species of nematodes transmit disease-producing viruses, but their importance in field spread of viruses cannot be evaluated fully. However, vineyards from which fan leaf-infected grape vines have been removed cannot be replanted with virus-free plants for several years because nematodes transmit the virus from infected grape roots remaining in the ground to the new vines.

Estimating nematode damage in the field is subject to the variables and complications common to all crop loss estimates plus the difficulty or impossibility of identifying nematodes except with a microscope. For this reason, nematode damage often escaped notice in the past or was attributed to some other cause. With the increasing use of nematocides in experimental work and by growers since 1950, it has become possible to measure differences in growth between nematode-infected and nematode-free plants. The best information on the effects of nematodes on plants has come from comparisons between the growth of plants on soil to which a nematocide had been applied and on adjacent untreated soil. Estimated average annual losses due to nematodes are given in table 9 for 18 farm crops widely grown in the United States. No data are available for the others or for losses to the multimillion dollar a year ornamentals and nursery business; leaf nematodes cause estimated annual losses of 1 percent to the chrysanthemum industry, for example.

FIELD AND FORAGE CROPS

Losses from nematodes have been estimated for eight field and forage crops: Alfalfa, corn, cotton, lespedeza, peanuts, soybeans, sugarbeets, and tobacco. The estimated average annual losses caused by nematodes in these eight crops total $300,041,000 (table 9). Losses for all field crops would be considerably more.

Alfalfa

Of the nematodes that attack alfalfa, the best known are the stem nematode, species of root-lesion nematodes, and several species of root-knot nematodes. These nematodes have been reported from all parts of the United States in which alfalfa is grown. Where alfalfa is grown in rotation with annual crops, the root-knot nematodes that increase on alfalfa may also damage the rotation crop.

Corn

Corn is attacked by several species of root-knot nematodes, sting nematode, stubby-root nematode, root-lesion nematode, stunt nematode, and others. Nematode damage is often severe; in 41 experiments, mostly in the Southern States, the average yield on nematocide-treated plots was 33 percent more than on untreated plots.

Cotton

Cotton is attacked by several kinds of nematodes, of which the best known are the cotton root-knot nematode and the southern root-knot nematode. Nematodes occur wherever cotton is grown in the United States and take a steady toll year after year. Often associated with damage from root-knot nematode is fusarium wilt. Research on the two in combination has developed nematode- and wilt-resistant varieties. In scattered fields in the Southeast, severe damage due to sting nematode is not uncommon. Damage to cotton by reniform nematode has been reported in several locations in Louisiana.

TABLE 9.—*Estimated average annual losses to various crops caused by nematodes, and cost of nematode control*

Crop group and commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Field and forage crops:				
Alfalfa	Ton	3	2,195	48,581
Corn	Bushel	3	103,263	131,821
Cotton	Bale	2	310	50,153
Lespedeza	Pound	3	4,109	457
Peanuts	do	3	53,544	5,755
Soybeans	Bushel	2	9,179	20,405
Sugarbeets	Ton	4	605	6,814
Tobacco	Pound	3	66,382	36,055
Total				300,041
Fruit crops:				
Lemons	Ton	4	26	1,782
Oranges	do	4	229	12,853
Peaches	Bushel	4	2,826	5,658
Raspberries	Quart	4	23,618	4,134
Total				24,427
Vegetable crops:				
Beans:				
Green lima	Hundredweight	5	131	961
Green snap	do	5	646	4,413
Cantaloups	do	5	647	2,852
Potatoes	do	4	9,484	18,848
Tomatoes:				
Fresh market	do	8	1,728	12,114
Processing	Ton	8	333	8,679
Total				47,867
Total, all crop groups				372,335
Cost of controlling nematodes				16,000
Grand total				388,335

[1] See table 2, footnote 1.

[2] See table 2, footnote 2.

Lespedeza

In all parts of the country where it is grown, lespedeza is attacked by a variety of nematodes. In the Southeast, damage due to attacks by various species of root-knot nematodes is often very severe, and root-knot nematodes that increase on lespedeza injure crops grown in rotation with it. Lespedeza is also reported as a good host of the stubby-root nematode, the soybean cyst nematode, and the recently discovered lespedeza cyst nematode.

Peanuts

Wherever peanuts are grown, they are subject to attack by two species of root-knot nematodes, by the root-lesion nematode, and in the sandy soils of the Southern Coastal Plain by the sting nematode. Damage from a heavy infestation of any one of these can be severe; reductions in yield of more than 50 percent are not uncommon. The damage is due partly to reduced yields because of root damage and partly to loss of pods because of rotting of the stems. Often root-lesion nematodes invade the shells and cause brown lesions, which reduce the grade. Brown lesions are particularly serious on peanuts sold in the shell.

Soybeans

Soybeans in the Southeastern States are widely attacked by the southern root-knot nematode and the cotton root-knot nematode; in the States north of the Ohio River by northern root-knot nematodes. In all parts of the United States soybeans are attacked by various species of root-lesion nematodes. The soybean cyst nematode has been found infesting about 70,000 acres of soybeans in parts of eight States. Where the soil is heavily infested by any of these nematodes, yields of soybeans are reduced. The best information on reduction of yield by nematodes is available for the soybean cyst nematode. In sandy soils of the Coastal Plain in North Carolina, it can reduce yields as much as 75 percent. In the Mississippi Valley, yield reductions of 30 percent have been reported.

Sugarbeets

The nematode of most concern to sugarbeet growers is the sugarbeet nematode. It has been found in nearly all sugarbeet-growing regions of the United States. In some locations it is a major pest. In addition, sugarbeets are attacked by several species of root-knot nematodes; they are a serious problem in California. In Colorado, Nebraska, and Wyoming, sugarbeets are attacked by the hairy-gall nematode. Reductions in yield often amount to more than 50 percent.

Tobacco

Probably the data on reduction of yields of tobacco in the Carolinas, Florida, Georgia, and Virginia are the best-documented information available on damage due to nematodes. The nematodes most common on tobacco in these States are species of root-knot nematodes (mostly cotton root-knot nematodes), tobacco stunt nematode, and species of root-lesion nematodes. All these nematodes damage the root systems and reduce yields. In 151 experiments, mostly in North Carolina, yield reductions averaged 13 percent with reductions of 30 to 50 percent in some fields.

FRUIT CROPS

Losses from nematodes have been estimated for four fruit crops: Lemons, oranges, peaches, and raspberries. The estimated average annual losses caused by nematodes in these four crops total $24,427,000 (table 9). Loss data for other fruit crops and for nut crops are not available.

Citrus fruits

The best known nematode pest of citrus in all citrus-growing regions of the United States is the citrus nematode. It is said to infect 95 percent of citrus trees in California and is known to occur on a considerable proportion of citrus trees in other parts of the United States. In Florida, an intensive survey indicated that several thousand acres of citrus are infected by the burrowing nematode. In addition, species of root-lesion nematodes, sting nematode, and others are widely distributed on citrus. Nematodes attack the feeder roots and initiate rots, which are extended by bacteria and fungi. If enough roots are damaged, the tree declines. Leaves may be abnormally small and have poor color; twigs without leaves appear at the top of the tree; and fruit production declines, partly because of decreased size of the fruit. Extensive data are not available, but where citrus nematodes were controlled in producing citrus groves in Arizona, yields were increased an average of 25 percent. In similar experiments in California, yield increases of about 20 percent were reported.

Peaches

Peaches in Southeastern United States and California are often attacked by root-knot nematodes (mostly cotton root-knot and Javanese root-knot nematodes). The root system is distorted and reduced by heavy infections, and the tree grows and produces poorly. In only a few experiments could nematode-infected and nematode-free trees be compared. In these experiments, yields from the nematode-free trees were 50 percent or more higher than from the nematode-infected trees.

Raspberries

The principal nematode pests of raspberries are the root-lesion nematodes, found wherever raspberries are grown in the United States. Root-lesion nematodes destroy cells of the root cortex and lead to general root rot if the damage is extended by bacteria and fungi.

VEGETABLE CROPS

Losses from nematodes have been estimated for six vegetable crops: green lima beans, green snap beans, cantaloups, potatoes, tomatoes for fresh market, and tomatoes for processing. The estimated average annual losses caused by nematodes in these six crops total $47,867,000 (table 9). The total for all vegetable crops cannot be estimated because data are lacking.

Beans

Green lima and snap beans are attacked by various species of root-knot nematodes in the Southern States. These nematodes cause root damage, which reduces growth and yield. Losses range from negligible to as much as 75 percent.

Cantaloups

In the warmer parts of the country cantaloups are often heavily infected and seriously injured by several species of root-knot nematodes. Heavily attacked plants have much reduced and thinned root systems and grow and produce poorly. In 17 experiments in the Southeast, cantaloups infected with root-knot nematodes produced 33 percent less than plants on adjacent plots treated with nematocides.

Potatoes

Potato roots and tubers are attacked by various nematode species, of which the most important are root-knot nematodes, root-lesion nematodes, the golden nematode, and the potato-rot nematode. Attack on the roots reduces yield. Invasion of the tubers by root-knot nematodes causes formation of knots; root-lesion nematodes cause dark-colored, partly decayed spots on the surface of the tubers; and potato-rot nematodes cause internal rotting. In fields heavily infested by nematodes, yields are low and there are many culls. In 14 experiments in Idaho, Nevada, New York, and Ohio, the average yield on nematocide-treated plots was 75 percent more than on untreated plots.

Root-knot nematodes are found in all parts of the United States where potatoes are grown. In the Northern States, the species is almost invariably the northern root-knot nematode; in the Southern States, it may be the cotton root-knot nematode or another species. Root-lesion nematodes are also widely distributed in the potato-growing regions of the United States. The golden nematode has been found in the United States on only about 13,000 acres on Long Island, N.Y. Over half of this area has been sold for real estate development and is no longer used for farming; the remainder is under strict quarantine. The potato-rot nematode has been found in potato fields in Idaho and Wisconsin, where strenuous efforts are being made to exterminate it.

Tomatoes

Probably the most important nematode parasites of tomato are various species of root-knot nematodes, which are widely distributed over the United States. Heavy infections of cotton root-knot nematodes are common in the warmer parts of the country. In the North, the northern root-knot nematode is the species generally found. All root-knot nematode species cause galling of the roots, which interferes with their efficiency. If a large portion of the root system is affected, the plant grows and produces poorly. In 64 experiments reported from Arizona, California, and Georgia, the average increase in yield on plots where nematocides were used was 72 percent more than on adjacent untreated plots.

Chapter 4.—Injurious Crop Insects

According to the Yearbook of Agriculture for 1952, approximately 10,000 species of insects in the United States are important enough to be called public enemies. About four-fifths of them are injurious to crops. They reduce the yield, lower the quality, contaminate the marketed product, and increase the cost of producing, processing, and marketing the crop. Many species, however, are limited in distribution and cause only occasional damage.

Estimates of the losses caused by insects in this country have been assembled by different workers at various times, but no adequate basis is available for estimating the total loss by all destructive species. Estimates that have been made concern only a few species, chiefly those of major economic importance. Persons attempting to develop estimates soon find that many variables and complicating factors make the task a formidable one. For instance, the crop damage caused by one species differs from year to year and from one area to another. Furthermore, most insects of economic importance tend to appear in cycles of abundance. Some of them inflict heavy losses each year while others cause little or fairly uniform damage for several years, followed by an upsurge of damage when they reach outbreak proportions.

Insect losses to many crops in any one year differ greatly from those of a few years earlier. Some pests, particularly those not native to this country, have spread to new areas and have thus extended their damage. Examples are the spotted alfalfa aphid, the cereal leaf beetle, and the face fly. Other insects have modified their habits and have become pests of economic importance on crops not previously attacked. For example, the green peach aphid did not become an important problem on tobacco until about 1946.

Changing agricultural conditions and practices also affect insect losses. In 1935, the tomato pinworm was a major pest of the tomato crop in southern California. This insect has become of minor importance chiefly because of changes in cultural practices that involve destruction of crop remnants. The development of new insecticides has appreciably changed the situation with respect to many insects. The chlorinated hydrocarbon, organic phosphorus, and carbamate insecticides have, for the first time, made it practicable to control insects on some crops. But along with their widespread use have come such complicating problems as the resistance of certain pests to some of the materials that at first provided good control, and the hazards of insecticides and their residues to man and animals.

Estimates of losses for selected insects attacking field, forage, seed, fruit, nut, vegetable, and horticultural specialty crops are given in tables 10 to 15. Included also are estimates of losses caused by insects to turf, landscape flowers and ornamentals, and the honey bee industry. Altogether these losses total $3,812, 906,000.

The average annual losses in value for the various crop groups during production, and for honey bees, are shown in table 10. Insects other than those included in these estimates cause considerable losses to crops grown in the United States. However, with available data, dependable estimates of these additional crop losses cannot be made.

Insects, including aphids, beetles, grasshoppers, leafhoppers, and thrips, are known as vectors of many viruses that infect cultivated crops and cause heavy losses. Such crop losses, for which insect vectors of plant diseases share an important part of the responsibility, are considered in chapter 2. The following examples illustrate the importance of insect vectors of plant diseases.

TABLE 10.—*Estimated average annual losses caused by insect pests to various groups of crops and to honey bees, 1951–60*

Crop group	Average annual loss
	1,000 dollars
Field crops	1,482,325
Forage crops (alfalfa)	242,905
Seed crops	25,927
Rangelands	80,000
Turf	827,000
Fruit and nut crops	121,295
Vegetable crops	185,892
Landscape flowers and ornamentals	768,000
Horticultural specialties	79,062
Honey bees	500
Total	[1] 3,812,906

[1] For cost of controlling crop insects, see table 51.

Aphids are responsible for transmitting infection of yellows viruses to sugarbeets in Arizona, California, and Washington, and to strawberries in Washington and most other States; and they carry cucumber mosaic and watermelon mosaic to cantaloup and other melons. In Arizona and California these insects transmit lettuce mosaic, and in the Pacific Northwest they also carry the iris mosaic of bulbous iris, the tulip mosaic of tulips, the narcissus mosaic of narcissus, and the necrotic fleck of Easter lily bulbs. Aphids are also vectors of sugarcane mosaic in Florida and Louisiana, and of barley yellow dwarf of small grains throughout the United States.

In Eastern United States aphids transmit aspermy virus from infected chrysanthemums to tomatoes and are vectors of dahlia and narcissus mosaic. The green peach aphid is a vector of more than 50 kinds of plant viruses, including several that infect potatoes and cause severe losses to that crop.

The beet leafhopper transmits the curly top virus to beans, cucumbers, pumpkins, squashes, sugarbeets, and tomatoes in Western United States. The plum leafhopper carries peach yellows to peach trees, and other leafhoppers are vectors of phony peach and other diseases of peach. In Kansas and neighboring States, the wheat curl mite transmits wheat streak mosaic, a serious virus disease of wheat.

The six-spotted leafhopper is responsible for introducing into the Eastern States the western strain of aster yellows, which infects dahlia, zinnia, carrots, and celery in New Jersey and New York. Losses from aster yellows transmitted by the leafhopper to lettuce were so severe in western Maryland and southwestern Pennsylvania that production of the crop in that area had to be discontinued.

Three species of cucumber beetles transmit squash mosaic to squash and bacterial wilt to cucurbits in eastern vegetable-growing areas; and corn flea beetles spread bacterial wilt in sweet corn.

Insects also transmit plant diseases to alfalfa, clover, lupines, citrus, elm, grapes, onions, tobacco, and other plants, and additional instances of the insect vector–plant disease relation will likely be discovered.

FIELD CROPS

As indicated in table 11, estimated average annual losses caused by insects to field crops are $1,482,325,000.

Corn and sorghum

Corn rootworms (northern, southern, and western) are very destructive to corn. Although these insects are present throughout most of the Corn Belt, they are most serious in Iowa, Kansas, Minnesota, Nebraska, South Dakota, and Wisconsin, where they have developed resistance to previously recommended insecticides. Larvae of the rootworms feed on the roots of the corn plants, causing the plants to lodge and reducing crop yield.

The corn earworm is a most destructive enemy of field corn, sweet corn, and popcorn. In addition, it infests alfalfa, cotton, peanuts,

TABLE 11.—FIELD CROPS: *Estimated average annual losses due to insects, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Barley	Bushel	5	20,177	19,787
Beans, dry	Hundredweight	20	4,027	29,335
Corn	Bushel	12	413,051	527,285
Cotton	Bale	19	2,943	476,457
Hops	Pound	15	8,140	3,829
Mint [3]	do	15	468	2,211
Oats	Bushel	4	57,006	37,794
Peanuts	Pound	3	53,544	5,755
Peas, dry	Hundredweight	6	229	1,030
Rice	do	4	2,214	10,742
Sorghum (grain)	Bushel	9	33,866	34,072
Soybeans	do	3	13,768	30,607
Sugarbeets	Ton	12	1,815	20,441
Sugarcane	do	15	1,243	8,818
Tobacco	Pound	11	243,355	132,179
Wheat	Bushel	6	74,533	141,983
Total				1,482,325

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Peppermint and spearmint.

sorghums, soybeans, tobacco, and vetch, and tomatoes and other vegetable crops. Larvae of the corn earworm feed on the buds or central shoots of young corn plants, stunting them and reducing the yield. Later the worms go down through the silks of the ears and destroy many of the kernels. Sometimes they chew off the silks and prevent pollination. Their feeding in the ears also allows molds to enter, which increases the total damage.

The European corn borer is one of the most injurious pests of field and sweet corn in the United States. Discovered in Massachusetts and New York in 1917, the corn borer has spread westward until it now infests the entire Corn Belt; it reaches to the eastern edges of Colorado and Montana, and occurs southward as far as Alabama, Arkansas, Georgia, Louisiana, northern Mississippi, northeastern Oklahoma, and South Carolina. The European corn borer reduces the yield and increases the cost of harvesting by causing broken stalks, poor ear development, and dropped ears. Maximum damage by this insect occurred in 1954, when losses to field corn were estimated at $261,415,000.

The southwestern corn borer is a pest of corn in parts of Arizona, Arkansas, Colorado, Kansas, New Mexico, Oklahoma, and Texas, and in a few counties in Alabama, Louisiana, Mississippi, Missouri, and Tennessee. The larvae feed on the leaves of the young corn plants, and retard their growth. The larvae also damage the ears and girdle and tunnel the stalks. This damage weakens, stunts, and sometimes kills the plants. The girdling and tunneling in the lower part of the stalks in the fall cause many plants to fall over, and their ears are lost at harvesttime.

Chinch bugs, corn earworm, sorghum midge, and sorghum webworm may cause severe injury to grain sorghums. Insects that do less damage to grain sorghums include the corn leaf aphid, cutworms and armyworms, and the southwestern corn borer.

Estimated average annual losses in yield of corn and grain sorghums caused by specific insects for the period 1951–60 are as follows:

Crop and insect	*Average annual loss (percent)*
Corn:	
Corn earworm	4.0
European corn borer	3.5
Corn rootworms	2.1
Grasshoppers	.6
Fall armyworms	.5
Corn leaf aphid	.4
Chinch bug	.2
Southwestern corn borer	.2
Other insects	.5
Total	12.0
Grain sorghums:	
Corn earworm	4.1
Sorghum webworm	1.4
Chinch bug	1.3
Sorghum midge	1.1
Cutworms and armyworms	.5
Corn leaf aphid	.4
Southwestern corn borer	.2
Total	9.0

Cotton

The boll weevil reduces cotton yields more than any other pest. Seventy-eight percent of the cotton acreage in the United States is infested with this insect. The boll weevil occurs where cotton is grown from the eastern two-thirds of Oklahoma and Texas east to the Atlantic Ocean. Damage varies between States and between years. The adult weevils puncture the cotton squares and bolls and the females lay their eggs in them. Larvae develop inside the fruiting forms. Many of the punctured squares and small bolls are shed by the plants. Infested large bolls that remain on the plant often produce no cotton, or only a little of inferior quality.

The bollworm and tobacco budworm, two closely related pests, reduce cotton yields. The adult moths lay their eggs on the tender growth of cotton plants and the larvae hatching from them feed on the squares and bolls. Damage often occurs so late in the season that the plants do not have time to mature another crop of bolls. The bollworm usually causes its greatest damage in the Southwest and West.

Lygus bugs are major pests of cotton in the West; in the Southwest the cotton fleahopper ranks after the boll weevil and bollworm as a serious pest. These and other hemipterous insects injure the cotton plant by feeding on the juices from the tender parts.

Appreciable reduction in cotton yield can be attributed to the beet armyworm, cabbage looper, cotton aphid, cotton leaf perforator, cotton leafworm, pink bollworm, spider mites, thrips, and other insects that sometimes attack cotton. The cotton leaf perforator is of major economic importance in the West, and thrips cause considerable damage in several areas. Infestations by some of these pests are sporadic and considerable damage is frequently inflicted to the crop before growers realize the need for control measures.

Estimated average annual losses in yield of cotton caused by insects for the period 1951–60 are as follows:

Insect	Average annual loss (percent)
Boll weevil	8.0
Bollworms	4.0
Lygus bugs, cotton fleahopper, and other sucking insects	3.4
Thrips, spider mites, cotton aphid, cabbage looper, cotton leaf perforator, pink bollworm, beet armyworm, cotton leafworm, and other insects	3.6
Total	19.0

Hops

Spider mites adversely affect the yield and quality of hops by puncturing the lower leaf surfaces and withdrawing the plant sap. The hop aphid also feeds on the plant sap, reducing the yield of the harvested crop and lowering its quality by contamination with insect fragments and excrement. The corn earworm, the hop butterfly, the hop looper, and various cutworms and armyworms chew the foliage; and cucumber beetles, the garden symphylan, root weevils, white grubs, and wireworms feed on the roots of hops.

Estimated average annual losses in yield of hops caused by insects for the period 1951–60 are as follows:

Insect	Average annual loss (percent)
Spider mites	6.0
Aphids	4.0
Other insects	5.0
Total	15.0

Mint

The two-spotted spider mite is the most widely distributed pest of peppermint and spearmint, and causes greatest losses to the crop. The cabbage looper, the mint looper, and various cutworms feed on the leaves of mint plants and are especially destructive in the Midwest. Aphids and the mint flea beetle also feed on the leaves, especially in the Northwest. Root weevils and the garden symphylan commonly attack the roots of the plants, and losses from these insects may accumulate before their damage is recognized.

Estimated average annual losses in yield of mint caused by specific insects for the period 1951–60 are as follows:

Insect	Average annual loss (percent)
Spider mites	7.0
Caterpillars and flea beetles	4.7
Soil insects	2.1
Aphids	1.2
Total	15.0

Peanuts

The southern corn rootworm annually destroys an appreciable quantity of field-cured peanuts grown on heavy soils in the Virginia–North Carolina area. The larvae bore into the pods and feed on the developing kernels. The velvetbean caterpillar has sporadically damaged severely and sometimes destroyed peanut plantings. Cutworms, leafhoppers, the red-necked peanut worm, thrips, and white-fringed beetles are destructive pests of peanuts in some areas in certain years.

Estimated average annual losses in yield of peanuts caused by insects for the period 1951–60 are as follows:

Insect	Average annual loss (percent)
Southern corn rootworm	0.8
Leafhoppers, thrips, red-necked peanut worm, white-fringed beetles, cutworms, and velvetbean caterpillar	2.2
Total	3.0

Small grains

Greenbugs frequently cause extensive losses to barley, oats, and wheat in various parts of the Great Plains from Texas north to Canada. However, in some years they do little damage.

The hessian fly is one of the most destructive insect enemies of wheat in the United States. It is distributed over the North Central and Northeastern States, a portion of the Southern States, and within limited areas in California, Oregon, and Washington. Local outbreaks occur nearly every year, and widespread damage can be expected at irregular intervals, sometimes as often as every 5 or 6 years. In the fall, the fly maggots suck the juices of the young plants, killing them outright or weakening them so that they cannot survive the winter. In the spring, they kill the plants in the same way; later in the season, they cause the stems to break so that the heads are missed by the harvesting machinery.

The wheat stem sawfly is a destructive pest of wheat in northern North Dakota and Montana. It is a pest of native grasses that has found wheat a favorable host. In 1951, loss by the sawfly in North Dakota and Montana was estimated at 4,918,484 bushels of wheat worth approximately $10 million. Damage by the insect in bordering States has been much less severe. Losses result from reduced weight of the wheat kernels caused by tunneling of the stems of wheat by the sawfly larvae, and the breaking over of stems girdled by the insect. When the stems are broken, the wheat heads cannot be recovered during harvesting.

Estimated average annual losses in yield of small grains caused by specific insect pests during the period 1951–60 are as follows:

Grain and insect	*Average annual loss (percent)*
Barley:	
Cutworms	2.8
Greenbug	1.9
Brown wheat mite	.3
Total	5.0
Oats:	
Greenbug	2.3
Cutworms	1.4
Brown wheat mite	.3
Total	4.0
Wheat:	
Greenbug	1.4
Hessian fly	1.2
Wheat stem sawfly	1.0
Cutworms	.9
Armyworm	.6
Brown wheat mite	.5
Grasshoppers	.4
Total	6.0

Rice

The two most important pests of rice are the rice stink bug and the rice water weevil. Most of the damage by the rice stink bug is caused by the nymphs, which suck the juice of the developing kernels and cause pecky rice. The adults of the rice water weevil feed on the newly emerged rice plants, and the larvae severely injure the roots.

Estimated average annual losses in yield of rice caused by these insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Rice stink bug	3.0
Rice water weevil	1.0
Total	4.0

Soybeans

Damage to soybeans is caused by the bean leaf weevil, garden fleahopper, Mexican bean beetle, mites, stink bugs, and velvetbean caterpillar. Feeding by stink bugs lowers the market quality of the beans.

Sugarbeets

Sugarbeets grown for seed in the Western States are planted in the fall and harvested the following summer. Caterpillars of various kinds attack the seedling plants. The beet leafhopper also feeds on the seedlings but, more important, it is the vector of curly top, a very destructive disease of sugarbeets.

In the spring, the seed crop is damaged by seed-feeding insects, primarily lygus bugs and stink bugs, in spite of control measures. Outbreaks of the Say stink bug are rare but cause very severe damage to the crop when they do occur. Spider mites and aphids also feed on the foliage and flower buds and cause a direct reduction in yield of seed. However, the primary damage by aphids is the spread of the virus diseases of beet yellows and beet Western yellows. These diseases result in heavy losses to the crop.

On the sugarbeet crop grown for sugar, major damage is caused by armyworms, the beet webworm, and other caterpillars, and by spider mites—all of which feed on the foliage; by root aphids, root maggots, symphylans, and wireworms attacking the roots; and, indirectly, by aphids and leafhoppers transmitting virus diseases.

Sugarcane

The sugarcane borer is the most injurious insect attacking sugarcane grown for sugar and seed in the United States. Estimates of loss by this insect in Florida and Louisiana are based on the percentage of bored sugarcane joints found in annual harvesttime surveys. In addition, the insect attacks corn, rice, and sorghums, causing large additional losses. Young larvae of the sugarcane borer bore into young plants, destroying the central tissues and causing dead hearts. In older plants, the borers attack the tops of the plants, causing them to die; and they tunnel in the stalks, weakening them so that they break over. Tunneling by the borer also causes a loss in weight and sucrose content and injures seed cane.

Estimated average annual losses in yield of sugarcane caused by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Sugarcane borer	12.1
Soil insects	1.8
Aphids	1.1
Total	15.0

Tobacco

Tobacco budworms and hornworms can destroy entire fields of tobacco. When severe damage is anticipated, growers apply insecticides several times during the growing season to reduce losses. North Carolina growers controlled light infestations of these insects in 1957 and 1958, and lowered the potential losses of flue-cured tobacco from about $36 to $5 per acre.

The green peach aphid is the most destructive insect of the tobacco crop in Kentucky and Maryland, and is particularly damaging to the shade-grown tobacco of Connecticut and Florida. Three other insect pests of tobacco—the cabbage looper, the southern potato wireworm, and the tobacco flea beetle—have developed resistance to insecticides that had formerly controlled them.

FORAGE AND SEED CROPS AND RANGELANDS

As indicated in table 12, the estimated average annual losses to alfalfa for forage from insect damage are $242,905,000. The annual losses caused by insects to seed crops are estimated at $25,927,000. Grasshoppers caused estimated annual losses of $80,000,000 to rangelands.

Alfalfa, clover, and other forage crops

Insects cause heavy losses to legume and grass forage and seed crops in many areas of the United States. However, the data required to satisfactorily estimate annual losses caused by a number of these pests are either inadequate or unavailable.

The alfalfa weevil, for many years a serious pest of alfalfa in the West, was found in Maryland in 1951. It has spread into 21 Eastern States where it has caused extensive losses, especially to first-cutting alfalfa. Larvae of this insect skeletonize the leaves of the plants, lowering hay yield and quality. High populations may cause a complete loss of first-crop hay, and so weaken the stand that some plants do not survive. Although thousands of acres of alfalfa are treated with insecticides each year to control the alfalfa weevil, the pest still destroys about 10 percent of the first crop in the infested area.

The spotted alfalfa aphid since its discovery in the United States in 1954 has become a pest of alfalfa grown in 33 States across the southern two-thirds of the country. Heavy damage is confined mainly to areas from Nebraska southwest to southern California. In 1955–57 this insect caused losses of more than $80 million to alfalfa. Chemical control, parasites and predators, and resistant varieties of alfalfa have reduced the damage. Even so, the spotted alfalfa aphid caused estimated losses of $1,929,000 to alfalfa in California alone in 1960, where an additional $1,303,000 was spent for its control. Adults and nymphs of the spotted alfalfa aphid suck the plant juices. causing stunted plants, leaf drop, reduced yields, and plant kill. The insects secrete large amounts of honey dew on which a black mold develops. The mold lowers the quality of the hay.

The meadow spittlebug causes appreciable losses to alfalfa, red clover, and other legumes. Feeding by the nymphs of this insect results in a stunted, rosetted plant growth that often reduces forage yields 50 percent or more. The increased use of insecticides to control the alfalfa weevil in the Eastern Coast States has reduced the damage caused by the spittlebug to alfalfa in much of this area.

Lygus bugs suck the juices from buds and flowers of alfalfa, causing blasted buds and flower drop. They also puncture the developing seeds and thus lower their quality. Modern insecticides have been very effective in controlling lygus bugs. However, in many areas these insects have developed resistance to certain chemicals and are becoming more serious pests of alfalfa.

TABLE 12.—FORAGE, SEED CROPS, AND RANGELANDS: *Estimated average annual losses due to insects, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Alfalfa for forage	Ton	15	10,976	242,905
Seed crops:				
Alfalfa	Pound	38	75,676	20,060
Crimson clover	do	15	3,113	639
Red clover	do	15	15,515	4,239
Ladino	do	17	1,265	842
Sugarbeets	do	10	[3] 980	[3] 147
Total				268,832
Rangelands: Pasture grass and other forage [4]				80,000
Total: Forage, seed crops, and rangelands				348,832

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Based on data from the 1959 Census of Agriculture.
[4] Losses caused by grasshoppers.

The alfalfa seed chalcid caused losses of 20 to 40 percent of the alfalfa seed grown in certain areas of California in 1960. Annual losses due to this pest in the Western States frequently average 10 percent. It is estimated that the clover seed chalcid does about half as much damage to clover seed. Larvae of these pests feed within and destroy the developing embryo, leaving only the hollow shell.

The potato leafhopper sucks the plant juices and causes extensive losses to alfalfa and red clover each year in the eastern half of the United States. Losses of one-fourth to one-half ton of hay per acre on second and third cuttings are not uncommon. In addition, the protein and carotene content of the hay is reduced. Stands are weakened so that many plants do not survive the winter.

Other insects of legume and grass crops destroy millions of dollars' worth of seed and forage every year. The more important of these pests are the clover aphid, clover leaf weevil, clover root borer, clover seed midge, clover seed weevils, vetch bruchid, chinch bugs, cutworms and armyworms, red harvester ant, scale insects, stink bugs, thrips, webworms, and white grubs.

The European chafer, an introduced insect distributed only in a limited portion of New York and in small local areas in Connecticut, New Jersey, and West Virginia, infests meadows, pastures, winter grains, and legumes, as well as lawns and other turf areas. Damage is due entirely to the feeding of the grubs on the roots of the host plants, and occurs annually once an infestation becomes well established.

Estimated average annual losses by specific insects are given only for alfalfa for hay and alfalfa for seed. For the period 1951–60, they are as follows:

Crop and insect	*Average annual loss (percent)*
Alfalfa for hay:	
Spotted alfalfa aphid	4.9
Potato leafhopper	3.1
Alfalfa weevil	2.5
Pea aphid	2.4
Grasshoppers	1.0
Meadow spittlebug	.8
Garden webworm	.2
Alfalfa caterpillar	.1
Total	15.0
Alfalfa for seed:	
Lygus bugs	24.4
Alfalfa seed chalcid	10.5
Alfalfa plant bug	2.1
Grasshoppers	.7
Spotted alfalfa aphid	.3
Total	38.0

Rangelands

About 20 species of grasshoppers are especially destructive to rangelands in the West, where they consume large quantities of forage that would otherwise support valuable livestock. Estimated overall losses on Federal–State and private rangelands in 17 Western States amount to approximately $80,000,000 annually.

TURF

The production of turf and the maintenance of lawns, golf courses, and other turf areas in the United States represent a considerable investment. Insect pests attack all types of grasses. They cause estimated average annual losses of at least 5 percent to turf areas, or about $827,000,000.

FRUIT AND NUT CROPS

Average annual losses caused to fruit and nut crops by insects are estimated at $121,295,000 (table 13).

Apples

Without control measures the apple crop would be almost a total loss because of attack by insects, principally the codling moth, several species of aphids, leaf rollers, and scale insects nationally; the apple maggot in the Northeastern and Great Lakes States; and the plum curculio in all States east of Nebraska. In recent years losses in commercial orchards have been held to a low level by the general application of effective insecticide programs. Insect losses to apples in backyard and farmstead plantings are estimated to be high since few such plantings are sprayed adequately and many are not sprayed at all.

Several leaf-feeding mites occur on apples in all producing areas; they reduce fruit bud formation, fruit set, leaf chlorophyll, and fruit color and size, and they cause premature dropping of fruit. Outbreaks are more likely to occur in orchards that are otherwise well cared for than in orchards that are poorly cared for or uncared for. Even 10 percent of foliage injury has reduced the color of the fruit as much as 20 percent and also fruit size. In the absence of adequate control measures for mites in orchards that are otherwise well cared for, yields may be reduced by from one-third to two-thirds. However, neglect of mite control involves only a small percentage of the total commercial acreage.

Losses caused to apples during the period 1951–60 by all insects are estimated at 6 percent and by all mites at 7 percent.

TABLE 13.—FRUIT AND NUT CROPS: *Estimated average annual losses due to insects, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Apples	Bushel	13	15,620	28,910
Blackberries	Quart	31	10,183	1,342
Cherries	Ton	3	7	1,544
Grapes, fresh	do	4	142	7,172
Grapefruit	do	5	87	2,549
Lemons	do	6	39	2,673
Oranges	do	6	343	19,280
Peaches	Bushel	4	2,826	5,658
Pears	do	6	1,973	3,592
Pecans	Pound	12	22,860	5,693
Plums	Ton	6	6	967
Prunes, fresh	do	6	29	2,937
Raspberries	Quart	23	[3] 11,164	[3] 3,142
Strawberries	Pound	25	[4] 147,612	[4] 25,836
Miscellaneous fruits and vegetables				[5] 10,000
Total				121,295

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Based on data from the 1959 Census of Agriculture.
[4] Basic data represent quantity marketed and value of quantity marketed.
[5] Damage by Japanese beetles.

Brambleberries

A large number of insects and mites frequently cause important losses to blackberries, boysenberries, dewberries, loganberries, raspberries, and youngberries. In the Northwest the redberry mite feeds on the green fruits of blackberry and prevents them from ripening properly. The raspberry fruitworm feeds within the fruits of the raspberry and blackberry and, unless controlled, may contaminate the harvested product. The garden symphylan eats the roots of the plants, and other insects bore into the canes and crowns.

Cherries

Cherries are less subject to severe insect damage than most other tree fruits; however, in the area east of the Rocky Mountains, the plum curculio at times injures a high percentage of the crop on unsprayed trees. Heavy losses are also caused by the black cherry aphid, cherry fruit fly, cherry fruitworm, eye-spotted bud moth, leaf rollers, mites, peach twig borer, tree borers, and scale insects. The presence of cherry fruit fly infestation can result in condemnation for canning of the entire crop in an orchard. In general, growers who apply recommended control measures thoroughly and on schedule suffer no appreciable loss; others may lose from 5 percent to nearly the total crop.

Citrus (grapefruit, lemons, and oranges)

Mites, scale insects, thrips, and aphids are the major pests of citrus. They seriously affect the vigor of trees and set of fruit and reduce the quality and grade of fruit. Heavy infestations may restrict tree growth and thus lower productiveness for extended periods after control has been achieved.

The Mexican fruit fly annually migrates across the Mexican border into citrus areas in the lower Rio Grande Valley in Texas where its presence creates a regulatory problem. Only rarely are larval infestations found, and these seldom reach 10 percent in fruits on infested properties. The oriental fruit fly may cause serious damage to occasional citrus trees in home gardens and to the limited commercial plantings in Hawaii.

Estimated average annual losses caused to citrus fruits by specific insects for the period 1951–60 are as follows:

Citrus fruit and insect	*Average annual loss (percent)*
Grapefruit:	
Mites	2.4
Scale insects	2.4
Other than mites and scales	.2
Total	5.0
Lemons:	
Mites	2.4
Scale insects	2.0
Other than mites and scales	1.6
Total	6.0
Oranges:	
Mites	2.7
Scale insects	2.5
Other than mites and scales	.8
Total	6.0

Grapes

Grapes are subject to damage by a variety of insects; in the West, most commonly by the grape leaf folder, leafhoppers, mites, and pomace flies; and in the East, usually by the grape berry moth, grape flea beetle, grape mealybug, grape phylloxera and other gall-forming insects, grape rootworm, red-banded leaf roller, rose chafer, and pomace flies. Injury from one or more of these pests may occur throughout the growing season and reduce the size and quality of the current crop and the size of subsequent crops, and weaken the vines. In the absence of control measures, losses are high. Damage by a leafhopper in California in 1960 was estimated at $4,840,000. General use of recommended control measures in the Great Lakes area has reduced damage by the grape berry moth, and other insects are under good control in that area.

Peaches and plums

Many kinds of insects and several species of mites damage peaches throughout the United States. Without the use of control measures little or no marketable fruit could be produced. In the area east of the Rocky Mountains losses are due to leaf rollers, oriental fruit moth, plum curculio, and sucking bugs, the more common pests that attack the fruit.

Estimated annual losses caused to peaches by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Peach tree borer	0.7
Other insects	3.3
Total	4.0

Pears

The major losses of pears are caused by the codling moth, mites, and pear psylla. Other insects may cause considerable damage at times. Control of codling moth and mites is much simpler on pears than on apples. Losses because of failure to secure control are greatly reduced in well-cared-for orchards.

The pear psylla, now occurring in all important commercial pear-producing areas, reduces the productivity of infested trees, causes premature defoliation, and excretes honey dew in which a sooty mold develops on leaves and fruit. Control of the pear psylla has become increasingly difficult in Oregon and Washington in recent years, because of the occurrence of strains that are resistant to certain recommended insecticides.

Pecans

The size and quality of the pecan crop is reduced annually by one or more of the insects and mites that infest pecan orchards. The black pecan aphid, the hickory shuckworm, mites, the pecan nut and leaf casebearers, the pecan phylloxera, and the pecan weevil are the economically important pests that attack the crop. They reduce—and sometimes destroy—the crop and lower the quality of the nuts. Although more and more growers are attempting to carry out an insect control program, many growers accept losses due to insects and mites and make no attempt to prevent them. Many seedling trees are inaccessible to spray equipment. Reduction in yield and quality due to feeding of the hickory shuckworm occurs in Alabama, Florida, and Georgia, and damage to nuts by the pecan weevil and nut casebearer is common in Georgia. Losses in yield and quality by the more injurious species, including the black pecan aphid, the hickory shuckworm, the pecan nut casebearer, the pecan phylloxera, the pecan weevil, and spider mites, occur in the western portion of the Pecan Belt (Arkansas, Louisiana, Mississippi, Oklahoma, and Texas). These losses occur in native seedlings as well as in cultivated varieties.

Estimated average annual losses caused to pecans by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Hickory shuckworm	6.2
Pecan nut casebearer	2.0
Pecan weevil	1.0
Other insects	2.8
Total	12.0

Strawberries

Many species of insects and related pests attack strawberries and cause heavy losses to growers. Mites and aphids suck the juices from the plants and reduce yield and quality of the fruit. Aphids also transmit plant virus diseases. In southern California, commercial strawberry fields are replanted each year as a result of damage caused by the cyclamen mite. This pest weakens the plants or kills them by continuous feeding on the terminal leaves and fruit buds. Several root weevils destroy strawberry plantings in the Northwest, and the strawberry weevil damages the fruiting buds in the Eastern States. Various caterpillars, cutworms, flea beetles, and plant bugs also cause losses.

Estimated average annual losses caused to strawberries by specific insects for the period 1951–60 are as follows:

Insect	Average annual loss (percent)
Spider mites	10.0
Aphids and white flies	5.0
Soil insects	3.3
Cyclamen mite	2.7
Insects attacking buds and fruit	2.0
Foliage-feeding insects	2.0
Total	25.0

Japanese beetle

The Japanese beetle attacks about 270 kinds of plants, including field and fruit crops, ornamentals, and shade trees, eating only the foliage of some, and the foliage, flowers, and fruit of others. When beetles are numerous, all leaf tissue on favored hosts may be eaten and the fruit destroyed completely, made unmarketable, or reduced in value. In addition, the grubs feed on plant roots and may severely damage lawns, golf courses, parks, pastures, and other turfed areas.

The beetle is generally distributed over about 100,000 square miles in the Eastern States from southern New Hampshire and Vermont into North Carolina and westward into Ohio and West Virginia. Portions of Indiana, Michigan, eastern Tennessee, and northern South Carolina are also infested and local colonies occur in several other States.

Damage by the Japanese beetle has decreased greatly in the older infested area where imported parasites and milky and other diseases have become established, but overall losses are maintained by spread to new areas where natural enemies are not yet well established. Losses in well-cared-for orchards are negligible but may be high in the absence of treatment.

VEGETABLE CROPS

Table 14 shows that insects cause an estimated average annual loss of $185,892,000 in vegetables.

Asparagus

The principal insects causing loss to asparagus are the asparagus beetle and cutworms. They eat into the stalks, either destroying them completely or causing deformed growths that necessitate culling the plants. Asparagus beetle larvae, the fern caterpillar, leaf miners, and spider mites feed on the ferns and lower plant vitality. Wireworms and millipedes eat the roots, weakening the plants and reducing the stand. The garden symphylan eats small pits

TABLE 14.—VEGETABLE CROPS: *Estimated average annual losses due to insects, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Asparagus	Hundredweight	15	578	6,789
Beans:				
Green lima	do	13	338	2,499
Green snap	do	12	1,552	10,591
Broccoli	do	17	392	3,139
Brussels sprouts	do	17	124	1,040
Cabbage	do	17	4,737	8,443
Cantaloups	do	8	1,035	4,563
Carrots	do	2	321	961
Cauliflower	do	17	496	3,137
Celery	do	14	2,433	8,949
Cucumber, fresh market	do	21	538	2,740
Escarole	do	7	54	250
Kale	do	17	34	148
Lettuce	do	7	2,496	10,077
Melon, honeydew	do	8	131	640
Onions	do	18	4,841	12,510
Peas, green	do	4	462	2,083
Peppers, green sweet	do	7	225	1,876
Potatoes	do	14	33,196	65,968
Spinach	do	4	202	750
Sweet corn	do	19	9,086	16,575
Sweetpotatoes	do	8	966	3,970
Tomatoes:				
Fresh market	do	7	1,512	10,600
Processing	Ton	7	292	7,594
Total				185,892

[1] See table 2, footnote 1.

[2] See table 2, footnote 2.

into the spears near the soil line during the harvest season.

Beans

Bean crops of all kinds, whether for processing, fresh market, or seed, or for sale as dry edible beans, are damaged by insects. Root maggots and wireworms attack the sprouting seeds and the young plants before they emerge. Cutworms and the lesser cornstalk borer feed on the stems of the young plants. Aphids, various caterpillars, cucumber beetles, leafhoppers, leaf miners, the Mexican bean beetle, slugs, spider mites, and thrips attack the foliage. In some areas, the bean pods are damaged by lygus bugs, the western bean cutworm, and the corn earworm. In California, lima bean pods are attacked by the lima bean pod borer. In the South, the canning crop of cowpeas (or blackeye beans) is damaged by the cowpea curculio, which feeds within the immature seeds causing them to be rejected for processing. During the period 1951–60 the major losses to beans were caused by aphids, leafhoppers, lygus bugs, the Mexican bean beetle, root maggots, spider mites, western bean cutworm, and wireworms.

With so many pests involved and so many types of damage, it is difficult to estimate the losses caused to beans by specific insects. One loss not discernible to the grower is the dropping of pods due to insect feeding. The most familiar loss to the grower of dry beans is the cost of sorting out the partially damaged beans at the warehouse. Another loss—the discarding of the more severely damaged beans during the threshing operation—is not often recognized.

Estimated average annual losses caused to green lima and green snap beans by specific insects during the period 1951–60 are as follows:

Crop and insect	*Average annual loss (percent)*
Green lima beans:	
Mexican bean beetle	8.0
Spider mites	3.0
Other insects	2.0
Total	13.0
Green snap beans:	
Mexican bean beetle	7.0
Spider mites	3.0
Other insects	2.0
Total	12.0

Carrots

Carrots are injured by soil pests such as root maggots, wireworm, and white grubs that burrow into the roots or leave feeding scars on them. Aphids, caterpillars, and leafhoppers feed on the leaves.

Celery

Aphids and leafhoppers suck the sap from the celery plants and transmit virus diseases. Spider mites also remove the sap from the leaves and devitalize the plants, which reduces yield. The celery leaf tier, celery looper, cutworms, and armyworms eat the foliage and detract from the appearance of the marketed product.

Estimated average annual losses caused to celery by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Aphids	5.0
Leaf tier	2.0
Looper	2.0
Cutworms	1.0
Spider mites	1.0
Other insects	3.0
Total	14.0

Cole crops

Cabbage, cauliflower, broccoli, brussels sprouts, collards, kale, mustard, and turnip suffer severe damage by a variety of similar insects. Losses are particularly heavy in the South. Thirteen caterpillars are important pests of cole crops. Development of resistance to DDT by the cabbage looper and the imported cabbageworm and lack of effective insecticides that can be used safely on the plants have increased losses by these two insects in recent years.

Other insects that damage cole crops in most areas of the country are aphids, leaf-feeding beetles, and root maggots. Harlequin bug, mole crickets, stink bugs, vegetable weevil, and several species of grubs also feed on these crops.

Corn, sweet

The corn earworm and the European corn borer are the two most serious pests of sweet corn. The corn earworm occurs over the entire country. The European corn borer ranges from the Atlantic Ocean west to eastern Colorado and Montana, and south into Alabama, Arkansas, Georgia, Louisiana, northern Mississippi, northeastern Oklahoma, and South Carolina. Both insects damage the ears being grown for market or processing. In addition, the European corn borer tunnels within the stalk, weakening it and interfering with growth. In certain areas in years of heavy infestation by either insect, sweet corn cannot be grown profitably unless insecticides are applied. In Florida and Texas, treatment with insecticides to control the corn earworm has made possible a valuable fresh market sweet corn industry where previously the ears were so severely injured that they could not be marketed. Corn sap beetles, cutworms, fall armyworm, Japanese beetle, rootworms, white grubs, and wireworms also infest sweet corn and, unless controlled with insecticides, they may cause serious damage to the crop.

Estimated average annual losses caused to sweet corn by specific insects during the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Corn earworm	13.8
European corn borer	4.1
Soil insects	1.1
Total	19.0

Cucumbers, squashes, and pumpkins

Cucumbers and summer squashes are susceptible to severe damage by several insects, the most injurious of which in the country as a whole are aphids and cucumber beetles. The pickleworm and the melonworm cause extensive injury in the South and occasionally spread into adjoining areas.

The squash vine borer and squash bug feed on all squashes and on pumpkins. Cutworms, leaf miners, and thrips are occasionally injurious to cucumbers, squashes, and pumpkins. Yield has been reduced 50 percent or more in many summer squash plantings in which the pickleworm, the squash vine borer, or squash bug was not adequately controlled.

Lettuce

In the Western States, young stands of fall-planted lettuce are attacked by various caterpillars. The beet armyworm, the yellow-striped armyworm, and various cutworms attack the young plants soon after emergence. A little later, the cabbage looper usually appears and infests the fields from the time of thinning to harvest. It often causes losses to mature heads of lettuce, even when the best control measures have been applied.

The corn earworm sometimes infests and ruins entire lettuce fields after head formation has started. The larvae work their way into the center of the heads where they cannot be reached by insecticides.

Aphids, chiefly the green peach aphid, are a problem on lettuce grown for spring harvest in the Western States. They sometimes become so numerous near harvest that some heads must be discarded. However, the greatest loss attributable to these insects is the transmission from plant to plant of the virus that causes the lettuce mosaic.

In Eastern United States heavy losses result to lettuce from infestation by the aster yellows disease transmitted solely by the six-spotted leafhopper. Efforts to establish the growing of head lettuce in the higher altitudes of western Maryland and southwestern Pennsylvania were terminated after several years of crop failure caused by aster yellows transmitted by this insect.

Estimated average annual losses caused to lettuce by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Cabbage looper	3.9
Corn earworm	2.3
Aphids	.8
Total	7.0

Melons

Cantaloups in the Western States are attacked by leaf miners, southern garden and western potato leafhoppers, and spider mites. These pests cause a loss of foliage and subject the melons to sunburn and a lowering of their quality due to reduction of total soluble solids. Losses due to leaf miners are sometimes very heavy. Losses caused by the southern garden leafhopper and the western potato leafhopper are sporadic.

In the West the beet leafhopper also infests fields of cantaloups, especially in the early stages of plant development. This insect transmits curly top disease, which frequently is responsible for heavy crop losses or even failure. Aphids are a problem every year in all areas. The principal damage by these insects in Arizona and California results from the transmission of mosaic viruses which in some years cause severe losses and occasionally destroy entire crops.

In the Southern and Gulf States, the pickleworm and melonworm cause severe damage to cantaloups. The melon aphid and cucumber beetles are also serious pests of cantaloups in the South. Unless these several insects are controlled, profitable production of melons in this area is not usually possible. The grubs of the cucumber beetles attack the roots of the plants, whereas the adults feed on the foliage and transmit bacterial blight and squash mosaic.

Onions

The most destructive pests of onions are the onion thrips, which draws the sap from the leaves and damages the blossoms, and the onion maggot, which feeds on the bulbs. The use of new insecticides has greatly reduced thrips damage in recent years. The onion maggot, however, began to increase over the Northern States in the early 1950's, when it developed resistance to insecticides; in many areas, for several years, damage reached 50 percent or higher.

Estimated average annual losses caused to onions by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Onion thrips	10.0
Onion and seed-corn maggots	8.0
Total	18.0

Peas

The pea aphid is the major widespread pest of peas in the United States. It sucks the sap from the leaves and transmits several mosaic diseases. It reduces the yield of dry edible or seed peas and lowers the quality of processing green peas. Outbreaks of the insect in 1954 and 1958 resulted in direct damage of more than 25 percent to the pea crop of the Northwest. Mosaic viruses carried by the insect caused additional losses. The pea weevil grub feeds on the immature seeds, making them unfit for either food or seed.

Minor pests of peas are beet armyworm, cutworms, leaf miners, pea moth, seed-corn maggot, thrips, and wireworms. These insects are mostly restricted to certain localities. In Oregon and Washington the alfalfa looper has a high nuisance value, as the larvae may find their way into the processed peas.

Estimated average annual losses caused to dry peas and green peas by specific insects for the period 1951–60 are as follows:

Crop and insect	*Average annual loss (percent)*
Dry peas:	
Pea aphid	4.0
Pea weevil	2.0
Total	6.0
Green peas:	
Pea aphid	3.6
Alfalfa looper	.4
Total	4.0

Peppers

Peppers are attacked by many of the insects that feed on potatoes and tomatoes, the most destructive and widespread of which is the green peach aphid. Dipterous leaf miners are destructive in California, Florida, and Texas. The pepper weevil damages the crop in California, and the pepper maggot does in the Northeast. Everywhere the young plants are attacked by cutworms, which either chew or cut off young plants. In California, it usually is necessary to apply insecticides to control the pepper weevil and green peach aphid.

Estimated average annual losses caused to green sweet peppers by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Green peach aphid	4.1
Pepper weevil	.8
Other insects	2.1
Total	7.0

Potatoes

The more economically important insect pests of potatoes of widespread occurrence in the United States are aphids, wireworms, Colorado potato beetle, flea beetles, and grasshoppers. Blister beetles, cutworms, the seed-corn maggot, plant bugs, stalk borers, and white grubs are also generally distributed but cause serious losses only in limited areas in certain years. Insects that cause severe damage to the crop in limited areas only are the white-fringed beetles in the South, and the potato psyllid in the high plains area and intermountain region of the West. Some of the aphids that damage potato plants are also carriers of mosaic and leaf-roll virus disease. It is still difficult, however, to prevent the spread of virus diseases of potatoes by controlling their insect vectors. Since 1953, aphids, the Colorado potato beetle, and flea beetles have become resistant to certain insecticides in some areas.

Except for the southern potato wireworm, losses from wireworms and other soil insects have decreased in recent years because of wider use of the more effective insecticides. Nevertheless, such losses are still considerable. By 1956 the southern potato wireworm in the Southwest had developed resistance to several insecticides. New materials, however, have given reasonably good control of this pest from 1958 to date.

The potato leafhopper, occurring generally throughout the eastern part of the United States, is the direct cause of hopperburn of potato. Frequently, the presence of the small inconspicuous leafhoppers is not recognized in time to apply an insecticide to prevent hopperburn.

During outbreaks of the six-spotted leafhopper, the purple top virus disease transmitted by this insect becomes a serious problem, particularly in the North Central States.

The potato crop in Colorado, Montana, western Nebraska, Utah, and Wyoming is subject to outbreaks of the potato psyllid, which feeds on the plants and causes the psyllid yellows disease. Outbreaks can be predicted in time to warn growers of the need to apply insecticides.

Estimated average annual losses caused to potatoes by specific insects for the period 1951–60 are as follows:

Insect	*Average annual loss (percent)*
Sucking insects	8.0
Foliage-feeding insects	3.0
Soil insects	3.0
Total	14.0

Spinach

In the Southern States spinach is chiefly attacked by the seed-corn maggot and the green peach aphid. Damage by the seed-corn maggot is sporadic, but at times entire fields need to be replanted because of poor plant stands caused by this insect. Aphids reduce the quality of the leaves on which they feed. In the Northwest, the alfalfa looper is a nuisance pest. Numbers of the insect are never large but the pupae, which are fastened on the underside of the leaves, may go through processing of the crop and show up in the finished product. For this reason, infested fields frequently are not harvested.

Sweetpotatoes

The foliage of sweetpotato is seldom damaged appreciably by insects, but the larvae of several cucumber beetles and flea beetles eat shallow holes in the roots or make tiny tunnels underneath the skin. White-fringed beetle larvae and wireworms also damage the roots. Recently, cucumber beetles have become very difficult to control, especially in Louisiana, where the banded cucumber beetle is abundant. During 1960, damage by this insect was so severe that 5 percent of the 65,000-acre Louisiana crop of sweetpotatoes was abandoned before harvest. In some areas the losses were as high as 50 percent.

The sweetpotato weevil usually is the most destructive pest of sweetpotato in limited areas of several Southern States where it occurs. It attacks the crop in the field and in storage. The grub burrows throughout the edible roots and makes them bitter so that they are unfit for food or feed.

Tomatoes

Tomatoes in seedbeds are attacked by cutworms, flea beetles, and other general feeders. The transplants are injured by aphids, blister beetles, various caterpillars, Colorado potato beetle, leaf miners, potato psyllid, spider mites, thrips, and tomato russet mite. The tomato fruitworm and armyworms damage the fruit, and Drosophila flies contaminate it with their eggs and larvae. The beet leafhopper transmits to tomatoes the virus that causes curly top, aphids carry various virus diseases, and potato psyllid nymphs are responsible for the nonpathogenic psyllid yellows on tomatoes. Damage by the beet leafhopper is confined principally to the west slopes of the Continental Divide where, at times, abundance of the insect results in almost complete crop failure. Leaf miners have caused damage in California, Florida, and Texas. Tomato russet mite is a pest of tomatoes in Arizona, California, Colorado, Utah, and some Eastern States. The cabbage looper and the Colorado potato beetle have damaged tomatoes along the Atlantic Coast.

LANDSCAPE FLOWERS AND ORNAMENTALS

Disfiguring of many outdoor ornamental plants by aphids, borers, cutworms, mealybugs, scales, and spider mites, and other pests reduces the aesthetic value of such plants (not for sale) in private, commercial, and public gardens. Each year many shrubs and flowering trees are replaced because of insect damage. A number of ornamental plants such as boxwood and gardenia have lost their popularity because the homeowner has not been able to cope with the insect damage. Annual losses by insects to these plantings are estimated to be well above 16 percent, or a total of $768,000,000.

HORTICULTURAL SPECIALTIES

The term horticultural specialties is used by the Bureau of the Census for a long list of horticultural crops grown for sale (table 15). None of these crops was included in the other estimates given in this chapter. Losses to horticultural specialties caused by insects are estimated to be $79,062,000 annually (table 15). This estimate does not include plants or other items not grown for sale.

Aphids, mealybugs, scales, spider mites, whiteflies, and other pests cause severe damage to plants in commercial greenhouses and nurseries. Changes in horticultural practices and the increase in resistance of spider mites to acaricides have resulted in increased crop damage in greenhouses during the past decade. Resistant strains of spider mites, recognized first on roses in 1949, are now also widespread on chrysanthemums and carnations.

TABLE 15.—HORTICULTURAL SPECIALTIES GROWN FOR SALE: *Estimated average annual losses due to insects, 1951–60*

Commodity	Losses from potential production [1]	
	Reduction [2]	Value [3]
	Percent	*1,000 dollars*
Nursery products (trees, shrubs, vines, ornamentals, etc.)	11	24,562
Cut flowers, potted plants, florist greens, and bedding plants	13	48,956
Vegetables grown under glass, flower seeds, vegetable plants, bulbs, and mushrooms	6	5,544
Total	--	79,062

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Based on wholesale value of sales in the United States, excluding Alaska and Hawaii; from the 1959 Census of Agriculture.

Florists throughout the country depend more and more on a few establishments for cuttings of young plants of chrysanthemum, carnation, geranium, and rose. As a result, new pests may be inadvertently distributed to many areas and cause serious losses before control measures can be applied. Some of the pests that have been spread in this way are the carnation shoot mite on carnation, the Lewis mite on poinsettia, *Liriomyza* leaf miner on chrysanthemum, and strains of the melon aphid and the green peach aphid that are particularly damaging to chrysanthemum.

LOSS TO HONEY BEE INDUSTRY

The greater wax moth destroys stored honey combs and brood combs of weak or medium-strength colonies, and causes damage to hives and other apiary fixtures. The estimated average annual loss to beekeepers as a result of damage by this pest amounts to $500,000.

Chapter 5.—Weeds

Weeds are plants growing where they are not wanted. They compete with desirable plants for nutrients, water, light, space, and other growth requirements. In addition, the cost of controlling weeds is enormous. Thus, the losses caused by weeds and the cost of their control constitute one of the highest losses in the production of food, feed, and fiber. Weeds increase the cost of labor and equipment; reduce the quality and quantity of crop and livestock products; harbor insects, nematodes, and disease-producing organisms; clog farm ponds, recreational lakes and streams, and irrigation and drainage ditches; and impair the health of livestock and humans. Weeds also cause losses and heavy expenditures in nonagricultural areas such as highway, utility, and railroad rights-of-way; and parks, lawns, and forests.

Herbaceous weeds and many woody species use tremendous quantities of water; certain phreatophytes such as saltcedar use up to 7 acre-feet of water per year. Weeds thus reduce the availability of water for agricultural, industrial, and potable uses in areas of critical water shortage. The water requirement of herbaceous weeds that infest crops is large as compared to that of cultivated plants. For example, the corn plant requires 368 pounds of water to produce a pound of corn (dry-matter basis), whereas lambsquarters and ragweed use 800 and 950 pounds, respectively, to produce a pound of dry matter. The sunflower plant requires almost twice as much water as corn to produce the same amount of dry matter, and the water requirement of ragweed is three times that of millet.

In this chapter, only estimated losses in production and quality of certain crop commodities are included. Direct and indirect losses that are attributable to weeds on farms but are not included in these estimates are losses in efficiency of cropland use; losses due to harboring of insects, disease-producing organisms, and rodents; losses in human efficiency due to allergy-causing and poisonous weeds; and other similar losses. Estimates on costs of weed control are given in chapter 12.

Specific examples of weed problems that cause serious losses in agriculture are presented. No estimates are given on weed losses in some crops and situations, because of lack of background data. Loss estimates are based on the best data available, but in some crops extrapolations and comparative estimates were necessary.

Estimated average annual losses by crop groups due to weeds are presented in table 16.

TABLE 16.—*Estimated average annual losses to various crop groups caused by weeds and cost of controlling weeds, 1951–60*

Crop group	Average annual loss
	1,000 dollars
Field crops	1,543,415
Forage seed crops	29,609
Pastures and rangelands	632,325
Fruits and nuts	132,032
Vegetables	122,249
Total	2,459,630
Cost of controlling weeds	2,551,050
Grand total	5,010,680

FIELD CROPS

The estimated average annual reduction in value of field crops due to weeds for the period 1951–60 is $1,543,415,000 (table 17). Losses in crop value due to weeds ranged from 8 percent for cotton to 17 percent for oats, for rice, and for soybeans. The estimated annual cost of weed control in field and seed crops is about $1,876,000,000 (chapter 12, table 54). Thus, the estimated annual losses due to weeds and the cost of their control in field crops total about $3,419,415,000.

Cotton

A wide variety of annual and perennial grasses, sedges, and broadleaf weeds constitute major production problems in cotton. Annual weeds such as barnyardgrass, crabgrass, morningglory, and pigweed also seriously damage cotton quality and reduce cotton yield. Late-season grass weeds in cotton, especially in the irrigated regions of the Southwest, reduce cotton quality one or two grades.

In the Mississippi Delta, intensive use of preemergence herbicides, made necessary by the lack of hoe-labor and satisfactory cultural practices, has excellently controlled annual broadleaf weeds and weed grasses. However, lack of an adequate supply of herbicides specific for the control of major problem weeds has resulted in invasion of thousands of acres of Delta land by johnsongrass, nutsedge, and redvine.

Grass weeds in cotton reduce fiber quality and mechanical harvesting and ginning efficiency. Losses in yield and quality due to weeds are particularly high in the humid cotton-producing areas of the South and also in the irrigated cotton-producing areas of the Western States. Average annual losses in the cotton crop due to reduced yields and quality, caused by weeds, amounted to about 8 percent of the value of the crops, or $205,628,000 per year, for the period 1951–60.

Corn

More than 30 species of annual and perennial broadleaf weeds and grass weeds and sedges reduce the yield and quality of corn each year. In the North Central States and the Northeast, barnyardgrass and foxtail have replaced crabgrass in importance, and lambsquarters has replaced pigweed as the major contributor to weed losses. Johnsongrass and a wide variety of perennial and annual broadleaf weeds cause severe losses in corn production in the river-bottom soils of the North Central States. In the southern humid regions, cocklebur, crabgrass, johnsongrass, morningglory, nutsedge, and pigweed are major problems. Weed competition for moisture, light, and mineral nutrients reduces both yield and quality; and quality losses also include dockage for weed contamination of the harvested crop. Weeds delay maturity and interfere with mechanized harvest of the crop; they result in a higher percentage of moisture in the harvested grain and reduced harvesting efficiency.

Rice

Barnyardgrass, other grass weeds, submerged and emerged aquatic weeds, and many broadleaf weeds seriously reduce yield and quality of rice. Weeds also greatly increase the cost of seedbed preparation, levee construction to maintain excessive water depth for weed control, water management and utilization,

TABLE 17.—FIELD CROPS: *Estimated average annual losses due to weeds, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Barley	Bushel	12	48,425	47,488
Beans, dry	Hundredweight	[3] 15	2,617	22,000
Corn	Bushel	10	344,209	439,404
Cotton	Bale	[4] 8	961	205,628
Flax (seed)	Bushel	[5] 12	3,381	13,924
Hops	Pound	10	5,427	2,552
Mints	do	12	375	1,769
Oats	Bushel	[5] 17	199,522	160,623
Peanuts	Pound	15	267,720	28,776
Rice	Hundredweight	[5] 17	7,195	45,654
Rye	Bushel	10	2,670	3,094
Safflower	Ton	13	17,707	666
Sesame	Pound	12	1,025	132
Sorghum:				
Grain	Bushel	13	48,917	49,216
Forage	Ton	13	2,156	12,350
Sweet	Gallon	13	401	855
Soybeans	Bushel	[3] 17	78,019	204,049
Sugarbeets	Ton	[6] 8	1,059	13,627
Sugarcane	do	13	1,077	7,642
Wheat	Bushel	[5] 12	136,644	283,966
Total				1,543,415
Cost of controlling weeds				1,876,000
Grand total				3,419,415

[1] See table 2, footnote 1.

[2] See table 2, footnote 2.

[3] Includes losses of 2 percent in quality of dry beans and 3 percent in soybeans due to weed seed dockage, damage in cleaning to remove weed seed, split beans due to presence of weeds, and off-flavors.

[4] Includes losses of 2 percent in fiber quality due to lowered grades caused by grass, weeds, and associated trash.

[5] Includes losses of 3 percent in quality of flax and oats, 4 percent in rice, and 1 percent in wheat due to weed seed dockage, delayed maturity, off-flavors, and cleaning losses.

[6] Includes losses of 2 percent in sugarbeet quality.

fertilizer practices, and planting and harvesting. Intensive use of 2,4-D and related herbicides to control broadleaf species has caused an ecological shift in the weed population. Barnyardgrass and other grass weeds, sedges, and aquatics are now among the most serious weed problems in rice production.

Estimated average annual losses in the potential value of rice due to reduced yield and quality amounted to 17 percent, or more than $45,654,000, for the period 1951–60. In addition to reducing yields, weeds were responsible for reducing quality because the grain was shriveled, immature, and contaminated.

Small grains (barley, oats, rye, and wheat)

Many annual and perennial broadleaf weeds and grass weeds cause severe losses in small grains. Canada thistle, field bindweed, milkweed, weed brome, wild buckwheat, wild garlic, and wild oats infestations are increasing in small grains. In addition, curled dock, quackgrass, weed brome, wild mustard species, and other weeds continue to cause severe losses in small grains. The herbicide 2,4-D and related phenoxy compounds have been used extensively to control weeds in small grains. The herbicide 2,4-D has been very effective in controlling broadleaf annual weeds. However, losses have increased from grass weeds such as weed brome and wild oats and from perennial broadleaf species such as milkweed, wild buckwheat, and wild garlic. In addition, 2,4-D cannot be used on about 35 million acres of small grains underseeded to legumes, because the legumes are sensitive to the herbicide. Weed losses on this acreage are heavy.

Postemergence herbicides are used to control weeds on about 20 of 111 million acres of barley, oats, rye, and wheat planted each year. Quality losses in the small grain crops are due to dockage for weed seed and fragments in the harvested grain and to wild onion or garlic bulblets, which cause off-flavor. Wild oats constitute one of the most serious problems in small grain production.

Estimated average annual yield and quality losses in barley, oats, rye, and wheat due to weeds were about $495,171,000 for the period 1951–60.

Sorghum, grain, forage, and sweet

Barnyardgrass, cocklebur, common morningglory, crabgrass, field bindweed, foxtail, goosegrass, johnsongrass, kochia, lambsquarters, milkweed, nutsedge, pigweed, ragweed, redvine, smartweed, sowthistle, sunflower, trumpetvine, and other weed species severely reduce yield and quality of sorghum. After intensive use of 2,4-D and related phenoxy herbicides to control broadleaf species in sorghum, an ecological shift in the weed population occurred. Weeds tolerant to 2,4-D and difficult to control increased. Among these weeds are field bindweed, milkweed, nutsedge, and the grasses such as barnyardgrass, foxtail, goosegrass, and johnsongrass.

Thorough seedbed preparation, rotary hoeing, tillage with weed-control implements, and from one to four sweep cultivations are used on most of the sorghum crop to control weeds. More than 2½ million acres of sorghum are treated each year with herbicides.

Estimated average annual losses in sorghum due to reduction in yields and quality by weeds amounted to 13 percent of the total value of the crop, or about $62,421,000, for the period 1951–60.

Oilseed crops

Flax (seed).—Weeds such as barnyardgrass, cocklebur, crabgrass, foxtail, lambsquarters, pigweed, ragweed, smartweed, sowthistle, wild mustard, and wild oats are among the species that most seriously limit flax production in the North Central States. These same weeds plus Canada thistle, curled dock, field bindweed, and quackgrass cause serious problems in flax production in the West.

Recently, use of herbicides on flax has increased. For example, there was a threefold increase in the acreage treated with herbicides in Minnesota between 1951 and 1954. Increases in other States where flax is grown were comparable.

Estimated average annual losses in the flax crop due to reduced yield and quality caused by weeds amounted to 12 percent of the potential value, or about $13,924,000, for the period 1951–60 (table 17).

Peanuts.—Serious weeds in peanuts include bermudagrass, cocklebur, crabgrass, Florida parsley, goosegrass, morningglory, nutsedge, pigweed, purslane, and sandbur. A gradual shift from hand hoeing and mechanical weed control to the use of herbicides has reduced losses caused by weeds. In addition, southern root rot, a disease of peanuts that is favored by cultural practices needed to control weeds, has been reduced.

Approximately 300,000 acres of peanuts are being treated with herbicides each year. There is considerable interest among farmers in increasing the use of herbicides in peanuts. Mixtures of herbicides have also shown promise for controlling many broadleaf weeds, including nutsedge and other weeds difficult to control in this crop.

Estimated average annual losses in the peanut crop due to reduced yield and quality amounted to 15 percent of the potential value, or about $28,776,000, for the period 1951–60.

Soybeans.—Barnyardgrass, cocklebur, crabgrass, foxtail, jimsonweed, johnsongrass, lambsquarters, morningglory, nutsedge, pigweed, quackgrass, ragweed, and smartweed are serious weeds in most of the major soybean-producing regions. Other species are serious in certain regions. Weeds cause the greatest damage in the north-central and southern soybean-producing regions. Extended periods of rainfall, which do not permit timely rotary hoeing and cultivation, result in severe weed infestations and consequent severe yield and quality losses in soybean production. In addition to the area weeded by cultural weed control practices, approximately 2½ million acres of soybeans are being treated with herbicides each year at a cost of 11 million dollars. Cocklebur, pigweed, and velvetleaf have become so serious in many soybean-producing areas that more than 425,000 acres are being treated each year with 2,4-D and 4-(2,4-DB) to control these broadleaf species.

Weeds in soybeans in the Southeastern United States are especially serious and cause higher yield and quality losses than in the other producing areas.

Estimated average annual losses in yield and quality of soybeans due to weeds amounted to 17 percent of the potential value of the crop, or about $204,049,000, for the period 1951–60 (table 17).

Sugar crops

Sugarbeets.—Barnyardgrass, cocklebur, crabgrass, foxtail, kochia, lambsquarters, pigweed, sowthistle, sunflower, wild oats, and such perennial weeds as Canada thistle, field bindweed, milkweed, and quackgrass continue to spread and cause moderate to heavy reductions in yield and quality of sugarbeets. Weed competition occurs primarily between the time the crop is planted or emerges and the time the weeds are removed by hand hoeing or cultivation.

Even with thorough seedbed preparation, hand hoeing, and frequent cultivation to control weeds in sugarbeets, it is estimated that average annual losses in the crop due to reduced yield and quality caused by weeds were 8 percent of the potential value, or about $13,627,000, for the period 1951–60.

Sugarcane.—Troublesome and damaging weeds in sugarcane are bermudagrass, chickweed, cocklebur, curled dock, common morningglory, henbit, johnsongrass, nutsedge, pigweed, purslane, smartweed, wild lettuce, and wild mustard. These weeds are causing heavy reductions in yield and quality in U.S. mainland sugarcane. Johnsongrass is a particularly serious problem in mainland sugarcane, and on many plantations in Louisiana it is the most limiting factor in sugarcane production. There has been an important ecological shift in the seriousness of weed populations in sugarcane. Before the extensive use of 2,4-D to control weeds in this crop, broadleaf weed species were more serious than grass weeds. In recent years, the infestation trend of grass weeds has been up, and yield reductions caused by these species have been increasing.

There has been an increasing trend toward the use of herbicides to control weeds in sugarcane. Herbicides are currently used extensively to control some weeds in mainland sugarcane and the sugarcane-producing areas in Hawaii, Puerto Rico, and the Virgin Islands. All Hawaiian sugarcane acreage is treated with herbicides one or more times during the life cycle of the crop.

Estimated annual average losses in yield and quality of sugarcane due to weeds amounted to about 13 percent of the potential value of the crop, or about $7,642,000, for the period 1951–60.

FORAGE-SEED AND GRAZING CROPS

Forage crops grown for seed

Bedstraw, bermudagrass, black medic, brome, Canada thistle, chickweed, chicory, crabgrass, curled dock, dodder, foxtail, henbit, johnsongrass, lambsquarters, pigweed, quackgrass, red sorrel, smartweed, wild mustard, whitetop, and other weeds cause severe losses in forage crops grown for seed production. Dodder, a parasitic weed that attacks alfalfa, red clover, and other forage legumes, is a serious problem in the Pacific Northwest and Middle Atlantic States. Infestations of this weed are increasing in most of the alfalfa seed-producing areas.

Use of herbicides to selectively control weeds in forage crops grown for seed production has increased rapidly. With the use of herbicides, the weed population trends were toward grass weeds and parasitic weeds such as dodder.

Forage and turf crop seeds grown for certification must be relatively free of weed seeds before they can be sold. To prevent spread of weed seeds through forage and turf crop seeds grown for seed, very extensive seed-cleaning equipment is installed in most seed company establishments to remove contaminating weed seeds. The cost of removing weed seeds from forage and turf crop seeds constitutes a significant portion of the total weed losses in these crops.

Estimated average annual losses in the value of forage and turf crops grown for seed due to

TABLE 18.—FORAGE SEED CROPS: *Estimated average annual losses due to weeds, 1951–60*

Commodity	Production unit	Loss from potential production [1]: Reduction in— Yield	Reduction in— Quality	Reduction in— Cleaning loss	Total reduction [2]	Quantity	Value
		Percent	*Percent*	*Percent*	*Percent*	*1,000 units*	*1,000 dollars*
Alfalfa	Pound	12	2	4	18	23,897	9,502
Bluegrass, Kentucky [3]	do	10	1	5	16	2,186	1,050
Brome, smooth	do	7	1	4	12	922	189
Clover:							
Alsike	do	13	1	5	19	1,554	513
Crimson	do	14	1	5	20	2,906	852
Red	do	15	2	5	22	15,515	6,218
White (including ladino)	do	12	1	4	17	659	457
Fescue, tall	do	9	1	5	15	3,071	886
Grasses:							
Miscellaneous	do	11	1	4	16	9,230	1,995
Turf [4]	do	12	1	4	17	1,979	859
Legumes, miscellaneous [5]	do	12	1	4	17	12,032	1,319
Lespedeza	do	14	1	4	19	19,174	2,897
Lupines	do	10	1	3	14	3,040	149
Orchardgrass	do	8	1	5	14	1,056	296
Ryegrass	do	8	1	4	13	10,302	1,094
Sweetclover	do	10	1	4	15	4,057	540
Timothy	do	8	1	5	14	3,241	599
Trefoil, birdsfoot	do	12	1	4	17	178	194
Total							[6] 29,609

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Includes Merion bluegrass.
[4] Includes chewings fescue, red fescue, and bentgrass.
[5] Includes common vetch, hairy vetch, purple vetch, and Austrian winter peas.
[6] Loss due to reduced yields and quality and to cleaning. Does not include costs of weed control; for these costs, see table 55.

yield and quality reductions by weeds amounted to approximately $29,609,000 for the period 1951–60 (table 18).

Pastures and rangelands

Estimated losses due to weeds, including brush, in forage crops and on rangelands are given in table 19 as losses in production of forage only. The estimated losses would have been greater had information been available on weed losses due to ineffective management of livestock, sublethal poisoning that is often undetected, mechanical injury to animals from needles and thorns, and reduced quality of animal products. In addition, because of lack of adequate information, no estimates are included of losses from weeds in new seedings of forage crops, from weeds in hay crops, or from weeds in improved pastures. However, losses in stand in new seedings of forage crops and reductions in stand from weeds occur frequently. Also, losses in quality and quantity of hay from meadows and of pasturage in improved pastures are significant.

These estimates do not include weeds that reduce stands, make plants weak and spindling, and even cause failures in establishing forage crops, nor do they include poisoning of livestock grazed on weedy pastures and range-

TABLE 19.—PASTURES AND RANGELANDS: *Estimated average annual losses due to weeds and cost of controlling weeds, 1951–60*

Kind of land and location [1]	Loss from potential production [2]: Reduction [3]	Value [4]
	Percent	*1,000 dollars*
Pastures and rangelands in 31 Eastern States	20	395,635
Rangelands in 17 Western States	13	236,690
Total	--	632,325
Cost of controlling weeds	--	365,000
Grand total	--	997,325

[1] Includes grazing lands, cropland pasture, and forage lands grazed.
[2] See table 2, footnote 1.
[3] See table 2, footnote 2.
[4] Based on data from the 1959 Census of Agriculture obtained from the Economic Research Service.

lands. For instance, a bizarre abortion problem in both beef and dairy cattle grazing unimproved, lowland pastures was unsolved for at least 50 years in Wisconsin. Research showed that abortions were caused by weeds that had sublethal dosages of nitrate. Spraying these weeds with 2, 4–D solved the abortion problem in these pastures.

East.—Weed and brush species often attain greater stature and density under the humid conditions in the 31 Eastern States than they do in the 17 Western States. Studies indicate that controlling these weeds results in slightly higher increases in forage in the West than in the East. Control of hardwood brush species typical of the Eastern States resulted in yields at least four times those on untreated areas. Oaks, gums, hickories, and other hardwood brush species typical of the Eastern States decreased yields of forage in experiments in Louisiana, 69 percent; in Missouri, 77 and 88 percent; in Arkansas, 75 percent; and in eastern Texas, 83 percent. Therefore, it is estimated that brush reduced production in these areas 75 percent. However, less dense stands of brush occur in some areas, and some sites are extremely low in fertility; therefore, it was estimated that yields were decreased an average of 64 percent on the 51 million acres of grazing land infested with brush where control would improve grazing. The prorated loss from brush on the entire 230 million acres of land grazed in the 31 Eastern States equals 14 percent.

Estimated losses from herbaceous weeds typical of the Eastern States, such as bitterweed, ironweed, ragweed, and undesirable grasses, are based on available studies. In Nebraska, losses in the amount of forage eaten by cattle on continuously grazed pasture infested with ironweed, ragweed, and other species ranged from 38 to 69 percent. In a pasture study in eastern Oklahoma, ragweed decreased yields 75 percent and there was a 50-percent reduction from ragweed on all pastures sampled in that State. In Mississippi, weeds in a pasture reduced the forage eaten by cattle by 22 percent. Because the pastures in these experiments may have been more weedy than the average, the average loss of 50 percent from weeds was divided by two, giving an estimated loss of 25 percent on the 55 million acres of residual pasture. The prorated loss from herbaceous weeds on the entire 230 million acres of grazing land in the Eastern States equals 6 percent.

Losses on grazing land from brush and from herbaceous weeds for the 31 Eastern States total 20 percent.

West.—Examples of weed and brush species that cause losses on rangelands are blackjack oak, cacti, chaparral, halogeton, juniper, larkspur, medusahead, mesquite, post oak, rabbitbrush, rubberweed, sagebrush, shinnery oak, and weed brome. Many ranges have been overrun by brush and weeds that have encroached after overgrazing or because of unfavorable weather or other conditions. For instance, authorities in Oklahoma estimate that more acres of land go back to brush each year than are controlled in the active brush-control program in that State. Also, increase in mesquite, which is accelerated by drought, amounted to 1 percent a year during a 12-year period in southern New Mexico. In addition, heavy losses are caused by poisonous plants such as deathcamas, halogeton, locoweed, and tall larkspur, which reduce vigor and cause death of livestock.

Research on brush species in the 17 Western States indicates that yield of forage where brush is partially controlled is generally at least three times that on untreated areas. In Arizona, the occurrence of 250 velvet mesquite trees per acre resulted in a 65-percent loss of forage production. On Texas rangelands with a ground cover of post blackjack oak, forage production was 83 percent less with a 65-percent ground cover than with a 13-percent ground cover. A similar type of brush infestation reduced production 78 percent in Oklahoma and 82 percent in Missouri. Other typical losses are 76 percent from shinnery oak in Oklahoma; 50 percent from sagebrush in Colorado; 60 to 72 percent from sagebrush in Oregon; 75 percent from sagebrush in Wyoming; and 66 percent from juniper in Arizona. On the basis of these data it was assumed conservatively that brush reduced production 52 percent on the 169 million acres of the infested grazing lands where brush removal could improve grazing. Prorating this percentage over the entire 769 million acres in the 17 Western States gives an estimated loss of 11.4 percent.

Data on losses from herbaceous and other poisonous weeds are not readily available. However, losses due to poisonous and herbaceous weeds were estimated at 5 percent on 264 million acres of rangelands infested with such weeds. Prorating this percentage over the entire acreage of grazing lands in the West gives an estimated 1.7-percent loss. When the prorated figures for losses from brush are added to the losses from poisonous and herbaceous weeds, the total losses equal 13 percent.

FRUIT AND NUT CROPS

The average annual losses in potential value caused by weeds in fruit and nut crops are estimated at $132,032,000 (table 20).

TABLE 20.—FRUITS AND NUTS: *Estimated average annual losses due to weeds, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Almonds	Ton	7	3	1,961
Apples	Bushel	3	3,604	6,672
Avocados	Ton	6	3	590
Blueberries	Quart	20	7,885	3,290
Cranberries	Barrel	10	119	6,493
Grapes, fresh	Ton	15	533	44,828
Grapefruit	do	5	87	2,549
Lemons	do	5	33	2,227
Olives	do	4	2	350
Oranges	do	5	286	16,066
Peaches	Bushel	6	4,239	8,488
Strawberries	Pound	25	147,612	36,170
Tangerines	Ton	5	10	523
Walnuts	do	5	4	1,825
Total				[3] 132,032

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Does not include costs of weed control; for these costs, see table 56.

Small fruits

Blueberries.—Weed losses in blueberries are caused by broadleaf weeds and grass weeds, including bermudagrass, crabgrass, goosegrass, lambsquarters, nutsedge, pigweed, ragweed, and smartweed. These perennial and annual weeds are a serious problem in new plantings where they soon overgrow the young blueberry plants unless intensive cultivation and costly hand weeding are practiced. Older producing plantings are also subject to the effects of weed competition, which reduces yields and lowers quality. Hand weeding, though effective, is economically prohibitive. Close cultivation usually causes severe mechanical damage to branches and roots.

Cranberries.—Cranberries are grown commercially in five States on low-lying soils where the topography is suitable for developing canals for flooding. Cranberries are broadcast planted and cannot, therefore, be cultivated after they are established. Plantings may be productive for 10 to 20 years if weeds are controlled. Many grasses, broadleaf weeds, ferns, and sedges, including bracken fern, nutsedge, redroot, and witchgrass, are among the principal weeds that cause economic losses. Annual flooding as practiced in cranberry culture is effective in controlling some weed species, but it does not control the weeds named above. Cranberries are low growing and are, therefore, easily shaded by weeds; and diminished vigor and yield and associated reductions in such quality factors as size, color, and flavor result.

Grapes.—Major areas of grape production are in six States in the northeastern, north-central and Pacific coast regions. The crop had total annual value of approximately 160 million dollars in 1960. Losses in grapes are caused by a number of weeds, including perennial grass weeds such as bermudagrass, johnsongrass, and nutgrass; and annual weeds, including barnyardgrass, crabgrass, fall panicum, goosegrass, lambsquarters, pigweed, ragweed, and smartweed. Weeds harbor insects and disease-producing organisms and compete for light and moisture and thereby reduce fruit yield and quality factors such as size, color, and flavor. Weeds also decrease harvesting efficiency.

Strawberries.—The commercial acreage of strawberries in some 30 States dropped from approximately 140,000 acres in 1951 to approximately 95,000 acres in 1960. High production costs were the determining factor in acreage reductions. Control of weeds is one of the major production costs.

The perennial nature of strawberries exposes them to infestation by a succession of different weed species, including summer and winter annual and perennial weeds. Principal weed losses are caused by annual weeds, including annual bluegrass, chickweed, crabgrass, henbit, knotweed, lambsquarters, pigweed, ragweed, and smartweed, all of which compete strongly for light, nutrients, and water and reduce yield and quality, including color, flavor, and size. Because of their prostrate growth habit strawberries are easily overgrown by these successions of weeds and continuous weeding is, therefore, necessary. Hand labor is effective, but is often unavailable or too costly.

Tree fruits

One or more fruits (apples, apricots, avocados, cherries, citrus, dates, figs, olives, peaches, pears, plums, and prunes) are produced commercially in most States. Weed losses are caused by many annual and perennial weeds. Bermudagrass, cheatgrass, johnsongrass, and quackgrass are among the principal perennial grass weeds in many areas of production. Annual grass weeds of importance include barnyardgrass, crabgrass, fall panicum, and goosegrass. Woody weed species, including brambles, poison-ivy, and scrub brush of various species, are sources of economically direct or indirect losses.

Weeds compete with the crops for moisture and nutrients and reduce yields and quality of fruits in dry seasons. They also add to the burden of irrigation. Orchards infested with poison-ivy are often difficult to harvest because workers are unwilling to enter infested areas. Intensive cultivation to control weeds causes mechanical damage to trunks and roots, which restricts uptake and translocation of nutrients and water and provides loci for infection by disease-producing agents. Weeds also harbor nematodes, disease-producing organisms, insects, and rodents, and interfere with their effective economical control.

Tree nuts

The principal areas of commercial production of tree nuts, including almonds, filberts, hazelnuts, macadamia nuts, tung, and walnuts, are in approximately 20 States (including Hawaii) in the South and along the Pacific Coast. Weed problems, therefore, relate to many weed species of diverse character such as bermudagrass, johnsongrass, nutsedge, annual broadleaf weeds, annual grasses, and woody plants, including poison-ivy. Losses due to weeds are caused by competition for water nutrients and result in reduced yield and grade of the product. Bark damage and injury to the developing or mature nuts by cultivating equipment cause additional losses. Ground covers of weeds harbor rodents that feed on roots and nuts and thus reduce both current yield and longevity of the plantings.

VEGETABLE CROPS

Losses due to weed infestations in commercial fields were estimated for a number of vegetable crops (table 21). Critical weed losses occur in many minor vegetable crops not mentioned here. Estimated average annual losses to vegetable crops due to weeds for the period 1951–60 are $122,249,000.

Beans, green lima

Weed losses in lima beans are caused by many broadleaf weeds and grass weeds. Major losses are due to crabgrass, goosegrass, and pigweed. These weeds emerge with the crop and after each cultivation. If rains prevent early cultivation, the crop may be lost because of weeds. Weeds that emerge after the last cultivation compete for space, light, moisture, and nutrients. Weed competition reduces yields and lowers quality by reducing sieve sizes and increasing the number of white, or overmature, beans. Beans of low quality reduce efficiency in the processing plant because expensive and time-consuming quality separations are required and the percentage of high-quality pack is reduced.

Commercial lima bean production is highly mechanized. The efficiency of mechanical harvesting depends on effective weed-control practices. Weeds carried with the crop into the bean viners cause losses due to carryover of beans with the mass of weed and crop foliage.

Beans, green snap

Weed losses in snap beans are the result of intense competition of a number of broadleaf and grass weeds, including crabgrass, lambsquarters, and pigweed. Some varieties of snap beans mature approximately 50 days after planting. Large amounts of fertilizer and moisture are needed to maintain rapid growth. Exposure to intense weed competition for even a very short period can delay maturity, lower yields, and reduce quality, including color and uniformity of maturity of pods. Growing of snap beans is being rapidly mechanized. Weeds reduce the efficiency of mechanical bean pickers. Yield losses due to weeds, therefore, occur during the harvesting.

Beets, table

Annual broadleaf and grass weeds that emerge with beets interfere with growth at a critical stage and cause losses in yield and quality factors such as color, size, and shape. Beet plants are small at emergence and grow slowly. During this initial period of slow growth, weeds can quickly overgrow the beets, especially in wet years. The small size of the plants limits the effective use of mechanical cultivating equipment. The efficiency of mechanical and hand harvesting is impaired by weeds.

Cantaloups, cucumbers, and watermelons

Major losses in cantaloups, cucumbers, and watermelons are caused by weeds that emerge after the lengthening vines prevent further cultivation. Principal weeds include broadleaf

TABLE 21.—VEGETABLES: *Estimated average annual losses due to weeds, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Beans:				
Green lima	Hundredweight	[3] 8	157	1,538
Green snap	do	[3] 9	905	7,943
Beets, table	do	[3] 6	153	289
Cantaloups	do	6	776	3,422
Carrots	do	[3] 9	1,123	4,326
Corn, sweet	do	10	4,782	8,724
Cucumbers:				
Fresh market	do	6	269	1,370
Pickling	Bushel	6	897	1,233
Lettuce	Hundredweight	7	2,496	10,077
Onions	do	[3] 7	1,345	4,865
Peas, green	do	[4] 13	1,501	8,331
Peppers, green sweet	do	[4] 7	225	2,680
Potatoes	do	[4] 3	7,113	28,272
Spinach	do	[5] 13	656	6,567
Sweetpotatoes	do	[6] 4	482	3,970
Tomatoes:				
Fresh	do	[4] 7	1,512	15,143
Processing	Ton	[4] 7	292	10,849
Watermelons	do	6	1,875	2,650
Total				[7] 122,249

[1] See table 2, footnote 1.
[2] See table 2, footnote 2.
[3] Includes 2-percent loss due to reduction in quality.
[4] Includes 3-percent loss due to reduction in quality.
[5] Includes 22-percent loss due to reduction in quality.
[6] Includes 4-percent loss due to reduction in quality.
[7] Does not include the costs of controlling weeds; for these costs, see table 56.

and grass weeds such as crabgrass, goosegrass, lambsquarters, and pigweed. Weeds that emerge with the crop are also critical in seasons of initial high rainfall. Weeds quickly overgrow the foliage of vine crops. Yields are lowered by reduced fruit set and size; and fruit quality, including color, flavor, and texture, is lowered. Maturation of the crop is irregular and marketing is difficult when weeds are present.

Carrots

The control of weeds in carrots is a major production problem because of the small size and slow early growth of the plants, which prevent effective cultivation. Weeds in carrots include crabgrass, galensoga, goosegrass, lambsquarters, pigweed, and ragweed and others specific for each commercial production area. A large part of the commercial acreage is sprayed with Stoddard solvent or sulfuric acid to control weeds. These herbicides are not fully effective, and a number of weeds including galensoga, ragweed, and others remain to harbor insects and disease-producing agents and compete for moisture, light, and nutrients. Unless the weeds are removed by hand, they reduce both yield and quality of the crop.

Corn, sweet

The principal weeds causing losses in sweet corn are barnyardgrass, crabgrass, fall panicum, goosegrass, jimsonweed, nutsedge, pigweed, quackgrass, ragweed, and smartweed. Repeated thorough cultivation controls many of these weeds between the corn rows. In years of limited rainfall, weeds that remain in the rows sometimes reduce yields as much as 50 percent. Sweet corn surviving on a limited water supply because of weed competition produces low yields of poor-quality ears. Toughened seedcoats, low moisture content, and reduced soluble sugars are the result. Grades and cash returns are lowered accordingly.

Lettuce

Lettuce is grown in areas with cool climates. Irrigation is used in the absence of abundant rainfall. Lettuce plants have small root systems and are, therefore, poor competitors for nutrients and water. As a result, moderate weed infestations can cause severe yield losses when moisture is limited.

Onions

Onions are grown commercially in many areas where there are wide ranges of weed species and cultural practices. Major weed losses occur during the early period of growth, when the slow-growing, tender plants are becoming established. Grasses and broadleaf weeds, unless effectively controlled, quickly smother onion plants. Extensive cultivation and hand weeding are required. Weather or other conditions that interfere with control of weeds can easily result in severe yield losses or complete loss of the crop.

Principal weeds causing losses in onions vary with the local climate; they include bermudagrass, crabgrass, goosegrass, lambsquarters, nutsedge, pigweed, purslane, quackgrass, ragweed, and smartweed.

Peas, green

One of the principal causes of weed losses in peas grown for canning and freezing is Canada thistle. Peas are drilled in very narrow rows that do not permit cultivation in the usual way. Thistle buds are the same size and density as peas at harvest. They pass through the viner with the peas and are carried to the processing plant. Mechanical processing equipment will not effectively separate thistle buds from the peas and, therefore, they must be removed by hand from the picking belt. Dockage is determined by the number of thistle buds per pound of peas, and cash returns to the grower are reduced accordingly. Losses due to Canada thistle have been lowered by use of herbicides. Benefits from herbicides are reduced by lack of general use, incorrect application, and the effects of climate.

Yields and quality of peas are also reduced by many annual and perennial grass and broadleaf weeds when moisture is limiting. Weed competition under these conditions causes the normally tender high-quality peas (small-sieve size) to become hard. These small hard peas are difficult to separate in specific-gravity and mechanical-quality separators. They, therefore, lower the grade of the processed product. Grades of fresh peas are lowered, and the grower receives less for this crop.

Peppers, green sweet

Weeds that emerge immediately after transplanting and after the final cultivation are the major causes of weed losses in peppers. Wet weather or other factors that interrupt weed control measures during early growth can severely reduce yield and quality or cause complete loss of the crop.

Setting of fruits on peppers is reduced under low soil-moisture conditions. The strong competition of weeds for moisture during the blossoming and fruit-setting period can, therefore, cause severe yield losses. Competition for moisture during fruit enlargement often causes severe quality losses due to blossom-end rot.

Perhaps the most troublesome weeds in peppers are the annual grasses (barnyardgrass, crabgrass, and goosegrass). Many broadleaf weeds such as lambsquarters, pigweed, and ragweed contribute to the general weed complex.

Potatoes

Potatoes are grown commercially in many geographical areas representing a wide range of climates, soils, and cultural practices. Principal weeds contributing to losses in potatoes vary accordingly; among others they include barnyardgrass, bermudagrass, crabgrass, fall panicum, goosegrass, lambsquarters, nutsedge, pigweed, quackgrass, ragweed, and smartweed.

Perennial grasses, including bermudagrass, nutsedge, and quackgrass, reduce yields and cause potato tuber damage by penetrating roots and stolons. Grade losses up to 25 percent, caused by tuber damage, have been observed.

Late-season broadleaf and grass weeds that emerge, in some instances, after the last cultivation interfere with mechanical digging and may reduce the efficiency as much as 50 percent. Large clumps of weeds and associated soil passing over the digger belt carry potatoes with them that are covered and lost. Losses of more than 20 percent have been observed.

Spinach

Spinach is grown in many geographical areas during fall, winter, and spring. Weed losses during the early stages of growth in fall plantings are caused by a number of warm-weather weeds, including crabgrass, goosegrass, lambsquarters, and pigweed; the kind of weed depends on location. Cool-weather weeds, including annual bluegrass, chickweed, henbit, knotweed, and peppergrass, are also a major cause of economic loss.

Competition for moisture is critical during the early stages of growth. Cultivation and hand weeding can effectively control weeds. Cost, however, prevents the unlimited and continuous use of labor in spinach and other pot greens. As a result, the exposure of the crop to short periods of weed competition between weedings can be critical. Losses in yield and such quality factors as color, texture, and flavor are the result. Chlorotic leaves, tough texture, and bitter flavor prevent marketing the crop or greatly reduce its value. Hand weeding also causes severe yield losses due to incidental removal of crop plants with the weeds. Yield losses of one-third have been observed.

Sweetpotatoes

Losses in sweetpotatoes occur as a result of early-season infestations of annual broadleaf and grass weeds, including barnyardgrass, crabgrass, goosegrass, lambsquarters, and pigweed. Perennial grasses such as bermudagrass, johnsongrass, and nutsedge are also serious weed problems. Annual weeds between the rows can be controlled by cultivation until runners become too long. Thereafter, weeds must be removed by hand. Yields are reduced by weed competition, and quality factors such as size, shape, and color are lowered. Efficiency of mechanical harvesting is radically lowered by weeds.

Tomatoes

Major losses in tomatoes are caused by annual weeds that emerge with the direct-seeded crop and those that emerge after the last cultivation of both direct-seeded and transplanted tomatoes. Losses are caused by annual and perennial grass weeds and annual broadleaf weeds. Principal among them are barnyardgrass, crabgrass, goosegrass, lambsquarters, nutsedge, and pigweed. Weed competition for moisture during fruit enlargement reduces yields. When weeds infest the crop, fruits are small, full color does not develop, and blossom-end rot often damages many fruits. In New York and certain other Northeastern States, early infestations of broadleaf weeds, including pigweed and lambsquarters, are the major weed problems. In the Middle Atlantic States, grasses that emerge after the last cultivation are of primary concern. These grasses often overgrow tomato plants, interfere with harvesting, and produce humid conditions conducive to fruit diseases, which cause additional losses.

Chapter 6.—Inefficient Farm Operations and Fire

Crop production is subject to losses from inefficient farm operations. Mechanical damage to crops is due, directly or indirectly, to unsuitable types and improper use of machines, including excessive pesticide application and improper fertilizer placement, planting, and root pruning. All tend to reduce yields. Also, some farm produce is subject to losses caused by fire. Average annual losses from inefficient farm operations and fire are estimated to be about $510,887,000 for the period 1951–60 (table 22).

EXCESSIVE PESTICIDE APPLICATION

When pesticides are applied irregularly or with too low concentration on the plant foliage, larger amounts must be used than when they are applied uniformly and efficiently. The average annual value of the material wasted for the period 1951–60 is estimated at $64,847,000.

TABLE 22.—*Estimated average annual losses of agricultural crops caused by inefficient farm operations and fire, 1951–60*

Type of loss	Amount of loss
	1,000 dollars
Farm operation:	
Excessive pesticide application [1]	64,847
Improper fertilizer placement [2]	174,843
Improper planting	50,000
Root pruning [3]	70,297
Fire [4]	150,900
Total	510,887

[1] Represents 10 percent of the cost of controlling insects, plant diseases, and weeds (includes cost of chemicals and application).

[2] Represents 1 percent of total farm value of 59 crops.

[3] Represents 0.5 percent of total farm value of all cultivated crops.

[4] From Agricultural Finance Review, Vol. 22, Suppl., July 1961. Includes farm real estate, machinery, livestock, and stored products.

IMPROPER FERTILIZER PLACEMENT

Seeds and seedling roots are injured if the soluble salts of fertilizer are placed too near them or if too much is used. When the fertilizer is too widely scattered or too far away, lack of early plant stimulation, unavailability of part of the plant food, or weed stimulation and competition result in decreased yields. Damage varies widely, but average annual losses for the period 1951–60 are estimated at $174,843,000.

IMPROPER PLANTING

Planting seed either too deep or too shallow, insufficient compaction of the soil around the seed, moist surface soil pressed into a firm layer above the seed, improper elevation of the seed row with respect to the general level of the land, and other unfavorable planting conditions cause either delayed or low germination and an inferior stand of plants. The adverse effects on crop yields are manifest in many ways and are frequently severe enough to require replanting. Losses also result from faulty transplanting of seedlings and the use of excessive amounts of seed. Estimated average annual losses for the period 1951–60 are $50,000,000.

IMPROPER ROOT PRUNING

A plant suffers from lack of water and nutrition when too much of its root system is severed by tillage tools and furrow openers operated too deeply in the soil or too close to the plant. The location on the plant where the tools cause excessive pruning depends on the kind of crop or nature of the root system, and the stage of plant growth or extent of root development. Hot weather and low soil moisture may aggravate these effects, which are reflected in reduced yield. Estimated average annual losses for the period 1951–60 are $70,297,000.

Chapter 7.—Harvesting and Storage Losses

HARVESTING LOSSES

Many losses in agricultural commodities can be attributed to mechanical harvesting. When crops were hand harvested, inferior or immature products were not gathered, and harvesting costs often amounted to one-half or more of the total the producer received for some crops. Mechanical harvesting is indiscriminate—inferior or immature products are harvested along with good-quality mature products. But machinery has enabled the farmer to tend more acres with fewer workers at less cost and in better season than ever before.

Harvesting machines are designed for specific crops under specific conditions. When the weather changes, methods and equipment must be modified. Obviously, machines that work well on level land when harvesting oats may encounter difficulty on hilly land when harvesting lespedeza or burclover.

A most important consideration is the moisture content of the crop at harvesttime. To prevent shattering, to avoid harvesting during inclement weather, and to make the most efficient use of harvesting machines, some crops are harvested before the most desirable time. As a result, crops often contain more moisture than recommended for storage.

Average annual losses during harvesting of crops for the period 1951–60 are estimated to be $998,481,000 (table 23).

Cereals (wheat, oats, barley, rye, rice), safflower, and sesame

Most harvesting losses of cereals are due to (1) shattering of grain onto the ground and breakage of straw when the crop is too dry, and (2) improper adjustment and operation of the harvesting machine. Timely harvest will help to eliminate many of the losses due to shattering and breakage of straw, and some of those caused by wind, hail, and insects. Cutterbar losses can be minimized by proper reel adjustment, and other machine losses by correct cylinder speed, clearance between concaves, correct number of concaves, and proper airblast adjustment. Grain is usually combined at moisture contents not best suited for storage.

TABLE 23.—CROPS: *Estimated average annual losses during harvest, 1951–60*

Commodity	Production unit	Loss from potential production [1]		
		Reduction [2]	Quantity	Value
		Percent	*1,000 units*	*1,000 dollars*
Barley	Bushel	5	20,177	19,787
Castorbeans	Pound	7	2,144	117
Corn	Bushel	8	275,368	351,523
Cotton, lint and seed	Bale	5	775	125,383
Flax (seed)	Bushel	5	1,878	5,802
Oats	do	5	71,258	47,242
Peanuts	Pound	15	267,720	28,776
Potatoes	Hundredweight	7	54,536	108,375
Rice	do	5	2,767	13,428
Rye	Bushel	5	1,335	1,547
Safflower	Ton	5	6,810	256
Seed crops:				
Grasses	Pound	17	66,344	8,573
Legumes	do	30	231,692	46,216
Sesame	do	10	854	110
Sorghum, grain	Bushel	10	37,628	37,858
Soybeans	do	8	36,715	81,620
Sugarcane	Ton	5	414	2,939
Tung nuts	do	10	9	610
Wheat	Bushel	5	62,111	118,319
Total				998,481

[1] See table 2, footnote 1.

[2] See table 2, footnote 2.

Castorbeans

Harvesting losses of castorbeans are due to (1) shattering of capsules, (2) improper adjustment and operation of the harvesting machine, and (3) cracking of seed during hulling and handling. Timely harvest is often prevented because the field is too wet to enter; and when the field has dried enough, the crop has been damaged or depleted by adverse weather. Improper adjustment and mismanagement of the machine during harvesting, hulling, and handling fracture the seedcoats, which causes the oily meats to deteriorate.

Corn

Losses during harvest of corn are due largely to (1) ears dropping to the ground, (2) corn shelled off ears, (3) stalks broken down, (4) harvesting when corn is too dry, (5) crushing of kernels harvested with too high moisture content, (6) improper adjustment and operation of the machine, and (7) obsolete machinery. Many of these losses can be greatly reduced by earlier harvesting. This is practical if ventilation is used to dry the harvested corn or if high-moisture corn is ensiled in airtight storage. Losses can be further reduced by proper adjustment of snapping and husking rolls and gathering points on the machine.

Cotton, lint and seed

Losses during harvest of cotton are due to (1) plant population and irregular planting, (2) cultural practices influencing ground contour, (3) time and method of harvesting (percentage of bolls open), (4) harvest delay caused by weather, (5) bolls missed by harvester, (6) improper adjustment and operation of the machine, and (7) improper defoliation.

Flax (seed)

Harvesting losses of flax (seed) are due to (1) delayed harvest which results in dropped bolls, (2) combining from the swath before the crop is dry enough to thresh, (3) weather damage while the crop is in the swath, and (4) improper adjustment and operation of the combine. Flax is considered mature when 90 percent of the bolls have turned brown. Special care must be given flax when it is to be used as seed. The seedcoat is easily injured during threshing if the seeds are dry.

Peanuts

Losses of peanuts during harvest include: peanuts left in the ground because the digger is improperly adjusted; peanuts separated from the vine because of disease or during shaking and windrowing operations; and losses that occur in combine harvesting or manual handling when the peanuts are stacked. Additional losses in field-stacked peanuts are caused by weather and birds. Improper equipment or methods for artificially drying peanuts may cause loss in quality.

Potatoes

Harvesting losses of potatoes include those left in the field by the digger, some of them because they were severely cut or otherwise damaged. Harvesting losses can be reduced by using large, improved diggers designed to avoid damaging the potatoes and by setting the machines to dig deep enough to harvest the whole hill and to gather sufficient dirt to protect the potatoes as they go over the elevators and sorting belts.

Seed crops (grasses and legumes)

Losses of legume and grass seeds during harvest include shattering of ripe seed before it is fully mature and mechanical damage due to rough handling by the combine cylinder, concaves, beaters, and fans. The result of mechanical damage to seed is low germination. Much of the lighter seed is blown over if the cleaner fan is not properly adjusted. Vacuum machines are often used to pick up shattered seed from the ground after combining. Such machines are usually custom operated.

Sorghum, grain

Harvesting losses of sorghum are due chiefly to (1) breaking off of heads, (2) breaking of stalks, (3) shattering of grain, (4) incomplete threshing, and (5) improper adjustment and operation of harvesting equipment. Early harvest will prevent most losses due to breaking of heads and stalks and shattering. Methods of drying grain sorghum now being developed will make early harvesting feasible.

Soybeans

Losses during harvest of soybeans are due to (1) shattering of seeds, (2) breaking down of plants, (3) improper adjustment and operation of harvesting machines, and (4) breaking of seed during threshing.

Sugarcane

Harvesting losses of sugarcane are due to adverse weather, which prevents harvesting at the proper stage of development. In some years, freezes damage the crop before it can be harvested. Field losses caused by improper machine adjustment or operation are costly because extra labor is required for gleaning; however, the crop is usually saved. Loss of sucrose is related to the time that elapses between harvesting and milling operations. Excessive field trash contributes to loss in sugar production.

Tung nuts

A major portion of the tung crop is harvested by hand, and some losses are attributed to lack of harvest labor. But the main cause of loss is incomplete recovery of the fruit, which is mixed with dead wood and leaves on the ground. This accumulation of trash, together with an uneven ground surface, also results in inefficient mechanical harvesting.

STORAGE LOSSES

Stored-product insects

Estimates for the losses caused by stored-product insects to agricultural products after harvest are based on information from a number of sources. These sources include associa-

TABLE 24.—STORED PRODUCTS: *Estimated average annual losses caused by insects, 1951–60*

Commodity	Production unit	Loss in quantity		Loss in value
		Percent	*1,000 units*	*1,000 dollars*
Almonds	Ton	4.0	[1] 1,804	[1] 1,047
Apples, dried	Bushel	2.0	[2] 74	[2] 2,599
Apricots, dried	Ton	1.8		[3] 132
Barley	Bushel	2.5	12,723	12,978
Beans, dry edible	Bag	.5	[4] 84	[4] 623
Cereal breakfast foods		.4		[6] 1,495
Corn	Bushel	5.5	234,343	[7] 304,646
Cowpeas, dry edible	Bag	.5	[4] 4	[4] 17
Crackers, biscuits, and pretzels		.4		[6] 2,811
Dry corn milling products		.4		[6] 273
Dry milk (nonfat)				[8 9] 396
Figs, dried	Ton	20.0		[3] 868
Filberts	do	2.0	[1] 164	[1] 58
Macaroni and noodles		.1		[6] 161
Oats	Bushel	.01	29	[5] 20
Peaches, dried		1.5		45
Pears, dried		2.5		[3] 20
Peanuts		7.0	[4] 104,200	[4] 11,186
Pecans	Pound	2.0	[1] 3,172	[1] 790
Prepared flour and flour mixes		.4		[6] 1,651
Prunes, dried	Ton	.75		[3] 227
Raisins		2.3		[3] 9,803
Rice	Hundredweight	1.5	[10] 880	[10] 4,311
Rye	Bushel	1.2	477	[5] 1,016
Sorghum, grain	do	3.4	17,306	[7] 19,383
Tobacco:				
Flue-cured leaf	Pound	.8	[11] 20,562	[11] 11,104
Other than flue-cured leaf	do	.12		[12] 322
Manufactured products	do	.02		[13] 1,023
Walnuts	Ton	3.3	[1] 2,428	[1] 1,062
Wheat	Bushel	3.0	60,192	[5] 116,772
Wheat flour		.4		[6] 5,260
Wool:				
Products				[14] 350,000
In pianos				[14] 3,750
Total				856,849

[1] Production data and farm value, respectively.
[2] Represents quantity sold and price received. SRS Statistical Bul. 292 (1961) and 322 (1962).
[3] Computed from data in SRS Statistical Bul. 322 (1962).
[4] Quantity sold and amount of sales, respectively.
[5] Value of total supply on hand (July 1) at average prices received by farmers.
[6] Value of shipments; taken from Annual Survey of Manufacturers.
[7] Value of total supply on hand (Oct. 1) at average prices received by farmers.
[8] Loss of 1.0 percent in quality only.
[9] Computed on basis of announced ASCS purchase price in most common container.
[10] Value of total supply on hand (Aug. 1) at average prices received by farmers.
[11] Data from USDA, Agr. Marketing Service Bul. 200 (1956) and 308 (1962). Represents stocks on hand and average prices paid to growers, respectively.
[12] Excludes foreign-grown and turkish types. Data represent stocks on hand and average prices paid to farmers.
[13] Represents loss in retail sales adjusted downward by an estimated markup of 20 percent. Basic data include value of Federal and State tobacco taxes.
[14] Data furnished by the Market Quality Research Division, ARS.

tions and individual members of industry; government agencies involved in the procurement, storage, or distribution of commodities under the government price support program; Food and Drug Administration notices of judgments on foods seized because of insect infestation; and Federal, State, and industry surveys. The information obtained ranged from very precise to rather questionable data. The reliability of the source and of the information obtained was considered in arriving at each of the estimated losses. Whenever the information was questionable, a conservative approach was used in estimating the loss.

The losses shown in table 24, unless specifically noted, reflect only the loss of value at the time the insect damage occurred to the commodity. Furthermore, only the actual loss to the commodity was considered. The cost of handling and cost of insect control and sanitation, loss of prestige or business, and other secondary costs resulting from damage or contamination by insects were not included in the estimates.

Storage losses other than from insects

Losses in storage from causes other than insects occur in agricultural commodities in commercial or Government warehouses. These losses are given in table 25.

Cereals (Wheat, Oats, Barley, Rye, Rice).—Before the 1950's, most storage losses in cereal grains, aside from insect damage, were caused by mold and self-heating. The increased use of driers before storage and improvements in storage technology have reduced these losses a great deal. It is difficult to accurately measure losses from shrinkage or quality deterioration and gains from quality improvement through blending or for other reasons. For example, as of January 1958, Commodity Credit Corporation had unloaded 15,917,765 bushels of wheat that had been in storage for several years in Government ships at Astoria, Oreg. The quantity unloaded was 16,618 bushels less than had been originally loaded and 1,487 bushels had deteriorated in quality; 949,109 bushels had improved in grade from No. 2 Soft White to No. 1 Soft White because loss of moisture during storage had improved the test weight. The rest was equal in grade to that originally loaded. Total loss from shrinkage and deterioration was only 0.1 percent.

A study of wheat stored in bins at 53 sites in 29 counties in Kansas showed that average losses in the net value of wheat due to shrinkage and deterioration were quite small. Some 2½ million bushels of wheat from the 1952, 1953, and 1954 crops improved in grade while stored for an average of 2 years; however, weight losses resulting from removal of screenings resulted in a net decrease in value of 0.7 percent. Weight loss due to shrinkage was 0.55 percent.[1]

The Department of Agriculture's Farmer Cooperative Service concluded in 1955, after a study of operating costs of new country elevators in the hard winter wheat area, that shrinkage of 0.25 percent appears reasonable in handling or merchandising grain under good management, with an additional shrinkage of 0.25 percent in storage.[2]

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[1] TAYLOR, J. W., and CLIFTON, R. E. SHRINKAGE LOSSES AND GRADE CHANGES IN WHEAT STORED AT KANSAS BIN SITES. U.S. Dept. Agr., Agr. Mktg. Serv. AMS-325. 1959.

[2] FARMER COOPERATIVE SERVICE, U.S. DEPARTMENT OF AGRICULTURE. NEW LOCAL ELEVATORS: COST-VOLUME RELATIONS IN THE HARD WINTER WHEAT BELT. Serv. Rpt. 12. 1955.

TABLE 25.—FIELD CROPS AND HAY: *Estimated average annual losses during storage, 1951–60*[1]

Commodity	Production unit	Loss in quantity		Loss in quality	Loss in value
Crop:		*Percent*	*1,000 units*	*Percent*	*1,000 dollars*
Barley	Bushel	1.0	[2] 2,317	0.1	2,620
Corn	do	2.0	[3] 47,953	.2	68,573
Flaxseed	do	2.0	[2] 368	.2	1,266
Oats	do	1.0	[2] 10,294	.1	7,677
Rice	Hundredweight	1.0	[4] 46	.1	249
Rye	Bushel	1.0	[2] 144	.1	188
Sorghum, grain	do	2.0	[3] 2,202	.2	2,730
Soybeans	do	.5	[3] 731		1,696
Wheat	do	1.0	[2] 4,886	.1	10,476
Hay, all	Ton	5.0	[3] 3,866	2.0	89,739
Total					185,214

[1] Does not include insect damage.
[2] Average stocks, Oct. 1, 1951 to Oct. 1, 1960; first estimate following harvest (crops of 1951–60).
[3] Average stocks, Jan. 1, 1952 to Jan. 1, 1961; first estimate following harvest (crops of 1951–60).
[4] Average stocks, Jan. 1, 1952 to Jan. 1, 1961; first estimate following harvest (crops of 1951–60). Seven-year average stocks: 1952–53, 1957–61; 1954–56 not estimated.

In another study, wheat from the 1952, 1953, and 1954 crops stored in country elevators in Kansas was examined for shrinkage and deterioration. Shrinkage losses totaled about 0.25 percent for a storage period averaging 10½ months. About half of the loss was attributed to handling rather than to storage. The study disclosed no change in grade of the wheat, and the authors commented that, "Although loss in grade is a risk in storing grains the results of this study would seem to indicate that this factor is not of any great significance in normal operations of country elevators." [3]

Most of the losses, other than insect damage, in recent years have been due to handling, deterioration, shrinkage, and rodents.

Corn, Grain Sorghums, Soybeans, and Flaxseed.—Before the 1950's much of the loss in stored corn, other than insect damage, was due to mold and heating caused by high moisture and inadequate ventilation. Since that time the increased use of driers before storage has decreased losses of corn in storage. A study of some 18 million bushels of CCC-owned corn from the 1948, 1949, and 1950 crops, stored in bins in 10 Iowa counties for an average of about 3 years, showed an average annual loss of 0.85 percent from deterioration and 0.53 percent from shrinkage. Deterioration occurred when use of aeration was not widespread. The study indicated that because of improvements in storage technology, "the costs of quality deterioration might be expected to be less for present long-term corn storage than that incurred in the 1948 and 1949 corn."[4]

CCC records show that of 5,508,515 bushels of wheat, corn, and other grains that had been loaded in bins at 273 sites in Kansas from 1954 through 1958, 5,469,455 bushels were loaded out—a difference of 39,060 bushels, or an average shrinkage of 0.7 percent for the entire period of storage. At an additional 126 bin sites, 1,607,596 hundredweight of grain sorghums were loaded in and 1,597,750 hundredweight were loaded out—a difference of 9,846 hundredweight, or average shrinkage of 0.6 percent.

Most losses in storage, other than insect damage, are due to handling, deterioration, shrinkage, and rodents. Losses in farm-storage facilities are somewhat greater than losses in CCC storage. Many farm-storage facilities are older and are not as well protected against rodent losses. Also, since driers are not used by all farmers, the grain is sometimes stored with the moisture content too high for safe storage.

Estimated storage losses of corn and grain sorghums average about 2 percent of the production each year.

Estimated storage losses of soybeans average about 0.5 percent each year. Storage losses for soybeans are less than for corn and grain sorghum for two reasons. First, during the 1950's there was very little carryover from one year to the next since practically all of the soybeans were consumed. Second, most of the soybeans are moved off the farms into commercial-type storage, and losses in commercial-type storage are less than in farm-storage facilities.

Estimated storage losses for flaxseed average about 2 percent of the production each year.

A study was made of flaxseed marketing practices and costs at 265 country elevators in North Dakota, Minnesota, and South Dakota.[5] These three States produce over 90 percent of the annual U.S. flaxseed crop. Shrinkage from time of purchase to sale, including handling, averaged 1.53 percent at 175 elevators, or about 50 percent more than the average of 1.01 percent in other grains. Shrinkage resulted from (1) elevating, conditioning, and moving flaxseed within the elevators, (2) removing small or broken flaxseed kernels along with dockage in the cleaning process, (3) loss of moisture between the time of purchase and sale, (4) loading out flaxseed into boxcars or trucks, and (5) leakage of seed en route to terminals.

Most of the losses in flaxseed are due to shrinkage. The small size and slippery nature of flaxseed make it especially susceptible to losses in handling and transportation.

[3] TAYLOR, J. W., and CLIFTON, R. E. SHRINKAGE AND GRADE OF WHEAT STORED IN COUNTRY ELEVATORS IN KANSAS U.S. Dept. Agr., Agr. Mktg. Serv. AMS-291. 1959.

[4] MCDONALD, E. M. LOSSES FROM SHRINKAGE AND QUALITY DETERIORATION OF CORN STORED IN COUNTRY ELEVATORS AND AT BIN SITES IN IOWA. U.S. Dept. Agr., Agr. Mktg. Serv. AMS-173. 1957.

[5] MANION, W. M., and ANDERSON, C. M. FLAXSEED MARKETING PRACTICES AND COSTS AT COUNTRY ELEVATORS. U.S. Dept. Agr. MRR-301. 1959.

Chapter 8.—Livestock and Poultry Losses

Losses are sustained by livestock and poultry producers from infectious and noninfectious diseases, parasitism, nutritional disorders, and accidents (tables 26–30). With a rapidly expanding population, it is essential that these losses be reduced or eliminated as soon as research discloses an economical means of so doing. The United States is in a highly favorable position compared to the rest of the world in having reduced or eliminated losses from various causes. But in spite of the many advances that have been made, losses are still substantial.

INFECTIOUS DISEASES

Infectious diseases are responsible for a large part of the total losses in livestock and poultry (tables 26–30). These losses, as great as they are, represent only a fraction of those sustained before some of the major infectious diseases were brought under control or eradicated.

For example, in 1925 tuberculosis was estimated to be costing the livestock industry between 25 and 30 million dollars a year in direct losses from condemned carcasses and parts of slaughtered cattle and swine. At that time the eradication program had been underway 8 years and the prevalence of the disease had been reduced from 4.9 to 3.1 percent in cattle and from 15.2 to 14.5 percent in swine.

Brucellosis was estimated to be responsible for annual losses of $92 million before the accelerated eradication program was initiated in 1954. Elimination of most of these losses not only has increased the income of livestock producers but, even more important, has increased the supply of animal products and byproducts.

Some diseases are of special interest. Vesicular exanthema, a virus disease of swine, was a relatively unimportant disease confined to California until 1951, when it suddenly became widely disseminated. Although an eradication program was immediately organized and put into effect, the disease cost the swine industry an estimated $11 million before it was eradicated in 1956.

Anthrax does not cause a large loss to the livestock industry as a whole. However, for individual farmers, this disease can prove disastrous. Death losses are very high and so rapid that usually the first sign noticed by the farmer is the sudden death of several animals. In endemic areas, there is little choice but to vaccinate every year, and this adds to the cost of raising livestock in those areas.

Rabies, a virus disease, does not cause large losses either to the industry or to the individual farmer. But it is 100-percent fatal once symptoms develop and is a public health menace. Again, in endemic areas it is wiser to immunize than to take chances with the disease, because the cost of the disease far outweighs the cost of immunization.

NONINFECTIOUS DISEASES AND NUTRITIONAL DISORDERS

A large number of noninfectious diseases of livestock, particularly of cattle, result in failure to grow, reduced gains, the need for veterinary services, and death losses (tables 26–30). The origin of some of these diseases, but not all, is nutritional. Reports from a representative group of veterinarians in dairy sections showed that 70 percent of their calls to treat and advise on animal diseases were for those classified as noninfectious. Since noninfectious diseases are not the responsibility of State or Federal regulatory officials, except as they may affect the meat when the animal is slaughtered, morbidity and mortality reports are not made on them. Therefore, almost no reliable information is available on the number of animals that are affected or die from these causes. About the only useful information on these losses is in meat inspection records that list tumors and various other pathological alterations of the organs and tissues not associated with infectious diseases at the time of slaughter.

The greatest losses from noninfectious diseases are due to faulty management and feeding. In cattle, bloat, milk fever, acetonemia, calving troubles, sterility from endocrine disturbances, and chemical poisoning are common. Sheep are also frequently lost from bloat, poisonous plants, chemical poisoning, ketosis or lambing paralysis, and urinary calculi.

Pasture-improvement measures that result in a lush growth of legumes have increased losses from bloat; an effort has been made to determine these losses and they are included in the tables.

TABLE 26.—CATTLE: *Estimated average annual losses caused by infectious and noninfectious diseases, 1951–60*

Cause of loss	Production unit	Loss due to mortality: Reduction [1]	Loss due to mortality: Quantity [2]	Loss due to mortality: Value	Loss due to morbidity: Reduction [1]	Loss due to morbidity: Quantity [2]	Loss due to morbidity: Value	Total: Quantity	Total: Value [2]
		Percent	*1,000 units*	*1,000 dollars*	*Percent*	*1,000 units*	*1,000 dollars*	*1,000 units*	*1,000 dollars*
Anaplasmosis [3]		------	------	------	------	------	------	------	------
Anthrax: Beef	Pound	0.0007	98	19	------	------	------	98	19
Bloat:									
Beef	do	.06	83,941	16,222	1.5	209,521	40,490	293,462	56,712
Dairy	do	.4	37,220	7,193	------	------	------	37,220	7,193
Milk	do	------	------	------	.8	981,349	41,035	981,349	41,035
Bovine hyperkeratosis (X-disease): Beef, dairy and all calves [4]	do	.025	6,728	1,317	.009	2,421	474	9,149	[4] 1,791
Brucellosis:									
Beef	do	.4	55,961	10,814	.1	13,968	2,699	69,929	13,513
Dairy	do	.4	37,220	7,193	------	------	------	37,220	7,193
Milk	do	------	------	------	.5	613,343	25,647	613,343	25,647
Calf losses: Beef	do	22.0	537,526	113,843	------	------	------	537,526	113,843
Encephalitis (listeriosis):									
Beef	do	.002	280	54	------	------	------	280	54
Foot rot: Beef	do	------	------		.11	15,365	2,969	15,365	2,969
Grass tetany:									
Beef	do	.02	2,798	541				2,798	541
Dairy	do	.001	93	18	------	------	------	93	18
Milk	do	------	------	------	.002	2,453	103	2,453	103
Johne's disease:									
Beef, dairy, and all calves	do	.16	43,057	8,430	.1	26,901	5,267	69,958	13,697
Milk	do	------	------	------	.1	2,453	103	2,453	103
Ketosis:									
Dairy	do	.02	1,861	360	------	------	------	1,861	360
Milk	do	------	------	------	.03	36,801	1,539	36,801	1,539
Leptospirosis:									
Dairy	do	.25	23,262	4,495	------	------	------	23,262	4,495
Milk	do	------	------	------	.15	184,003	7,694	184,003	7,694
Mastitis:									
Dairy	do	.15	13,957	2,697	2.0	186,309	36,004	200,266	38,701
Milk	do	------	------	------	7.26	8,905,738	372,389	8,905,738	372,389
Milk fever:									
Dairy	do	.02	1,861	360	------	------	------	1,861	360
Milk	do	------	------	------	.2	245,337	10,259	245,337	10,259
Poisoning, chemical: Beef	do	.07	9,793	1,893	.07	9,778	1,890	19,571	3,783
Poisoning, plant: Beef	do	[5] .64	89,537	17,303	------	------	------	89,537	17,303
Rabies: Beef	do	.001	140	27	------	------	------	140	27
Tuberculosis: Beef	do	.023	3,218	622	------	------	------	3,218	[6] 622
Urinary calculi: Beef	do	.6	8,394	1,622	.09	8,381	2,430	16,775	4,052
Vibriosis Beef	do	------	------	-	3.86	539,168	104,194	539,168	104,194
Total:									
Animals	------	------	------	195,023	------	------	196,417	------	391,440
Milk	------	------	------	------	------	------	458,769	------	458,769
Grand total	------	------	------	195,023	------	------	655,186	------	850,209

[1] See table 2, footnote 2.
[2] See table 2, footnote 1.
[3] See table 31.
[4] 3 years only; disease eradicated in 1954.
[5] Based on data from 11 Western States.
[6] Excludes loss of $117,240 in meat.

TABLE 27.—SWINE: *Estimated average annual losses caused by infectious and noninfectious diseases, 1951–60*

Cause of loss	Production unit	Loss due to mortality			Loss due to morbidity			Total	
		Reduction [1]	Quantity [2]	Value	Reduction [1]	Quantity [2]	Value	Quantity	Value [2]
		Percent	*1,000 units*	*1,000 dollars*	*Percent*	*1,000 units*	*1,000 dollars*	*1,000 units*	*1,000 dollars*
Anthrax	Pound	0.001	194	34	0.0005	98	17	292	51
Atrophic rhinitis (sneezing sickness)	do	.0025	485	85	------	------	40,000	485	40,085
Baby pig losses [3]	Head	------	30,000	240,000	------	------	------	30,000	240,000
Brucellosis	Pound	------	------	------	.287	56,057	9,876	56,057	9,876
Cholera	do	.66	127,912	536	.07	13,672	2,409	141,584	[4] 2,945
Erysipelas	do	.07	13,566	2,390	------	------	[5] 3,100	13,566	[6] 5,490
Poisoning, chemical	do	.02	3,876	683	.02	3,906	688	7,782	1,371
Tuberculosis	do	------	------	------	------	------	------	18,400	([7])
Vesicular exanthema [8]	do	.002	388	68	.028	5,469	964	5,857	1,032
Total	------	------	------	243,796	------	------	57,054	------	300,850

[1] See table 2, footnote 2.
[2] See table 2, footnote 1.
[3] Includes losses from all causes; data supplied by Animal Husbandry Research Division.
[4] Excludes cost of biologics ($22,000,000).
[5] Data from Animal Disease Eradication Division.
[6] Excludes loss due to condemned parts ($416,000).
[7] Losses in meat only ($3,250,000).
[8] Disease eradicated in 1956; no loss thereafter.

TABLE 28.—SHEEP, LAMBS, AND WOOL: *Estimated average annual losses caused by infectious and noninfectious diseases, 1951–60*

Cause of loss	Production unit	Loss due to mortality			Loss due to morbidity			Total	
		Reduction [1]	Quantity [2]	Value	Reduction [1]	Quantity [2]	Value	Quantity	Value [2]
		Percent	*1,000 units*	*1,000 dollars*	*Percent*	*1,000 units*	*1,000 dollars*	*1,000 units*	*1,000 dollars*
Anthrax: Sheep	Pound	0.0003	1	([3])	------	------	------	1	([3])
Bluetongue: Sheep	do	.0001	([3])	([3])	0.0019	6	([3])	6	([3])
Circling disease: Sheep	do	.2	647	50	------	------	------	647	50
Death at birth and to weaning: Lambs [4]	Head	24.0	7,000	67,953	------	------	------	7,000	67,953
Enterotoxemia: Lambs	Pound	.5	6,261	1,278	------	------	------	6,261	1,278
Foot rot: Sheep	do	------	------	------	.22	707	55	707	55
Poisoning, chemical: Sheep	do	.1	324	25	------	------	------	324	25
Poisoning, plant: [5]									
Sheep	do	------	------	4,430	------	------	------	------	4,430
Wool	do	------	------	------	------	------	1,378	------	1,378
Rabies: Sheep	do	.0001	([3])	([3])	------	------	------	------	([3])
Sore mouth: [5]									
Sheep and lambs	do	------	------	------	------	------	4,560	------	4,560
Lambs, feeder	do	.3	4,161	848	------	------	------	4,161	848
Vibriosis:									
Sheep	do	.123	398	31	.3	963	74	1,361	105
Wool	do	------	------	------	.2	485	251	485	251
Total:									
Animals	------	------	------	74,615	------	------	4,689	------	79,304
Wool	------	------	------	------	------	------	1,629	------	1,629
Grand total	------	------	------	74,615	------	------	6,318	------	80,933

[1] See table 2, footnote 2.
[2] See table 2, footnote 1.
[3] Less than $1,000.
[4] Data supplied by Animal Husbandry Research Division.
[5] Data supplied by Animal Disease and Parasite Research Division.

TABLE 29.—POULTRY AND POULTRY PRODUCTS: *Estimated average annual losses caused by infectious and noninfectious poultry diseases, 1951–60*

Cause of loss	Production unit	Loss due to mortality			Loss due to morbidity		Total loss
		Reduction [1]	Quantity [2]	Value	Reduction [1]	Value	Value [2]
		Percent	*1,000 units*	*1,000 dollars*	*Percent*	*1,000 dollars*	*1,000 dollars*
POULTRY							
Blue comb:							
Chickens	Head	0.25	995	788	0.25	777	1,565
Turkeys	do	1.8	1,294	6,195	.9	3,090	9,285
Cholera:							
Chickens	do	.38	1,513	1,197	.25	777	1,974
Turkeys	do	.36	259	1,239	.25	858	2,097
Enteritis: Turkeys	do	.83	579	2,856	.6	2,060	4,916
Erysipelas: Turkeys	do	.36	259	1,239	.54	1,854	3,093
Infectious bronchitis: Chickens	do	.85	3,360	2,659	4.0	12,922	15,581
Infectious sinusitis (air sac infection):							
Chickens	do	3.0	11,944	9,451	.5	1,553	11,004
Turkeys	do	.5	359	1,721	1.5	5,150	6,871
Laryngotracheitis: Chickens	do	.2	796	630	.09	280	910
Lymphomatosis: Chickens and broilers	do	(3)	------	58,960	------	------	58,960
Mycotic disease: Turkeys	do	.3	216	1,032	.1	343	1,375
Newcastle disease: Chickens	do	1.3	5,176	4,095	.8	2,485	6,580
Paratyphoid and paracolon infection:							
Chickens	do	.008	32	25	------	------	25
Turkeys	do	2.5	1,797	8,604	.6	2,060	10,664
Pox:							
Chickens	do	.047	187	148	.03	93	241
Turkeys	do	------	------	------	.15	515	515
Pullorum disease:							
Chickens	do	.5	1,991	1,575	------	------	1,575
Turkeys	do	.4	288	1,377	------	------	1,377
Tuberculosis: Chickens	do	.1	398	315	------	------	315
Typhoid:							
Chickens	do	.35	1,393	1,103	------	------	1,103
Turkeys	do	.25	180	860	------	------	860
Total	----------	------	------	106,069	------	34,817	140,886
POULTRY PRODUCTS [4]							
Eggs, defects (chickens)	Number	------	------	------	------	79,200	79,200
Eggs, low hatchability:							
Chickens	do	------	934,160	51,379	------	------	51,379
Turkeys	do	------	63,240	16,759	------	------	16,759
Total:							
Poultry	----------	------	------	106,069	------	34,817	140,886
Poultry products	----------	------	------	68,138	------	79,200	147,338
Grand total	----------	------	------	174,207	------	114,017	288,224

1 See table 2, footnote 2.
2 See table 2, footnote 1.
3 Mortality: 1 percent in broilers; 10 percent in all other chickens.
4 Data supplied by Animal Husbandry Research Division.

TABLE 30.—GOATS, HORSES AND MULES, MINKS, AND RABBITS: *Estimated average annual losses caused by infectious and noninfectious diseases, 1951–60*

Cause of loss	Production unit	Loss due to mortality			Loss due to morbidity			Total	
		Reduction [1]	Quantity [2]	Value	Reduction [1]	Quantity [2]	Value	Quantity [2]	Value [2]
		Percent	*1,000 units*	*1,000 dollars*	*Percent*	*1,000 units*	*1,000 dollars*	*1,000 units*	*1,000 dollars*
GOATS									
Brucellosis	Pound	------	------	------	0.63	239	26	239	26
Poisoning, chemical	do	0.1	38	4	------	------	------	38	4
Rabies	do	.0001	(3)	(3)	------	------	------	------	(3)
Total	------	------	38	4	------	239	26	277	30
HORSES AND MULES									
Anthrax	Head	.002	(3)	(3)	------	------	------	------	(3)
Equine encephalomyelitis (sleeping sickness) [4]	do	------	------	450	------	------	300	------	750
Equine rhinopneumonitis (virus abortion) [4]	do	------	------	4,750	------	------	250	------	5,000
Infertility [4]	do	------	------	------	------	------	4,000	------	4,000
Poisoning:									
Chemical	do	.01	(3)	2	------	------	------	------	2
Plant [5]	do	.2	(3)	36	------	------	134	------	170
Rabies	do	.0004	(3)	(3)	------	------	------	------	(3)
Respiratory disease (acute) [4]	do	------	------	25	------	------	475	------	500
Strongyles [4]	do	------	------	100	------	------	1,900	------	2,000
Total	------	------	------	5,363	------	------	7,059	------	12,422
MINKS									
Bacterial diseases	Pelt	.48	20	396	------	------	776	------	1,172
Infant mortality	do	18.0	735	14,848	------	------	------	------	14,848
Mismanagement	do	.5	20	412	.25	------	202	------	614
Nursing sickness	do	.1	4	82	.1	------	81	------	163
Other nutritional diseases	do	.1	4	82	.05	------	40	------	122
Parasitic diseases	do	.12	5	99	.12	------	97	------	196
Urinary caculi	do	.10	4	82	.15	------	121	------	203
Virus diseases	do	1.5	61	1,237	3.0	------	2,419	------	3,656
Yellow fat	do	.02	1	16	.013	------	10	------	26
Total	------	------	------	17,254	------	------	3,746	------	21,000
RABBITS									
Enteritis	Pound	12.0	10,557	3,174	17.0	15,536	4,671	26,093	7,845
Other disorders (including mismanagement)	do	6.0	5,278	1,587	8.0	7,311	2,198	12,589	3,785
Pneumonia	do	6.0	5,278	1,587	9.0	8,225	2,473	13,503	4,060
Total	------	------	------	6,348	------	------	9,342	------	15,690
Grand total	------	------	------	------	------	------	------	------	49,142

[1] See table 2, footnote 2.
[2] See table 2, footnote 1.
[3] Less than $1,000.
[4] Data supplied by Animal Disease Eradication Division.
[5] In 11 Western States only.

The increased use of agricultural chemicals, especially insecticides, herbicides, and fungicides, has directed attention to possible chemical poisoning as a cause of livestock losses. For this reason, and because poisoning of livestock by lead, arsenic, selenium, fluorine, and poisonous plants has been reported from time to time by the Department of Agriculture and by some of the veterinary college clinics, an effort has been made to tabulate such losses.

Nutritional disorders of livestock and poultry vary widely in nature, distribution, and intensity, and in the resulting economic loss. Obviously, they result from the feed that the livestock and poultry consume. Nutritional disorders may result from either a deficiency or an excess of a single nutrient or of several nutrients. Sometimes nutritional disorders are complicated with other classes of diseases. Many nutrients are essential for animal life. They include minerals, vitamins, proteins, amino acids, fats, and carbohydrates. Various metabolic and physiological factors, including hormones, which regulate body functions, are also involved. Accordingly, the number of possible nutritional disorders is extremely large. Many are ill-defined or unrecognized. Only a few are well described, and their regional or nationwide importance is recognized.

The damage due to nutritional disorders may result in death, reproductive failure, impairment of growth, or lowered productivity of meat, milk, eggs, or wool. The quality of the product may be decreased. No exact figures of total losses are possible, because the diseases cannot be segregated. Although feeding standards have been proposed or established for most classes of livestock, actual requirements for some of the essential nutrients are not yet known. Therefore, ideal rationing of animals is not yet possible, and there is no standard by which to judge farm production.

The term "baby pig losses" implies death. Pigs may be dead at birth or, more likely, may die within the first few weeks of life. Of all pigs born, approximately 25 percent are not raised to marketable weight. The losses given in table 27 were determined from the per head value of a pig at birth. The total dollar loss is equivalent to about 6 percent of the total value of production. These losses are traceable to factors such as chilling, failure to nurse, injury, death directly traceable to the sow, and various forms of enteritis due to infections or nutritional factors.

Grass tetany, or wheat-pasture poisoning, occurs chiefly among cattle and sheep grazing on lush growths of green forages. During the period 1951–60 there were severe losses in cattle grazed on green-wheat pasturage in the Texas Panhandle, and losses in both cattle and sheep in Kansas, Oklahoma, and adjoining areas. Losses occurred on other small-grain pastures in Mississippi and on perennial grass pastures in other parts of the country. The exact cause of this disorder is unknown, but it appears to be a physiological disturbance induced by the pasturage. In the wheat-growing areas of the Southwest, the disease fluctuates from year to year, depending on the weather and the growth of wheat during the fall and winter months.

Ketosis, or acetonemia, is one of the most troublesome and widely distributed diseases of milking cows. Animals are generally affected early in lactation, with a resultant drop in milk production. Death losses are low. About 4 percent of the milking cows are affected each year.

Urinary calculi occur principally in cattle and sheep, but losses are also serious in ranch-raised mink. In cattle, the disorder is most common in range areas and in the feed lots, chiefly among steers. In sheep, the principal losses are among wether lambs being fattened in feed lots.

Each year low hatchability of poultry eggs results in serious economic losses. Much of this low hatchability is due to nutritional deficiencies or imbalances in the diets of the breeding flocks, particularly vitamin and mineral deficiencies. Genetics, physiology, and management are also important factors.

The hatchability of chicken eggs is about 70 percent, which means that during the 1951–60 period, an average of 934 million eggs that were set each year did not hatch. The hatchability of turkey eggs is about 55 percent. During 1951–60, about 63 million turkey eggs that were set each year did not hatch.

Enteritis in rabbits has been tentatively classed as nutritional in origin, or at least as partly controllable by dietary means. Death losses are high, and weight gains of young rabbits are decreased.

Nursing sickness affects a significant number of female minks each spring. They lose their appetites and consequently their weight, and milk flow decreases. Death losses are heavy among the females as well as among their young.

Yellow fat, or steatitis, in minks is now considered to be nutritional in origin. Affected animals show brownish-yellow pigmentation in the body fat. The death rate is high and the pelts are poor quality. The disease occurs in minks fed diets high in unsaturated fats and low in vitamin E.

INTERNAL PARASITES OF LIVESTOCK AND POULTRY

Internal parasites of livestock and poultry cause losses in all parts of the country and in all seasons. However, climate, especially the weather from season to season, influences the type, spread, and intensity of parasitism. In general, warmth, moisture, and shade favor parasites. Control measures, by and large, are designed to take advantage of the destructive effects of unfavorable climatic factors on the free-living stages of these organisms.[1]

About 300 kinds of internal parasites are of economic importance in the United States. Some are very common and abundant, others less so.[2] Few animals are ever entirely free from them; and many harbor thousands of individual parasites, comprising a dozen or more injurious species. Losses occur in animals and birds of all ages, but are heaviest in the young.

The specific ways in which losses are sustained from parasites are legion, but a consideration of some of them will emphasize the difficulty, if not impossibility, of arriving at accurate estimates, as well as the reasons for regarding all presently available information, however carefully assembled, as fragmentary.

Mortality losses

Mortality losses (table 31) include death losses of breeder, or farm, stock and of stock produced for market.

Morbidity losses

Morbidity losses (table 31) may be classified as follows:

(1) Reduced yield and depreciation of animal products—milk, eggs, hides, wool, mohair, casings, medicinal preparations.
(2) Condemnations of parts and carcasses under Federal or other meat inspection procedure.
(3) Waste of feed, labor, and space to bring animals to productivity or useful maturity or to market.
(4) Interference with breeding and reproduction—sterility, diminished fertility and vigor, delayed conception, abortion, reduced litter size, lowered egg laying of poultry.
(5) Reduced quality of animals—lowered grades of market stock, reduced sale value.
(6) Lowered efficiency of work animals such as horses and mules.
(7) Depreciation of capital items—breeder animals, farm properties, abandonment of production.
(8) Inefficient utilization of pastures, barns, and pens by unproductive stock.
(9) Lowered resistance of infected stock to other diseases and parasites.
(10) Deaths, sufferings, and anxieties imposed on man by parasites transmitted from domestic animals, or by diseases carried by parasites that are primarily animal rather than human.
(11) Expenditures for worthless or inefficient drugs, treatments, and equipment.

Control costs

Control costs or charges ascribable to protection against parasites may be classified as follows:

(1) Drugs for treatment, prevention, eradication, and control.
(2) Veterinary and other services, and labor for administering drugs and effecting control.
(3) Prevention of parasite introduction.
(4) Research—Federal, State, and private.
(5) Regulatory services (Federal, State, and other), including inspection and quarantine of animals, meat inspection, and litigation.

Because internal parasites are ubiquitous, unseen, and of great variety and abundance, and because their effects are generally inapparent, they undermine the health of countless thousands of food animals and are a constant hazard to efficient, profitable production. Vigilance against parasites must be accepted as essential for efficient management. There is no way to estimate adequately or even to fully comprehend the hidden losses, and no attempt has been made to include either the cost of measures directed toward the control of parasites or the benefit accruing from these measures.

Among the principal objectives of the estimates in table 31 were conservatism and reliability, and an examination of the overall picture outlined above suggests that these estimates, for the most part, may be far too low.

The major items considered were (1) kinds or categories of parasites affecting each class of livestock; (2) their occurrence, distribution, and relative capacities for causing economic losses; (3) the nature of economic losses from parasites; (4) the ways in which the individual parasites injure their hosts; (5) official data on populations and value of annual production of the several classes of livestock and poultry in the United States, and (6) individual judg-

1 LUCKER, J. T. CLIMATE IN RELATION TO WORM PARASITES OF LIVESTOCK. *In* Climate and Man, 1941 Yearbook of Agriculture, pp. 517–527. 1941.

2 BECKLUND, W. W. REVISED CHECK LIST OF INTERNAL AND EXTERNAL PARASITES OF DOMESTIC ANIMALS IN THE UNITED STATES AND POSSESSIONS, AND IN CANADA. Amer. Jour. Vet. Res. 25 (108): 1380–1416. 1964.

TABLE 31.—LIVESTOCK AND POULTRY: *Estimated average annual losses caused by internal parasites, 1951–60*

Cause of loss	Production unit	Loss due to mortality: Reduction [1]	Loss due to mortality: Quantity [2]	Loss due to mortality: Value	Loss due to morbidity: Reduction [1]	Loss due to morbidity: Quantity [2]	Loss due to morbidity: Value	Total: Quantity	Total: Value
		Percent	*1,000 units*	*1,000 dollars*	*Percent*	*1,000 units*	*1,000 dollars*	*1,000 units*	*1,000 dollars*
CATTLE									
Anaplasmosis: Beef and dairy	Pound	0.2	46,590	9,004	0.6	139,701	26,997	186,291	36,001
Coccidiosis: Beef, dairy, and all calves [3]	do	------	------	3,777	------	------	10,792	------	14,569
Gastroenteritis (worm parasites): [3]									
Beef and dairy	do	------	------	23,042	------	------	69,127	------	92,169
All calves	do	------	------	3,151	------	------	4,726	------	7,877
Liver flukes: Beef, dairy, and all calves	do	.006	1,651	324	.05	13,758	2,698	15,409	[4] 3,022
Tapeworms and bladderworms: Beef	do	------	------	------	------	------	([5])	------	([5])
Trichomoniasis, genital: Beef and dairy [3]	do	------	------	------	------	------	8,040	------	8,040
Other parasitic diseases: Beef and dairy [3]	do	------	------	------	------	------	[6] 323	------	[6] 323
Total	------	------	------	39,298	------	------	122,703	------	162,001
SHEEP									
Coccidiosis: Lambs [3]	do	------	------	150	------	------	848	------	998
Gastroenteritis (worm parasites): [3]									
Sheep and lambs	do	------	------	7,315	------	------	10,967	------	18,282
Wool	do	------	------	------	2.7	6,631	3,427	6,631	3,427
Liver flukes: Sheep and lambs	do	.003	47	8	.032	506	[7] 90	553	[7] 98
Lungworms: Sheep and lambs	do	.01	158	28	.05	791	141	949	169
Nodular worms:									
Sheep and lambs	do	.01	158	28	.55	8,699	1,550	8,857	1,578
Wool	do	------	------	------	.1	246	127	246	127
Tapeworms: Sheep and lambs	do	.025	395	70	.02	316	56	711	126
Other parasites: Sheep and lambs [3]	do	------	------	------	------	------	([8])	------	([8])
Total:									
Sheep and lambs	------	------	------	7,599	------	------	13,652	------	21,251
Wool	------	------	------	------	------	6,877	3,554	6,877	3,554
Grand total	------	------	------	7,599	------	6,877	17,206	6,877	24,805
SWINE									
Kidney worms [3] [9]	do	------	------	512	------	------	16,547	------	[10] 17,059
Lungworms [3]	do	------	------	171	------	------	3,413	------	3,584
Nodular worms [3]	do	------	------	------	------	------	6,836	------	6,836
Roundworm, large [3]	do	------	------	683	------	------	34,129	------	[11] 34,812
Threadworm	do	.06	11,628	2,048	.02	3,876	683	15,504	2,731
Whipworms [3]	do	------	------	34	------	------	683	------	717
Total	------	------	------	3,448	------	------	62,291	------	65,739

TABLE 31.—LIVESTOCK AND POULTRY: *Estimated average annual losses caused by internal parasites. 1951–60*—Continued

Cause of loss	Production unit	Loss due to mortality			Loss due to morbidity			Total	
		Reduction [1]	Quantity [2]	Value	Reduction [1]	Quantity [2]	Value	Quantity	Value
POULTRY [12]		*Percent*	*1,000 units*	*1,000 dollars*	*Percent*	*1,000 units*	*1,000 dollars*	*1,000 units*	*1,000 dollars*
Blackhead: [3]									
Chicks and chickens	Head	.5	7,128	1,918	.45	-------	2,877	7,128	4,795
Poults and turkeys	do	.45	681	1,805	.68	-------	2,708	681	4,513
Coccidiosis:									
Chicks and chickens	do	2.3	56,198	15,123	3.0	-------	19,731	56,198	34,854
Poults and turkeys	do	1.5	2,239	5,933	1.5	-------	5,933	2,239	11,866
Eggs, chicken and turkey	-------	-------	-------	-------	-------	-------	317	-------	317
Hexamitiasis: Poults and turkeys [3]	do	-------	316	838	-------	-------	1,057	316	1,895
Leucocytozoonosis: Turkeys	do	.012	(13)	4	.018	-------	62	(13)	66
Trichomoniasis:									
Chicks and chickens	do	.05	1,222	330	.075	-------	493	1,222	823
Poults and turkeys	do	.12	179	474	.018	-------	712	179	1,186
Capillarids: Chicks, chickens, poults, and turkeys [3]	do	-------	-------	32	-------	-------	106	-------	138
Roundworms, except capillarids: Chicks, chickens, poults, and turkeys [3]	do	.37	9,593	3,899	1.23	-------	12,958	9,593	16,857
Tapeworms: Chicks, chickens, poults, and turkeys [3]	do	-------	-------	16	-------	-------	106	-------	122
Total:									
Poultry	-------	-------	-------	30,372	-------	-------	46,743	-------	77,115
Eggs	-------	-------	-------	-------	-------	-------	317	-------	317
Grand total	-------	-------	-------	30,372		-------	47,000	-------	77,432
HORSES AND MULES									
Piroplasmosis [14]	-------	-------	-------	100	.05	-------	400	-------	500
Roundworm, large [15]	do	.0005	-------	(13)	.05	-------	9	-------	9
Stomach bots [15]	do	.021	-------	4	.2	-------	36	-------	40
Strongyles (bloodworms) [3] [15]	do	-------	-------	54	-------	-------	490	-------	544
Total	-------	-------	-------	158	-------	-------	935	-------	1,093
Summary: Losses to livestock and poultry:									
Animals and birds	-------	-------	-------	80,875	-------	-------	246,324	-------	327,199
Wool and eggs	-------	-------	-------	-------	-------	-------	3,871	-------	3,871
Meat condemnations [16]	-------	-------	-------	-------	-------	-------	9,136	-------	9,136
Grand total	-------	-------	-------	80,875	-------	-------	259,331	-------	340,206

1 See table 2, footnote 2.
2 See table 2, footnote 1.
3 Data supplied by Animal Disease and Parasite Research Division.
4 Includes weight loss and reduced milk production. Excludes loss of $1,657,000 due to condemned livers.
5 Loss of $973,000 due to condemned livers and carcasses; excluded from total.
6 Excludes loss of $472,000 due to condemned livers.
7 Excludes loss of $842,000 due to condemned livers and carcasses.
8 Loss of $37,000 in value of meat only; excluded from total.
9 Estimates limited to Southeastern States.
10 Excludes loss of $3,920,000 due to meat condemnations.
11 Excludes loss of $1,235,000 due to condemned parts.
12 Data based on both hatchery and farm production except leucocytozoonosis, which is based on farm production only.
13 Less than $1,000.
14 Data supplied by Animal Disease Eradication Division.
15 Based on data from Bluegrass region of Kentucky.
16 Includes losses itemized in footnotes 4, 5, 6, 7, 8, 10, and 11.

ments of authorities on the comparative importance of diseases and parasites as causative factors of economic loss among the several classes of livestock.

Following are brief comments on certain parasitic infections for which no loss estimates were made.

Eperythrozoa are frequently seen in the red blood cells of cattle in many areas of the country, often in conjunction with *Anaplasma*. Certain difficulties have been encountered, however, in the correct identification of the organism. In this connection, there have been several reports of a condition in pregnant cattle, diagnosed as eperythrozoonosis, in which some of the cows and some calves died.

The *Anaplasma* organism has been reported from sheep, but information is not available on losses ascribable to the parasite.

Infection with *Giardia*, a microscopic flagellated parasite of the intestine, was diagnosed in a lot of feeder lambs in Utah. Because no information is available on the effect of the parasite on infected animals or on occurrences elsewhere, estimates of losses were not attempted.

Eperythrozoa appear to have caused death of some newly born pigs or very young swine. However, data from which reliable loss estimates can be made are lacking. Infections with this parasite have been found most frequently in the Midwest, but they have occurred also in Alabama, North Carolina, and Texas. In some herds in Texas, about 50 percent of the pigs were sick, and about 2 percent died. In Missouri, 73 of 90 pigs farrowed by 17 sows died during the first week after birth; death was associated with *Eperythrozoa* infections. In Iowa herds, mortality has been reported to range from 10 to 40 percent. In a single herd in Alabama, 21 of 70 pigs were affected and 9 died.

Infections of *Trichomonas* (trichomonads) in the gastrointestinal tract and in the nasal cavity are widespread among swine. It is not known whether these parasites are associated with gastrointestinal disorders; but flagellates occur with some frequency in the nasal tract of pigs affected with atrophic rhinitis.

The ciliated protozoan, *Balantidium*, occurs in varying numbers in the large intestine and blind gut of swine, particularly in hogs on rations containing a high proportion of starch, such as corn. This parasite, thought to be transmissible to human beings, may not seriously inconvenience swine, however, unless present in large numbers. Instances of severe diarrhea associated with *Balantidium* have been reported in swine fed a diet of corn.

Plasmodium, a malarialike parasite new to the United States, was found in Wisconsin chickens in 1961. Through 1962, it was found in a total of 7 flocks in that State. The effect of this parasite on the health of birds and on egg production has not been determined, but *Plasmodium* infections are reported highly pathogenic to fowl in certain foreign countries.

There have been several studies of coccidiosis in swine, but none relate to economic losses.

INSECT PESTS OF LIVESTOCK AND POULTRY

All kinds of livestock and poultry are subject to year-round attack by a wide variety of insects, ticks, and mites. Biting horn flies, stable flies, horse flies, mosquitoes, black flies, and certain ticks are serious pests during the warm months. A new nonbiting fly, the face fly, has become a major summertime livestock problem in the Northeastern and North Central States. The cold winter months favor the development of heavy infestations of lice, sheep keds, cattle grubs, certain ticks, and mites on animals. The screw-worm occurs throughout the year in parts of the Southwestern States and frequently spreads as far north as Kansas and as far east as Mississippi during the summer.

Losses to the livestock and poultry industries directly attributable to insects, ticks, and mites are difficult to measure. Damage from screwworms and fleece worms is readily apparent to the grower, and he can assess losses on the basis of the wounds; destruction of tissue, wool, and mohair; and death of animals. This is also true with heavy infestations of lice, ticks, mites, and sheep keds. Visible damage and measureable losses may also be determined from heavy attacks of the face fly and biting flies and mosquitoes. Cattle grubs cause tangible losses in damaged hides and carcass trim. Losses resulting from light or moderate infestations of livestock and poultry pests, although they may not be apparent to individual growers, constitute an important part of the overall loss in the Nation.

Insect pests cause estimated average annual losses in livestock and poultry of $877,850,000 (table 32).

Cattle

Face Fly.—The face fly, which was first found in this country in New York in 1953, now occurs in 32 States. It has become a serious pest of livestock in the Northeastern and North Central States. The face fly does not bite but its habit of clustering around the eyes, mouth, and nostrils is extremely annoying to

TABLE 32.—LIVESTOCK AND POULTRY: *Estimated average annual losses caused by insects, 1951–60*

Cause of loss	Reduction in value [1]			Total
	Weight	Milk	Production	
	1,000 dollars	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*
All cattle and calves:				
Face fly	42,000	26,000	[2] 22,000	68,000
Grubs	115,000	55,000	22,000	192,000
Hornfly	115,000	64,000	-------	179,000
Horse flies and deer flies	30,000	10,000	-------	40,000
Lice	41,000	6,000	-------	47,000
Mosquitoes	15,000	10,000	-------	25,000
Scabies mites	3,000	-------	-------	3,000
Stable fly	74,000	68,000	-------	142,000
Ticks	60,000	-------	-------	60,000
Total	495,000	239,000	-------	756,000
Goats: Lice and mites	-------	-------	[3] 800	800
Sheep:				
Bots	8,000	-------	-------	8,000
Keds	9,400	-------	-------	9,400
Lice	4,700	-------	-------	4,700
Scabies	2,000	-------	-------	2,000
Tick, including ear tick	4,700	-------	-------	4,700
Total	28,800	-------	-------	28,800
Swine: Lice and mites	3,000	-------	-------	3,000
Chickens and turkeys:				
Fowl ticks	[4] 750	-------	-------	750
Lice and mites	75,000	-------	-------	75,000
Mosquitoes	13,500	-------	-------	13,500
Total	89,250	-------	-------	89,250
Grand total	616,050	239,000	22,800	877,850

[1] Data furnished by Entomology Research Division.
[2] Loss of hides.
[3] Loss of mohair.
[4] Losses limited to southern part of United States.

animals, interferes with their vision and breathing, and prevents normal grazing. Large populations force animals to leave pastures and seek relief in wooded areas and shelters. The face fly is such a new problem that its effect on weight gains and milk production has not been fully determined. This fly may be more troublesome and cause greater losses than horn flies.

Cattle Grubs.—Cattle grubs occur throughout the United States and cause serious losses in the cattle industry, especially in the northern half of the country where two species are present. Newly hatched grub larvae infest cattle during the spring and summer, migrate through tissues of the animal, and after 6 or 7 months appear in the backs where they complete their development over a period of 1 to 2 months. Both the grubs and the adults developing from them injure the animals and cause losses in the following four ways:

(1) Reduced weight gains and milk flow. Cattle infested with grubs do not gain as much weight or produce as much milk as uninfested animals.

(2) Damage to hides. Hides having five or more grub holes are classed as No. 2 grade and sell for $0.50 to $1 less than No. 1 hides. Hides with large numbers of holes are fit only for making glue and bring only 1 or 2 cents per pound.

(3) Loss of meat in dressed carcasses. Grub-infested cattle are downgraded and sell for 1 or 2 cents per pound less than clean animals. Loss from trimming away damaged meat, frequently from the best steak cuts, may average $5 to $7 per animal slaughtered during the grub season.

(4) Running from flies. Cattle tend to panic when adult flies seek to oviposit on them. Animals frequently run to exhaustion trying to escape, and many are injured or killed as a result of colliding with each other or with obstacles. Running causes losses in weight and milk production.

Horn Flies.—Horn flies are abundant in all sections of the country during the warm months. Many growers consider these insects the most important of all pests of cattle. These small, biting flies remain constantly on cattle and feed on them several times a day. Their biting irritates animals and prevents proper feeding and resting; weight gains and milk production are reduced. Studies by a number of workers have shown that beef cattle treated with insecticides to control horn flies gain from 10 to 50 pounds per month more than untreated cattle. Also, treated dairy herds produce significantly more milk than untreated herds.

Horse Flies and deer Flies.—Horse flies and deer flies are serious summertime pests in many sections of the Southern, Midwestern, and Western States. There is a succession of species in most locations from late spring to early fall, but, as a rule, three or four species compose the majority of the population and are responsible for most of the loss. Most species are somewhat larger than stable flies and their bites are more severe and annoying. Small populations can remove much blood from animals and prevent them from grazing or resting poperly. Losses from horse flies and deer flies vary from year to year and from location to location, in proportion to the population of the insects present. Some studies have indicated that even small numbers of the flies can reduce weight gains significantly and milk flow by as much as 10 to 20 percent.

Lice.—Lice are very irritating to cattle and cause reduced weight gains and milk production. Heavy infestations lower animal vitality and can cause pronounced anemia. Cattle lice are a year-round problem in most sections of the country but the heaviest infestations and damage occur during the winter months, especially in Northern States. In several of these States lice are considered the most serious pest of cattle.

Mosquitoes.—Mosquitoes are among the most serious pests of cattle in western irrigated areas, and in States that receive heavy rainfall. The heaviest attacks frequently occur at night so growers seldom observe or appreciate the losses inflicted in reduced milk production and weight gains.

Scabies.—Scabies mites produce skin lesions and cause intense itching, which animals try to alleviate by rubbing and scratching. Hides are often severely damaged by the mites. Infested animals do not feed properly and, as a result, do not gain weight or produce milk at normal rates. Cattle scabies mites of one or more kinds are widespread but are most prevalent in the North Central and Northeastern States.

Stable Flies.—Stable flies are distributed throughout the country, but are especially serious pests during the summer months in North Central, East Coast, and Southeastern States. These vicious biting flies are capable of reducing weight gains and milk production even more than horn flies. Studies in Illinois have shown that an average of 40 flies per animal can reduce milk production by as much as 28 percent and reduce weight gains significantly.

Ticks.—Ticks are a spring-to-fall problem for cattlemen in many sections of the country. The spinose ear tick infests cattle the year around and the winter tick is prevalent from late fall to early spring in many areas. Ticks are extremely irritating to animals and heavy infestations cause unthriftiness, loss of weight, and damage to hides. Lesions from tick bites are a pathway for infections and, in the Southwest, they invite screw-worm infestation.

Goats

Lice and mites are common pests wherever goats are raised. They irritate the animals and make them unthrifty. They reduce the production and quality of mohair. The action of goats in biting and rubbing, to relieve irritation by the pests, damages the hair and skin and may render these products unmarketable.

Sheep

Ticks, mites, and insects such as lice, bots, and keds attack sheep in all sections of the country. Sheep infested with any of these pests do not gain weight as rapidly as pest-free animals, nor do they produce as much or as high-quality wool. Rubbing and biting by the sheep to relieve irritation caused by the pests reduce the amount and quality of wool and the value of the skin.

Swine

Swine are subject to attack by one species of lice and two species of mites. These pests occur throughout the country and, if not controlled, cause important reductions in weight gains and quality of the meat and skins.

Poultry

Insects, mites, and ticks are common pests of all classes of poultry throughout the country. They cause birds to look unsightly, reduce weight gains and egg production, and mar the skin. The result is downgrading of quality and lower market value. Heavy infestations cause high mortality among young poultry. Workers have shown that poultry lice and mites can sometimes reduce weight gains and egg production from 2 to 25 percent or more.

Screw-worm (all livestock)

The screw-worm fly has been eradicated from the Southeastern States, but it is still the most serious pest of livestock in Texas and in parts of New Mexico, Arizona, and California. In some years it spreads and causes heavy losses as far north as Kansas and as far east as Mississippi. This insect infests wounds on animals, and the worms feed on the living flesh. Infested animals become sick, do not feed normally, and lose weight. In some years in certain areas, the screw-worm infests every newborn calf. If not controlled, the infestation increases rapidly and results in the death of animals within a few days. Constant vigil and treatment are necessary from early spring to late fall to prevent catastrophic losses from this pest and require extra labor to locate animals, chemicals for treatment, and feed for hositalized stock. These extra, but necessary, expenses increase production costs significantly.

Chapter 9.—Marketing and Processing Losses

Losses that occur during commercial marketing and processing of farm crops are considered here. Losses that occur after the commodities reach the kitchen are not included, nor are marketing and processing losses of livestock and poultry products.

Many tons of farm commodities are damaged or destroyed by diseases and other causes between the time they are harvested and the time they reach the dining table. The losses are shared by growers, packer-shipper-storage and transportation companies, processors, wholesalers, retailers, and consumers. Losses may be small, with only a trace of damage throughout the load; or they may be extensive, with the entire carload or truckload spoiled. Commodities that deteriorate after harvest must be sold at a reduced price. Sometimes additional costs are added in sorting out damaged produce and in repacking the sound product. Losses during marketing are more serious than losses in the field or orchard, because the cost of marketing services such as grading, packaging, storage, and transportation is added to the cost of the commodity.

MARKETING FRUITS AND VEGETABLES

There are a variety of causes of losses of fresh fruits and vegetables after harvest. Most obvious losses are caused by mechanical injury, decay, and aging. Losses in moisture, vitamins, sugars, and starches are less obvious, but they adversely affect quality and nutrition. Rough handling and holding at undesirably high or low temperatures increase losses of all kinds.

Steps in marketing vary, but may include storage, transportation, wholesale distribution, and retailing. An overall estimate of losses during the entire marketing period is, therefore, difficult to obtain.

The data in table 33 are, in part, from inspection certificates from the Pittsburg Produce Inspection Service for the period 1957–61. The certificates are filed numerically, and the tabulation was based on information from a

TABLE 33.—FRUITS: *Estimated average annual losses during transit and unloading*

Commodity	Unit of measure	Loss in quantity [1,2]		Loss in quality	Loss in value [2]
		Percent	*1,000 units*	*Percent*	*1,000 dollars*
Apples	Bushel	[3] 2	2,110	2.0	7,801
Apricots	Ton	[4] 1	2		232
Avocados	do	[4] 2	1		181
Cherries	do	[4] 2	2		475
Grapefruit	do	[3] 1	16	.5	722
Grapes	do	[3] 1	29	8.0	13,626
Lemons	do	[3] 1	6	.1	436
Limes	Box	[4] 5	1		64
Oranges	Ton	[3] 1	53	3.0	11,841
Peaches	Bushel	[3] 3	1,842	5.0	9,768
Pears	do	[3] 1	277	.4	707
Plums	Ton	[3] 1	837	1.0	285
Pomegranates	do	[4] 1	([5])		2
Prunes	do	[3] 1	4	2.0	1,328
Strawberries	Pound	[3] 5	11,649	5.0	5,017
Tangerines	Ton	[3] 2	4	3.0	468
Total					52,953

[1] Percentage data include that part of the packaged commodity which is inedible because of disease or destruction.

[2] Basic data for quantity and value represent the quantity marketed and value of the quantity marketed, respectively.

[3] Judgment estimates made by specialists.

[4] Losses are based on information from inspection certificates from Pittsburg Produce Inspection Service from 1957 to 1961.

[5] Less than 1,000 tons.

random sample representing about one-fifth of the certificates. The PPIS contract covered inspection for 16 firms. Before September 1961, when the Pennsylvania Railroad began renting space on the railroad docks, contract inspections primarily covered rail arrivals. Since that time, many truck arrivals for the contracting firms have been inspected. As indicated in the table, the data shown are not strictly transportation losses. Storage losses may be included for some commodities; also, sometimes the inspections were continued during the period of unloading, and the losses include part of the losses during wholesale marketing.

A statement is included on storage losses of apples, grapes, and potatoes; an estimate of losses during ripening and repacking is given for tomatoes.

Information that may affect prices of vegetables as compiled from the Pittsburgh Inspection certificates is shown in table 34. These include such factors as apple scab, tipburn of lettuce, skin blemishes of citrus fruits, and bruising injury.

Transit and unloading losses in fruits

Apples.—Losses of apples due to decay and internal breakdown amount to about 2.2 percent during the transit and unloading period. Internal breakdown causes more loss than decay. Partial loss such as scald, which would affect the price, amounts to about 1.6 percent.

Decay during storage has declined in recent years. Excepting apples stored for 7 months or longer, the decay during storage probably does not exceed 2 percent. Internal breakdown, scald, bitter pit, and decay account for most losses.

Apricots.—Brown rot, Rhizopus rot, and gray mold cause about 0.8 percent of apricots

TABLE 34.—VEGETABLES: *Estimated average annual losses during transit and unloading*

Commodity	Unit of measure	Loss in quantity: Percentage [1]	Loss in quantity: Amount [2]	Loss in quality	Loss in value [2]
		Percent	*1,000 units*	*Percent*	*1,000 dollars*
Artichokes	Hundredweight	[3] 1	3	----	31
Asparagus	Ton	[4] 3	35	----	472
Beans:					
Lima	Bushel	[4] 13	54	----	445
Snap	--do	[4] 8	385	----	3,328
Beets	--do	[4] 1	6	----	16
Broccoli	Hundredweight	[3] 0.5	10	0.4	149
Brussels sprouts	Ton	[4] 2	12	----	102
Cabbage	Hundredweight	[3] 1	195	3.0	1,622
Carrots	--do	[3] 1	151	.1	503
Cantaloups	--do	[3] 1	118	5.0	3,115
Cauliflower	--do	[3] 3	76	4.0	1,127
Celery	--do	[3] 2	294	1.0	1,620
Corn, sweet	--do	----	----	[2] .2	89
Cucumbers	Bushel	[4] 2	79	----	400
Eggplant	--do	[4] 5	23	----	120
Escarole	Hundredweight	[3] 17	122	4.0	701
Lettuce	--do	[3] 3	976	7.0	13,139
Melons, honeydew	--do	[3] 3	44	4.0	497
Onions:					
Dry	--do	[3] 4	916	1.0	3,060
Green	--do	[3] 2	3	2.0	37
Peas (in shell)	--do	[3] 1	4	----	31
Peppers, sweet	--do	[3] 3	87	1.0	987
Potatoes	--do	[3] 1	2,010	1.0	8,160
Spinach	--do	[3] 1	18	2.0	318
Sweetpotatoes	Bushel	[4] 19	2,055	----	8,591
Tomatoes	Hundredweight	[3] 4	767	6.0	13,681
Watermelons	--do	[3] 8	2,299	8.0	6,499
Total	----				68,840

[1] Percentage data include that part of the packaged commodity which is inedible because of disease or destruction.

[2] Basic data for quantity and value represent the quantity marketed and value of quantity marketed, respectively.

[3] Losses are based on information from inspection certificates from Pittsburg Produce Inspection Service from 1957 to 1961.

[4] Judgment estimates made by specialists.

to decay during shipment. Decay per car ranges from 0 to 19 percent.

Avocados.—Very little loss occurs in avocados during transit. Extensive losses may occur during distribution and retailing if chilling temperatures go below 45° F., or if movement through retailing is slow enough to permit softening and breakdown.

Cherries.—Decay, due mostly to Rhizopus rot, green mold, brown rot, and gray mold, causes losses in cherries of about 2 percent during shipment. Decay per car ranges from 0 to 49 percent.

Grapefruit.—Blue mold and stem-end rot cause losses of about 1 percent in grapefruit during transit. Decay ranges from 0 to 16 percent, and is lowest in December and highest in July. Blue mold rot is the principal type of loss in California and Texas fruit. The diseases are equally important in Florida.

Grapes.—Average losses during transit and unloading of grapes is relatively small (1 percent). Losses are primarily due to gray mold rot and Rhizopus rot. Grapes are usually sorted following storage and storage losses average about 4 percent.

Lemons.—Decay of lemons during transit and unloading ranges from 0 to 8 percent with an average of 1 percent. Blue mold rot, brown rot, and alternaria rot are the main causes of loss. The greatest losses in lemons occur following prolonged storage.

Limes.—Losses of about 5 percent caused by blue mold rot and chilling injury occur during marketing of limes.

Oranges.—Decay, caused mostly by blue mold and stem-end rot, destroys about 1 percent of oranges during transportation and unloading. Decay per car ranges from 0 to 25 percent. No stem-end rot occurs on California oranges. Blue mold and stem-end rot are equally important on Florida oranges.

Peaches.—Decay, mostly from brown rot and Rhizopus rot, damages about 3 percent of peaches during shipment. Decay per car ranges from 0 to 35 percent. Serious losses also occur if peaches are stored too long or at improper temperatures.

Pears.—About 1 percent of pears decay during shipment. The decay is caused mostly by blue mold and gray mold. Decay per car ranges from 0 to 25 percent.

Plums and Prunes.—Decay, mostly from blue mold and Rhizopus rot, causes losses of about 1 percent in plums and prunes during shipment. Decay per car ranges from 0 to 11 percent.

Pomegranates.—Gray mold and blue mold cause decay in pomegranates during shipment. Decay per car ranges from 0 to 24 percent, and averages about 1 percent.

Strawberries.—Decay, due mostly to gray mold and Rhizopus rot, causes losses of about 5 percent in strawberries during transit and unloading. Decay per car ranges from less than 1 to over 50 percent. Strawberries are highly perishable and losses increase greatly with each additional day on the market.

Tangerines.—Blue mold and stem-end rot cause losses of about 2 percent in tangerines during shipment and unloading. Decay per car ranges from about 0 to 15 percent.

Transit and unloading losses in vegetables

Artichokes.—Most of the globe artichokes are grown in California. Losses of about 1 percent occur during transit and unloading. Decay per car ranges from 0 to 8 percent. The decay, which is mostly gray mold rot, is most prevalent during the first 5 months of the year.

Asparagus.—About 3 percent of the asparagus decays during transit and unloading. Decay per car ranges from 0 to 44 percent and is mostly bacterial soft rot, phytophthora rot, and blue mold rot.

Beans, Lima.—Lima beans may be damaged by gray mold, bacterial soft rot, watery soft rot, bacterial blight, and other diseases during transit and marketing. Some of these diseases destroy the pods and beans. Others make them so unattractive that their market value is reduced.

Beans, Snap.—About 8 percent of the snap beans shipped to market are lost during transit and marketing because of watery soft rot, soil rot, pythium rot, and gray mold rot. Salability of the beans is reduced by pod spots caused by bacterial blight or anthracnose. In some cars, 44 percent of the beans are affected.

Beets.—Most of the damage to beets during transit and marketing is due to bacterial soft rot and gray mold rot of the leaves of bunched beets. This does not affect the edibility of the root but does seriously detract from the market value. About 91 percent of the shipments are free of decay, but as much as 79 percent of the beets in some cars may be affected.

Broccoli.—Decay of broccoli is not extensive during transit and unloading. It ranges from 0 to 10 percent per car and averages about 0.5 percent. Most of the losses are due to bacterial soft rot and gray mold rot and occur in shipments made from January through March.

Brussels Sprouts.—Bacterial soft rot causes losses of about 2 percent in brussels sprouts during transit and probably additional losses during marketing. It is found in about 40 percent of the cars shipped, and in some cars damage may be as high as 39 percent.

Cabbage.—Losses during transit and marketing of cabbage caused by bacterial soft rot, watery soft rot, gray mold rot, and black rot range from 0 to 26 percent and average about 1 percent during transit and unloading.

Carrots.—Bacterial soft rot, watery soft rot, and occasionally certain other diseases cause an average loss of about 1 percent in carrots during transit and marketing. Decay per car ranges from 0 to 50 percent, and is worse where carrots are shipped in polyethylene bags without adequate refrigeration. The average loss of carrots for processing stored from 2 to 4 months is about 10 to 12 percent and losses are higher in some years.

Cauliflower.—Losses during transit and unloading of cauliflower average about 3 percent. These losses are caused mostly by bacterial soft rot, watery soft rot, and alternaria rot of the curd. Bacterial soft rot may affect both the leaves and the curd.

Celery.—An average of about 2 percent of the celery is spoiled during transit and unloading. Most of the losses are caused by watery soft rot, bacterial soft rot, and blackheart (physiological). These diseases rapidly destroy the celery bunches and make them unfit for food. About 56 percent of the shipments contain from a trace to over 50 percent of decay.

Cucumbers.—An average of about 2 percent of the cucumbers are damaged during transit. Losses are caused by bacterial soft rot, cottony leak, watery soft rot, and chilling injury. The cucumbers in more than half of the cars are affected, and decay per car ranges from a trace to about 24 percent.

Eggplant.—Alternaria rot following chilling injury and phomopsis rot are the principal causes of losses during transit and marketing of eggplant.

Escarole.—Data on losses during transit and marketing of escarole are too limited for making a satisfactory estimate. Tabulations from 29 carloads showed serious losses from bacterial soft rot. The average loss from this decay was 17 percent. About 10 percent of the cars showed no loss; in the other 90 percent of the cars, losses ranged from 1 to over 50 percent.

Lettuce.—Bacterial soft rot and watery rot are the principal causes of losses in lettuce during transit and marketing. Losses from these decays average about 3 percent, and decay per car ranges from 0 to 50 percent. Much of the bacterial soft rot follows tipburn, a physiological disease present at harvest. Diseases such as tipburn, rib discoloration, russet spotting, and pink rib cause losses either in reduced prices or in excessive trimming. Of about 2,100 carloads tabulated, 12 percent had no decay, 73 percent had up to 6 percent, 12 percent had from 6 to 15 percent, and 3 percent had from 16 to over 50 percent.

Muskmelons (Cantaloup).—Losses during transit and unloading of muskmelons (cantaloup) average about 1 percent. About 51 percent of the cars are free of decay. In other cars, superficial and penetrating decay ranges from less than 1 percent to over 50 percent. Most of the decay is caused by cladosporium rot.

Melons (Honeydew and Honeyball).—Melon losses during transit and unloading average about 3 percent. Losses per car range from 0 to over 50 percent. Of the cars for which data were tabulated, about 38 percent had over 5 percent decay. Cladosporium rot was most frequently reported.

Onions.—Bacterial soft rot, gray mold rot, black mold rot, and smudge are the principal causes of losses during storage, transit, and marketing of onions. Losses from decay during transit and unloading, which probably includes some storage losses, average about 4 percent. Decay per car ranges from 0 to 50 percent. Freezing and sprouting cause additional losses of about 1 percent.

Peppers.—Bacterial soft rot, Rhizopus rot, gray mold rot, and alternaria rot following chilling injury cause average losses of about 3 percent in peppers. Losses per car range from 0 to over 50 percent. Bacterial soft rot gains entrance through stem ends torn during harvesting and during washing.

Potatoes.—Losses caused primarily by bacterial soft rot and blackheart (a physiological disease) average about 1 percent during transit and unloading of potatoes. Losses per car range from 0 to 50 percent, but the majority of cars show less than 1 percent decay. Freezing injury during this period of marketing takes its toll, but data on losses could not be obtained.

Spinach.—The sample of data is too small for making a satisfactory estimate on losses in spinach. The cars for which data were tabulated had an average loss of 1 percent. Decay caused by bacterial soft rot ranged from 0 to 8 percent per car, with the majority of cars showing less than 1 percent.

Sweetpotatoes.—Losses in sweetpotatoes occur in storage, in transit, and on the market. Data on losses, however, were not obtained. Some losses occur because of chilling injury, especially in the early marketing of uncured roots. Most decay is caused by Rhizopus rot, but other diseases such as fusarium rot, surface rot, and charcoal rot take a toll.

Tomatoes.—The principal causes of spoilage of tomatoes during transit and unloading are bacterial soft rot, watery rot, soil rot, Rhizopus rot, gray mold rot, and alternaria rot if chilling injury occurs. Decay in the domestic crop probably does not average more than 1.5 percent during transit. The data presented here from the Pittsburgh market, however, involved a number of shipments of Mexican-grown tomatoes that developed extensive alternaria rot during unloading. Transit losses, therefore, were abnormally high. Decay averaged 4 percent and ranged from 0 to over 50 percent per car. Additional losses during ripening and repacking of tomatoes shipped mature green are estimated to average from 10 to 12 percent. However, losses may be much higher in tomatoes affected by such conditions as late blight rot, chilling injury, or freezing injury, or in tomatoes subjected to poor handling practices.

Watermelons.—Average losses of about 8 percent due to decay and breakage occur during transit and unloading of watermelons. Losses per car range from 0 to over 50 percent. The decay is primarily black rot and stem-end rot. However, watermelons from certain localities show a very high incidence of anthracnose.

FRUITS AND VEGETABLES IN RETAIL STORES

Most losses in retail stores depend more on the ability of the produce manager to judge his rate of sale than on any inherent differences in the quality or condition of the product. In self-service food stores, produce must be "exposed" to the customer in order for it to sell. As a result, it is often roughly handled and subjected to higher-than-desirable temperatures. When proper quantities are placed on display, the product sells while its condition is still good. Overly large displays may result in deterioration beyond limits acceptable to the customer.

If the produce items remain in the display after they have deteriorated, loss of sales for the total display results.

One source of loss is the waste from trimming vegetables in order to present a salable product to the consumer. Another source is the discarded fruits and vegetables that are not salable. However, a major loss in value occurs from price markdowns or price discounting because of deterioration in the product. This constitutes almost two-thirds of the losses in value to fruits and vegetables in retail stores.

Estimated average annual losses of fruits in retail stores are $37,710,000 (table 35) and of vegetables, $30,131,000 (table 36). The losses shown in the tables are expressed in percentage of full retail price.

PROCESSING CROPS

In addition to the losses to crops and livestock at the farm level and those incurred in transporting, handling, and marketing the unprocessed material, physical losses are incurred during preprocessing and processing proce-

TABLE 35.—FRUITS: *Estimated average annual losses during marketing in retail stores, 1951–60*[1]

Commodity	Unit of measure	Loss in quantity [2]		Loss in value [2]
		Percent	*1,000 units*	*1,000 dollars*
Apples	Bushel	3	3,101	5,617
Cantaloups	Hundredweight	4	471	2,077
Cherries	Ton	2	4	877
Cranberries	Barrel	1	11	115
Grapefruit	Ton	1	15	474
Grapes	do	7	186	9,644
Lemons	do	7	40	2,719
Melons, honeydew	Hundredweight	1	14	65
Oranges	Ton	.4	21	1,137
Peaches	Bushel	6	3,573	6,740
Pears	do	2	548	960
Plums, fresh	Ton	2	2	279
Prunes, fresh	do	2	9	859
Pomegranates	do	.1	3	213
Strawberries	Pound	10	21,900	4,465
Tangerines	Ton	5	9	445
Watermelons	Hundredweight	3	793	1,024
Total				37,710

[1] Based on marketing studies in six retail stores covering all four seasons.

[2] Basic data for quantity and value represent the quantity marketed and value of quantity marketed, respectively, less the quantity and value of the losses incurred during transit and unloading.

TABLE 36.—VEGETABLES: *Estimated average annual losses during marketing in retail stores, 1951–60*[1]

Commodity	Unit of measure	Loss in quantity[2]		Loss in value[2]
		Percent	*1,000 units*	*1,000 dollars*
Asparagus	Hundredweight	1	34	398
Beans:				
Snap	do	2	96	832
Lima	do	1	4	34
Beets	do	6	36	97
Broccoli	do	9	186	1,480
Brussels sprouts	do	1	6	51
Cabbage	do	15	2,896	365
Carrots	do	2	299	905
Cauliflower	do	4	99	599
Celery	do	2	287	1,037
Cucumber	do	5	197	1,001
Eggplant	do	21	88	404
Escarole	do	11	55	190
Lettuce	do	7	2,279	8,277
Onions, dry	do	2	440	1,163
Peas (in shell)	do	10	38	311
Peppers	do	13	363	3,048
Potatoes	do	.2	398	799
Scallions	do	10	13	88
Spinach	do	3	55	308
Sweet potatoes	do	3	324	1,356
Tomatoes	do	6	1,105	7,388
Total				30,131

[1] Based on marketing studies in six retail stores covering all four seasons.

[2] Basic data for quantity and value represent the quantity marketed and value of quantity marketed, respectively, less the quantity and value of the losses incurred during transit and unloading.

dures. Many of these losses could be avoided, but some only at prohibitive cost. When products are improperly handled on the farm, preventive or corrective measures during processing are of little avail.

During the period 1951–60, improvements in processing techniques have reduced physical losses of many farm crops. For example, crude cottonseed oil yield per ton of cottonseed crushed has increased from a yearly average of 316 pounds in 1942–51 to 334 pounds in 1951–60. For the 3-year period 1958–60, average oil yield was 339 pounds per ton.

The distinction between avoidable and unavoidable losses is not always well defined. The removal of fruit and vegetable peel or rind before canning, freezing, or dehydration is an example of the difficulty of making such a determination. Citrus rind is processed for human consumption and as cattle feed; therefore, rind that is not recovered is a physical loss of a byproduct but may not be an economic loss because of the cost of recovery. Peels and pits of some other fruits are not acceptable for feed and when removed do not constitute a loss in themselves. However, appreciable amounts of the fruit or vegetable pulp may be removed with the peel and would be considered a loss. In the process of juice extraction there are losses due to spillage and failure to recover the juice from the rag and peel. Economical recovery and use of these edible juices has not always been possible, and frequently where these juices are recovered it is done to avoid stream contamination.

Another loss in processing crops is the reduction in nutritive value. Loss of carotene in the harvesting, drying (in the field or in a rotary drier), and storage of alfalfa is an example. However, methods for reducing this loss are available.

The discarding or unwise use of materials known as agricultural residues has not been included among the losses covered in this report. Among these materials are wheat and other grain straws, corn stover and cobs, stems and pods of soybeans, cotton stalks, and sugarcane bagasse. Uses for nutshells have been suggested. One use is to return them to the soil; and they are frequently used as fuel. Cottonseed hulls and rice hulls are also frequently used as fuel. Oat hulls are used in the production of chemicals. Possibly cottonseed and rice hulls could also be used this way. If so, their use as fuel might not be the best use for national welfare.

The percentage of loss on fruits and vegetables relates only to the loss of edible materials—materials that might have been used as human food. Even though discarded edible material is used for some other purpose such as animal feeds, fertilizers, or industrial products, it is nevertheless considered a loss.

Field crops

Estimated average annual losses during processing of field crops total $20,198,000 (table 37).

Rice.—In rice milling, bran layers adhere tightly to the endosperm. Under present milling practices the bran layers can be removed only by vigorous abrasion. Some broken grains always occur from this step. The broken-grain rice must be sold at lower prices than whole-grain rice.

Sugarbeets.—Beets grown for sugar are subject to losses during storage and processing in the mills through respiration of the living beet tissue, destruction of the tissue by microorganisms, molasses formation, and inclusion of sugars in wash waters. Unextracted sugar in beet pulp is not considered a loss because of the value of the sugar in the beet pulp when fed to livestock.

Sugarcane.—About 7 million tons of cane are processed annually in this country. Losses arise from the presence of trash and dirt, sugar inversion and loss of weight between harvest and milling, and sugar left in the bagasse during extraction. The sugar content of blackstrap molasses is not considered an economic loss because of the demand for molasses in mixed livestock feeds.

Tung Oil.—Tung fruit is hulled as a preliminary step to further processing in oil production. Tung hulls accumulate and present a disposal problem. Only limited use has been established for these hulls. Their bulk is a deterrent to shipping them to centers where they might be used. Also, chemical constituents such as potash or tannins can be obtained to better advantage from other sources.

Oil is lost both in the hulling and in the expression of oil from the hulled fruit. Broken kernels, which are the source of oil, and oil released from the kernels on breaking are carried along with the hulls as they are removed from the fruit. Improved methods of separating the hulls from the fruit have reduced the loss of broken kernels in recent years. In the milling operation, oil is either polymerized or retained in the press cake and, therefore, is considered lost.

Fruit crops

The estimated average annual losses in processing fruits total $45,493,000 (table 38).

Adequate and accurate data are not available on losses occurring in the processing of fruits. For example, companies can give figures on yield of cases of canned fruit per ton of incoming fruit, but not on losses in preparation and subsequent handling. The number of cases per ton is not adequate for several reasons: (1) The edible loss is not known and calculated losses include inedible portions; (2) leaching losses occur, replacing nutritive solids by water, sirup, or brine; and (3) cans are filled with both fruit and sirup, the fruit varying by size and grade and the sirup varying in density.

Only loss of edible material has been estimated. For example, in the production of orange juice there is a loss of skin and seeds and inedible and edible juice, which cannot be or is not extracted by available methods. The unextracted juice, later utilized in cattle feed, is considered a food loss.

TABLE 37.—FIELD CROPS: *Estimated average annual losses in processing, 1951–60*

Commodity	Unit of measure	Loss in quantity [1]		Loss in value [1 2]
		Percent	*1,000 units*	*1,000 dollars*
Maple sirup	Gallon	[3] 10.0	147	678
Rice	Hundredweight	7.0	3,588	17,534
Sugarbeets	Ton	.4	50	578
Sugarcane	do	1.4	96	684
Tobacco-cigar binder	Pound	5.0	1,896	724
Total				20,198

[1] See table 2, footnote 1.

[2] The average price of the crop produced was used to determine the value of the processed product. The average price may be a composite of the contract price offered for the cream of the crop fresh, a lower price offered for a fresh crop of lesser quality, and a still lower price offered for the usable portion of the crop remaining that can be used for processing.

[3] Loss in value of production for sirup.

TABLE 38.—FRUIT CROPS: *Estimated average annual losses in processing, 1951–60*

Commodity	Unit of measure	Loss in quantity [1]		Loss in value [1 2]
		Percent	*1,000 units*	*1,000 dollars*
Apples	Bushel	12.0	4,124	7,695
Apricots	Ton	8.0	14	1,653
Blackberries	Pound	5.0	1,608	156
Cherries	Ton	8.0	13	2,957
Cranberries	Barrel	2.0	12	127
Figs, dried and canned	Ton	1.0	(3)	56
Grapefruit	do	3.0	22	658
Grapes, dried [4]	do	7.0	60	3,077
Grapes, canned	do	7.0	2	118
Lemons	do	3.0	7	475
Olives	do	7.0	3	615
Oranges	do	3.0	94	5,285
Peaches	Bushel	20.0	6,202	12,416
Pears	do	12.0	1,921	3,510
Plums, fresh, canned or frozen	Ton	6.0	(5)	57
Prunes, dried	do	6.0	23	2,383
Raspberries	Pound	5.0	2,188	350
Strawberries	do	10.0	23	3,356
Tung oil	Ton	10.0	[6] 8	549
Total				45,493

[1] See table 2, footnote 1.

[2] The average price of the crop produced was used to determine the value of the processed product. The average price may be a composite of the contract price offered for the cream of the crop fresh, a lower price offered for a fresh crop of lesser quality, and a still lower price offered for the usable portion of the crop remaining that can be used for processing.

[3] 804 tons loss.

[4] Dried for raisins, fresh basis.

[5] 333 tons loss.

[6] Loss based on total production of tung nuts.

TABLE 39.—VEGETABLE CROPS: *Estimated average annual losses in processing, 1951–60*

Commodity	Unit of measure	Loss in quantity [1]		Loss in value [1 2]
		Percent	*1,000 units*	*1,000 dollars*
Asparagus	Ton	3.2	3	769
Beans:				
Green lima	do	6.0	6	837
Green snap	do	5.0	17	1,906
Beets	do	7.0	11	214
Broccoli	Hundredweight	20.0	[3] 18	144
Brussels sprouts	do	10.0	[3] 3	25
Cabbage (kraut)	Ton	5.0	10	139
Carrots	Hundredweight	18.0	[3] 49	146
Cauliflower	do	8.0	[3] 4	25
Corn, sweet	Ton	20.0	289	6,009
Cucumber, pickling	Bushel	5.0	684	940
Peas, green	Ton	6.0	29	2,576
Potatoes	Hundredweight	5.0	[3] 118	242
Spinach	Ton	10.0	13	530
Sweet potatoes	Hundredweight	15.0	[3] 16	71
Tomatoes	Ton	5.0	184	4,867
Total				19,440

[1] See table 2, footnote 1.

[2] The average price of the crop produced was used to determine the value of the processed product. The average price may be a composite of the contract price offered for the cream of the crop fresh, a lower price offered for a fresh crop of lesser quality, and a still lower price offered for the usable portion of the crop remaining that can be used for processing.

[3] 1959–61 averages of quantities processed.

TABLE 40.— POULTRY AND POULTRY PRODUCTS: *Estimated average annual marketing and processing losses, 1951–60*

Cause of loss	Marketing unit	Loss in—			
		Quality	Quantity		Value
		Percent	*Percent*	*1,000 units*	*1,000 dollars*
Chickens and turkeys: [1]					
Grade reductions for bruises, cuts, etc.	Number	1.0			5,779
Eggs and chickens: [2]					
Broken (cracked)	do		0.5	275,000	8,983
Defects	do	.7			12,576
Grade reductions	do	2.8			50,306
Total					77,644

[1] Average number of farm chickens and turkeys sold, and cash receipts from the sales.

[2] Average number and cash value of eggs sold annually.

Edible losses occur in several places along the processing line:

(1) Preparation losses result from excessive peeling and trimming; flesh removal when a fruit is pitted; juices lost through handling; removal of culls, moldy fruit, and otherwise undesirable material; and removal of outside protective leaves. Not considered as edible losses are peel, stems, caps, pits, and seeds.

(2) Leaching is always a problem with cut material. Leaching losses can only be guessed because of inadequate data and variable processing conditions throughout the country. When water blanching, fluming, or both are employed, losses are high. Nominal allowances for leaching losses are included in the tables.

(3) Respiratory losses may occur in any fruit held before processing. Pears are particularly susceptible, as they are picked green and allowed to ripen. Dried fruits held in sweat boxes until packaging also lose weight. Respiratory and other storage losses are included in the tables.

TABLE 41.—*Estimated average annual losses (condemnations) in value occurring during slaughter of livestock and poultry, 1951–60*

Species of animal	Losses in value		
	Condemned carcasses	Condemned parts	Total
	1,000 dollars	*1,000 dollars*	*1,000 dollars*
Calves	1,451	21	1,472
Cattle	10,963	1,303	12,266
Goats	7	(1)	7
Horses	21	27	48
Poultry	6,818	(2)	6,818
Sheep and lambs	1,271	199	1,470
Swine	5,410	4,611	10,021
Total	25,941	6,161	32,102

[1] Loss of $152.

[2] Included in condemned carcasses.

Vegetable crops

Average annual losses in vegetable crops during processing are estimated at $19,440,000 (table 39).

Many of the comments relating to fruit-processing losses are equally applicable to vegetables. The estimates cover the destruction of edible material during preparation, leaching losses, and respiratory losses. Pea and lima bean pods, corn husks, and corn cobs are not considered edible and their removal was not included in the estimates.

MARKETING AND PROCESSING POULTRY AND POULTRY PRODUCTS

During the marketing and processing of poultry and poultry products, losses result from

TABLE 42.—*Estimated average annual losses (condemnations) to animal livers at slaughter and meat and meat products during processing, 1951–60*

Commodity	Loss in quantity	Loss in value
	1,000 pounds	*1,000 dollars*
Livers:		
Calves	430	172
Cattle	26,901	10,760
Goats	52	21
Sheep	3,958	1,583
Swine	25,519	10,208
Total	56,860	22,744
Meat and meat products	18,088	5,456
Total	74,948	28,200

several causes, including accidents, lack of care, disease, deterioration, and spoilage. These losses represent an estimated average annual reduction in value of $77,644,000 (table 40).

Market egg defects

Defects such as meat and blood spots occur in eggs wherever they are produced. Faulty nutrition is suspected as a factor, as well as genetics, poor management, and physiological disturbances. As much as 0.7 percent of the eggs produced may show these spots.

Other losses arise from factors such as breakage, shell abnormalities, dirt, and spoilage.

Accidents, bruising, and downgrading of poultry

Marketed poultry is subject to downgrading because of cuts and bruising, poor conformation, discoloration, pinfeathers, and poor condition due to improper management.

MEAT AND POULTRY CONDEMNATIONS

The removal from food channels of unwholesome products and meat from diseased and abnormal animals is the most important function of the meat and poultry inspection programs. The condemned products include losses from disease and abnormal conditions identified during the ante-mortem inspections of livestock and poultry, the post-mortem inspection of the carcasses, and the reinspection of the meat products during processing operations at federally inspected establishments. The estimated average annual losses in value as a result of condemnations during slaughter and processing are given in tables 41 and 42.

Chapter 10.—Forest Resources and Forest Products Losses

The unsalvaged losses of standing timber in U.S. forests resulting from natural causes are estimated at about 4,809 million cubic feet annually for the period 1951–60 (table 43). In terms of sawtimber, the unsalvaged losses from all natural causes total about 17,015 million board feet annually. These losses, which represent about 23 percent of the annual growth of timber crops, result primarily from insects, fire, disease, and wind, and often are aggravated by natural overstocking and old age of wild and unmanaged forest stands.

Growth losses due to destruction of seedlings and saplings, delays in restocking, reduced growth and increased cull in larger trees, and deterioration of soils are substantially higher than losses from natural causes. These losses are estimated at 6,975 million cubic feet annually, including about 27,870 million board feet of sawtimber.

Serious losses of lumber and other forest products in buildings and other structures also result from fire and other natural causes.

FIRE LOSSES

More than 7 million acres of forest land were burned over annually in the United States during the period 1951–60. The volume of standing timber and trees more than 5 inches in diameter destroyed by forest fires and not salvaged is roughly estimated at about 280 million cubic feet annually. Annual losses of sawtimber due to fires total about 1,069 million board feet (table 43).

Far exceeding these losses of standing timber, however, is the loss of current and prospective timber growth on burned-over areas caused by the destruction of seedlings and small trees, by deterioration of site quality, by reduction in growth rates of damaged trees, and by increased cull in damaged trees. In the United States as a whole, the growth loss from current forest fires is estimated to be more than 5 percent of the potential timber growth. This constitutes an annual growth loss of about 725 million cubic feet, including about 3,300 million board feet in terms of sawtimber-size trees.

Annual losses due to forest fires are difficult to measure. They include the timber destroyed by fire, possibly amounting to $10,690,000 per year in terms of stumpage value, and the timber growth that would have occurred in the absence of fire, amounting to possibly $9,900,000. Destruction of timber raw material may involve lower industrial output and decreased payrolls in forest cummunities. Fires also reduce hunting and fishing values, lower yields of usable water, and increase erosion and flood damage. In some areas the value of watershed losses far exceeds the direct monetary value of timber or other vegetation destroyed.

A part of the losses from forest fires is attributable to lightning; but smokers, incendiarism, burning of debris, and camp fires account for most of the damage. Losses from forest fires undoubtedly can be further reduced through more effective public education and more intensive control programs.

Additional losses of lumber, plywood, and other forest products result from building fires. The value of lumber and other forest products lost only in dwellings destroyed by fire is estimated to be about $25,000,000 annually, exclusive of costs of fabrication into buildings, for the period 1951–60.

INSECT LOSSES

Unsalvaged losses of standing timber more than 5 inches in diameter from attacks by insects are estimated at about 991 million cubic feet annually (table 43). In terms of sawtimber, these losses are estimated at about 4,664 million board feet. They reflect the sporadic outbreaks of bark beetles, some defoliators, and the less striking endemic losses caused by the white-pine weevil, wood borers, and other forest insects. The monetary value of losses of standing timber due to insects is estimated at $46,640,000 annually for the period 1951–60.

In addition to direct losses of standing timber from annual insect attacks, other serious losses, more difficult to estimate, arise from reduced growth, lowered quality of timber, and destruction of forest reproduction. Although outbreaks of defoliators may cause little direct loss of trees, they reduce tree growth rates to a point where little wood is produced. Deformities caused by the white-pine weevil and increased cull due to damage by boring insects are reflected in lower commercial values of the timber crop. A large number of aphids, scales,

TABLE 43.—FOREST TREES, NURSERIES, AND FOREST PRODUCTS: *Estimated average annual losses due to fire, insects, disease, and other causes, 1951–60*[1]

Kind of loss	Loss from potential production			
	Reduction	Growing stock [2]	Saw-timber [3]	Value [4]
	Percent	*Million cubic feet*	*Million board feet*	*1,000 dollars*
Forest losses				
Fire:				
Unsalvaged loss	------	280	1,069	10,690
Growth loss	------	725	3,300	9,900
Total	------	1,005	4,369	20,590
Insects:				
Unsalvaged loss	------	991	4,664	46,640
Growth loss	------	780	3,580	10,740
Total	------	1,771	8,244	57,380
Disease:				
Unsalvaged loss	------	978	2,969	29,690
Growth loss	------	4,280	17,650	52,950
Total	------	5,258	20,619	82,640
Other losses: [5]				
Unsalvaged loss	------	2,560	8,313	83,130
Growth loss	------	1,190	3,340	10,020
Total	------	3,750	11,653	93,150
Total:				
Unsalvaged loss	------	4,809	17,015	170,150
Growth loss	------	6,975	27,870	83,610
Grand total	44	11,784	44,885	253,760
Losses in nurseries and forest products				
Nurseries	------	-------	-------	160
Forest products: [6]				
Insects	------	-------	-------	500,000
Disease	------	-------	-------	300,000
Fire [7]	------	-------	-------	25,000
Total				825,160

[1] All data on annual unsalvaged losses are for 1962. All other data on annual growth loss and acreage are for 1952, taken or adapted from "Timber Resources for America's Future," Forest Resource Report No. 14, USDA, Forest Service, 1958. Since data are incomplete for other years, the growth loss data for 1952 are assumed to represent the trend level growth losses for the 1950 decade, except for losses caused by fire. Volume growth lost in 1952 due to fire was adjusted downward by 50 percent to obtain an estimate more representative of the trend level during the decade as indicated by the downward trend in acreage of forest burned between the decade of the 1940's and the 1950's.

[2] Volume growth of growing stock, i.e., in sound live trees 5 inches and larger in diameter on commercial forest land.

[3] Volume growth (scaled in international ¼-inch log rule) in sawtimber trees on commercial forest land. Softwood sawtimber trees are at least 9 inches in diameter except in California, Oregon, Washington, and coastal Alaska where they are at least 11 inches in diameter. Hardwood sawtimber trees are at least 11 inches in diameter. Each sawtimber tree contains at least one saw log.

[4] Value of annual board-foot losses in 1963 dollars. The unsalvaged loss is estimated to have an average stumpage value of $10 per thousand board feet. The average stumpage value of growth losses, discounted to allow for the time period by which the potential harvest was deferred because of the damaging agent, is estimated at $3 per thousand board feet. The value for loss in nurseries is the estimated cost of replacing tree seedlings lost primarily because of diseases. Values for losses in forest products are the estimated 1963 market values of the wood products that are lost (sawlogs, lumber, etc.) less allowance for depreciation. They do not include costs of fabricating the wood into furniture or buildings and other structures after it leaves the lumber yard.

[5] Weather, animals, suppression, and mortality from unknown causes.

[6] Includes losses of logs, lumber, and other forest products in storage and also losses of wood in use in furniture and in buildings and other structures.

[7] Losses only in dwellings destroyed by fire, based on Census of Housing showing loss of about 35,000 dwellings annually due to a variety of causes (fire, flood, condemnation, etc.), of which fire destroys most (possibly 25,000).

and other sucking insects feed on and injure trees by removing the plant juices. They cause damage by killing trees, reducing wood production, introducing disease organisms, or making trees susceptible to secondary pests. Seed and cone insects sometimes destroy practically all of a seed crop and prevent regeneration. The total value of such losses in timber growth is estimated at $10,740,000 annually for the period 1951–60.

Heavy losses of forest products also result from insect attacks. From the time a tree is felled until it is finally used in structures, equipment, or furniture products, insects take their toll. Damage by termites, for example, requires large amounts of lumber for repairs and replacement. Many millions of dollars are also spent for treatments to prevent termite damage. Ambrosia beetles and other wood borers attack green logs and lumber, causing losses during processing, storage, and use. Pulp logs are subject to attack, and heavy losses occur in storage. Powder post beetles also attack stored lumber, furniture, and other wood products.

Altogether, product losses due to insects for the period 1951–60 are estimated at about $500,000,000 annually excluding any costs of fabricating lumber or other products for final use in furniture, or in buildings and other structures (table 43).

DISEASE LOSSES

Unsalvaged losses of standing timber in trees more than 5 inches in diameter due to forest diseases are estimated at about 978 million cubic feet annually, including 2,969 million board feet of sawtimber (table 43). Heavy damage occurs year in and year out from attacks by many kinds of diseases, including bark canker fungi, wilts, rusts, and viruses. Root rots also reduce growth and make trees susceptible to attacks by insects or subject to windthrow.

Losses due to reduced growth and lowered quality because of disease are far greater than losses of standing timber. Heart rots are of particular importance, since they attack all species of timber and cause heavy losses in the form of cull and lowered quality of the remaining wood. These growth losses total an estimated 4,280 million cubic feet annually, including about 17,650 million board feet of sawtimber. Annual losses caused by forest diseases for the period 1951–60 amount to possibly $82,640,000 of which $52,950,000 represents growth loss and $29,690,000 loss of standing timber.

Heavy losses of forest products also result from decay of wood in use and storage. Decay in buildings and other structures arising from improper construction, lack of wood preservation, and other factors requires replacement of the damaged wood and involves labor and other costs that far exceed the market value of the destroyed wood. Some sawlogs and pulpwood in storage are also lost to decay. The estimated average annual value of such losses is approximately $300,000,000 for the period 1951–60 (table 43).

OTHER LOSSES

Unsalvaged losses of standing timber in trees more than 5 inches in diameter from windthrow, animals, suppression, or other causes amount to an estimated 2,560 million cubic feet annually, including 8,313 million board feet of sawtimber. The average annual value of this unsalvaged loss is roughly estimated at about $83,130,000 for the period 1951–60 (table 43).

In many areas, reduction of timber growth and future yields as a result of rodents is more serious than the direct loss of standing timber. Mice and other animals consume large quantities of seed of important species such as ponderosa pine, preventing their reproduction and thereby encouraging invasion of worthless brush. Damage to live timber by porcupines, deer, and other animals also causes losses in the form of reduced growth, lowered quality, and delayed regeneration amounting to about 1,190 million cubic feet annually, including about 3,340 million board feet of sawtimber. These cumulative losses from damage are estimated at approximately $10,020,000 annually for the period 1951–60 (table 43).

Chapter 11.—Soil and Water Losses

EROSION, WATER, AND UNFAVORABLE SOIL CONDITIONS

Nature of agricultural losses

Estimating agricultural losses due to soil deterioration, and more specifically to erosion, excess water, and unfavorable soil conditions, presents difficulties not encountered in estimating direct losses such as those caused by crop diseases, insects, hail, and fire. Year-to-year losses inflicted on growing crops by floodwaters, sediment deposition, and soil erosion are tangible; although these losses have not been regularly tabulated, a somewhat firm basis for estimating their magnitude exists. Physical damage to or loss of the resource itself is much less tangible. Not only is the magnitude of such losses difficult to estimate, but placing dollar value on them is even more uncertain.

In this discussion, consideration is given primarily to losses that arise essentially from physical soil deterioration. These losses include erosion by runoff water, blowing (wind erosion), unfavorable soil conditions, alkali accumulation, waterlogging, floodwater, sediment, and related watershed damage; they are assumed to be preventable. Not included are losses of organic matter and replaceable plant nutrients that are the normal result of crop production.

Additional agricultural losses involving cropland, which are not considered here, include extensive areas deliberately inundated by permanent dam backwaters and the estimated 410,000 acres of cropland absorbed annually by urban and industrial expansion, by highway and airport construction, and by recreation facilities. Nor is consideration given here to areas where low soil productivity is a natural consequence of an original state of infertility, drought, or climatic conditions.

Computation Procedure.—The following basic data and estimates were used to calculate the losses of soil and water:

(1) Acreage of crops harvested and their value for each State.[1]

(2) Estimates by the Agricultural Research Service of productivity lost per acre and the years that the land has been subject to hazards noted under the three categories in item 3.

(3) Acreage of cropland needing treatment[2] where—

(a) dominant problem is erosion,

(b) dominant problem is excess water, or

(c) dominant problem is unfavorable soil conditions.

From these data, the annual rate of loss in dollars was capitalized at a 4-percent interest rate to arrive at its present worth. This capitalized value is the average annual loss. It was estimated on a State-by-State basis, and the totals for the three categories as given [under items 1, 2, and 3] in table 44. Estimates of losses from floodwater, sediment, and related watershed damage in table 44 were prepared by the Soil Conservation Service.

Economic Evaluation of Losses.—Although there is no satisfactory method for evaluating physical soil deterioration on cropland on a national scale, various estimates have been made. The annual losses from erosion alone, in terms of the cost of replacing through commercial fertilizers the major nutrient elements removed through soil erosion, have been estimated at several billion dollars. The cost (at 1960 prices) of replacing only the nitrogen and phosphorus is estimated by investigators of the Department at $4.3 billion, and of replacing the nitrogen, phosphorus, and one-fourth of the potassium at $7.75 billion. This does not include, however, large supplies of these nutrients uncovered in many soils by both natural and accelerated erosion. The estimated annual losses (table 44) for wind and water erosion on cropland are about $800 million, on grazing land $150 million, and on forest land $16.5 million—a total of about $967 million. If the estimates of $291 million for losses due to excess water and of $353 million for unfavorable soil conditions are included, the total approaches $1.6 billion.

The total value of U.S. farm real estate ranged from about $86 billion in 1951 to $130.2 billion in 1960.[3] The average for the period 1951–60 is about $108 billion. On the basis of this figure, the $1.6 billion loss is equal to about

[1] U.S. CENSUS OF AGRICULTURE, 1950, 1954, and 1959.

[2] CONSERVATION NEEDS INVENTORY COMMITTEE OF THE U.S. DEPARTMENT OF AGRICULTURE. NATIONAL INVENTORY OF SOIL AND WATER CONSERVATION NEEDS. U.S. Dept. Agr. Statis. Bul. 317, 1962.

[3] ECONOMICS RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE. FARM REAL ESTATE MARKET DEVELOPMENT, CD 61. June 1962.

TABLE 44.—SOIL AND WATER: *Estimated average annual losses due to different causes and cost of controlling these losses, 1951–60*

Kind of loss	Average annual loss
	1,000 dollars
On cropland acreage needing treatment where dominant problem is due to—	
1. Erosion by wind or water or both [1]	800,325
2. Excess water (high water table or temporary flooding) [1]	291,000
3. Unfavorable soil conditions (salinity, alkalinity, deterioration of soil structure, etc.)	353,050
Annual flood damage for upstream and downstream areas:	
4. Floodwater, sediment, and related watershed damage [1]	1,345,454
On other lands:	
5. Forest land erosion by wind or water or both	16,500
6. Rangeland erosion by wind or water or both	150,000
Water losses due to—	
7. Irrigation	665,000
8. Evapotranspiration—	
On cropped acreage	166,000
On fallow acreage	38,000
Total losses	3,825,329
Cost of controlling losses	238,080
Grand total	4,063,409

[1] These items have been adjusted to eliminate double counting.

1½ percent of the average value of farm real estate.

However, annual losses of 1½ percent of the dollar value of farm real estate does not imply that within 75 or 100 years the value will approach zero. With appropriate antideterioration measures, many of these losses can be prevented.

Erosion

Erosion on Cropland.—Estimated average annual losses of about 800 million dollars are attributed to soil erosion by water or wind or both from croplands in the United States for the period 1951–60 (table 44). From the standpoint of physical deterioration of land, erosion undoubtedly causes greater damage than any other factor. Soil erosion has forced the abandonment for cultivation of an estimated 35 million acres of land that were originally suitable for crop production.

Water erosion and the accompanying sedimentation in the low-lying areas, valley lands, and reservoirs constitute a continuing threat to the land and water resources of this country. The physical removal of productive topsoil from cropland and grassland by sheet erosion amounts to many millions of dollars annually. Sedimentation attendant to soil erosion causes untold damage by covering up growing crops, reducing the productivity of good agricultural land, and reducing the effectiveness of water reservoirs.

For example, experiments conducted by research workers at the Midwest Claypan Soil Conservation Experiment Farm in Missouri showed that reduction in crop yields per inch of surface soil lost through erosion was as follows:

Crop	*Bushels per acre*
Oats in south Missouri	5
Corn in north Missouri	4
Soybeans on claypan soils:	
Without fertilizer	1.5
With fertilizer	2.7

These losses in production indicate that in Missouri, in the places and under the conditions existing where the studies were made, namely on a claypan soil, a 100-acre farm with slight erosion became equal to only an 80-acre farm when it reached the stage of moderate erosion. It was equal to only 50 acres when it suffered severe erosion by loss of more than half of the original surface.

Although few reliable figures are available on the areas affected by soil blowing (wind erosion), it may be assumed that at least 75 million acres are subject to this type of loss. Perhaps 36 million acres need treatment and 10 million acres are seriously affected.

The effects on crop yields of losses from wind erosion are similar to losses from soil erosion caused by runoff water. The most fertile parts of the soil are removed, conveyed in the air for considerable distances, and then deposited on the land, in cities and towns, or in the sea. Much of the soil removed is redeposited on farmland, where it remains available for use.

However, much of it is deposited where no use can be made of it or where it creates major problems of removal. Dust storms, which represent severe soil blowing, cause additional damage through abrasive action on crops, machinery, and farm equipment.

Losses from soil blowing are generally limited to arid and semiarid areas but are widely distributed. Losses are greatest in the Great Plains States. Soil blowing in the humid areas, although less serious, does create acute local problems, particularly on drained and cultivated organic soils (peat and muck) and on very sandy soils.

Wind erosion is a major land management problem on lands in the Great Plains; it becomes acute during extended drought periods.

The immediate effect of wind erosion is on the surface crust. However, prolonged erosive winds—lasting a month or more—tend to reduce the quantity of crop residue, soil cloddiness, and surface roughness. Therefore, a gradual deterioration in resistance of surface to erosion by wind may be expected.

Erosion on Grazing Land (Pasture and Range).—The National Inventory of Soil and Water Conservation Needs estimates that in the 50 States 72,380,000 acres of grazing land need a vegetative cover established or reestablished. However, 44,768,000 acres of this land are coming into grazing from other uses, so no current loss to agriculture can be estimated under the grazing use. This leaves a total of 27,612,000 acres of grazing land that are presently inadequately vegetated. Much of this acreage is subject to erosion.

Land having a dominant problem of erosion makes up slightly more than half (53.6 percent) of all land classified as pasture and range in the Inventory. If this proportion applies to the acreage inadequately protected by vegetation, about 14,800,000 acres in the 50 States may be subject to active erosion. The Inventory includes 32,065,000 acres of pasture and range needing erosion control measures in addition to those that need a vegetative cover. Soil losses, therefore, may be occurring on a total of 46,865,000 acres of land in pasture and range.

The estimated annual loss for wind and water erosion on grazing land (pasture and range) is $150,000,000.

Erosion on Forest Land.—The National Inventory of Soil and Water Conservation Needs estimates that 12¼ million acres (1 acre out of 36) of non-Federal forest land need protection from erosion. Included is acreage that should be converted to forest because of serious erosion damage that occurred when the land was in some other use. Also included is present forest acreage with active wind or water erosion. Much of this erosion is in connection with the concentration of water along forest roads, skid trails, and other structures. Estimated losses resulting from decreased productivity, damage to growing stock, and increased cost of establishing trees or management if erosion is not controlled average about $1 per acre annually on this land, or a total of $12,350,000. If preventable erosion on Federal forest land is assumed to be only half that on non-Federal forest land (or 1 acre out of 72), the total cost of erosion on forest land is $16,500,000.

Excess water

Estimated average annual losses to croplands due to excess water for the period 1951–60 were $291,000,000 (table 44). These losses result from a high water table or from temporary flooding that prevents or limits use of conservation farming systems. According to the National Inventory of Soil and Water Conservation Needs, excess water is the dominant problem on 94 million acres of cropland, of which 60 million acres need treatment.

Poor drainage on much of the good land in the humid part of the country is a continuing threat to the productivity of the land affected.

Waterlogging, salinity, and alkalinity are component parts of a severe threat to the longtime productivity of irrigated lands of the Western United States. Detailed data showing relation of land-use changes to major soil problems are available in the Inventory for about 7.4 million acres of irrigated cropland in nine Great Plains States. These figures, when expanded to the entire acreage of irrigated cropland in the 17 Western States and Hawaii, indicate that about 85,000 acres of irrigated land having a dominant problem of excess water will be converted to pasture and range and to other land uses between 1958 and 1975, or about 5,000 acres annually. It can be assumed that this is land being taken out of cropland because of waterlogging. There probably are losses caused by decreased yields on areas where the condition is less severe and the land is not retired from cultivation. The Inventory shows that possibly 4,000,000 acres of cropland in these States need treatment to alleviate the effects of excess water.

Floodwater, Sediment, and Related Watershed Damage.—Floodwater, sediment, and related watershed damage cause heavy economic losses to agriculture in the United States each year. These losses include damage to crops and pasture; land damage in the form of gully and other channel erosion, flood plain scour, swamping, infertile overwash, or other kinds of sediment deposition; damage to farm buildings, fences, farm roads, stored crops, livestock, and irrigation and drainage facilities; and indirect losses such as those occasioned by delays in fieldwork and disruption or delays in marketing of farm products. Some of these losses are as follows:

Upstream agricultural flood damage:	
Damage to crops and pastures	$484,472,000
Sediment damage	88,819,000
Other damage	234,163,000
Total	807,454,000
Downstream flood damage areas:	
Downstream agricultural damage	179,000,000
Downstream nonagricultural damage	359,000,000
Total	538,000,000
Total upstream and downstream losses	1,345,454,000

The estimate of annual flood losses is made for "upstream" drainage areas of less than 390 square miles and for "downstream" drainage areas of more than 390 square miles. These estimates are based on data developed by the Soil Conservation Service in connection with the preparation of watershed work plans under the Watershed Protection and Flood Prevention Act (Public Law 566, as amended). Data from 361 watersheds covering about 31 million acres, in 46 States, were expanded by physiographic regions to estimate the total for the United States.

The Corps of Engineers estimated flood damage in downstream areas for 1957 conditions.[4] This estimate was not divided between agricultural and nonagricultural damage. However, Sanders and Black in 1958 estimated that about one-third of downstream damage was agricultural and two-thirds nonagricultural.[5] On this basis, it is apparent that about $179 million of the average annual downstream damage is agricultural and $359 million is nonagricultural. The available information is not adequate to determine downstream agricultural losses by types of damage or physiographic regions.

Flood plain damage by scour, channel erosion, gullying, and valley trenching is important monetarily and also from the viewpoint of our agricultural resources. About 6 percent of our total agricultural land lies in the alluvial flood plains of tributary valleys.[6] In general, this land is highly productive and if given flood protection, it will remain so for use by future generations. Some land damage is temporary; and proper treatment may restore productivity. The treatment, however, may prove costly.

Irrigation Water.—Figures in Geological Survey and Census reports [7, 8, 9] show that the actual plant needs for irrigation water average about 0.8 acre-foot per acre in the humid, eastern part of the United States, and 1.5 acre-feet per acre in the Western United States. To provide this water to the plants it was necessary to deliver to the farm 1 acre-foot in the East, and 2.8 acre-feet in the West.

Thus, in 1959 with 2.2 million acres of irrigated land in the East, 0.44 million acre-feet of water were lost and similarly in the West with 31.5 million acres, 32.8 million acre-feet were lost. In terms of dollars, if the very conservative figure of $20 per acre-foot is used,[10] these losses would amount to about $665,000,000 annually.

Also it is apparent, if this loss could be eliminated entirely, the acreage of irrigated land could be increased by from 60 to 70 percent.

Assuming that this reduction in water handled is a measure of a cost that is preventable by known methods, and that $1.50 per acre-foot is a reasonable cost-of-handling figure, the preventable cost of handling excess irrigation water amounts to $84,284,730 annually.

The U.S. Geological Survey estimated that in 1960, 103 million acre-feet of water were withdrawn to irrigate 33.7 million acres of land in the United States. Of this amount, 90 million acre-feet were actually delivered to the farms and 22 million acre-feet were lost in conveyance. In its report to the Senate Select Committee on Water Resources, the U.S. Department of Agriculture estimated that average farm efficiency in the use of water was 47 percent, but that 55 percent of the total losses could be recovered for reuse.[11]

Evapotranspiration

Evaporation loss from soil surfaces is undoubtedly the greatest loss of water to agriculture. Of the water that reaches the root zone under irrigated conditions, up to 50 percent is estimated to be lost by evaporation from the soil surface. There is evidence also to indicate that in the Midwest, where frequent summer showers occur, as much as 50 percent of the total water lost in a season can be accounted for by evaporation from the soil surface. In the Great Plains as much as 65 percent of the total water falling is lost by evaporation.

The assumption that 50 percent of the annual evapotranspiration is lost from cropped acreage is conservative, considering the high losses incurred from irrigated lands and the losses during intervals between crops. Assuming an average of 15 inches annual evapotranspiration, evaporation losses would amount to about 100 million acre-feet of water or about $166,000,000 (table 44) on the 170 million

[4] SELECT COMMITTEE ON NATIONAL WATER RESOURCES, UNITED STATES SENATE. FLOODS AND FLOOD CONTROL. Com. Print No. 15, 86th Cong., 2d Sess., 1960.

[5] SANDERS, T. J., and BLACK, N. S. WATER: PARTNERSHIP TO MANAGE WATER. *In* Land, 1958 Yearbook of Agr., p. 349. 1958.

[6] See footnote 2.

[7] U.S. CENSUS OF AGRICULTURE: 1959. Vol. III. IRRIGATION OF AGRICULTURAL LANDS. Washington, 1962.

[8] U.S. CENSUS OF AGRICULTURE: 1959. Vol. V, Special Reports, Part 2. IRRIGATION IN HUMID AREAS. Washington, 1960.

[9] MACKICHAN, K. A., and KAMMERER, J. C. ESTIMATED USE OF WATER IN THE UNITED STATES, 1960. U.S. Dept. Int., Geol. Survey Cir. 456, 1961.

[10] WOLLMAN, NATHANIEL, and others. THE VALUE OF WATER IN ALTERNATIVE USES. Univ. of New Mexico Press, Albuquerque, 1962.

[11] SELECT COMMITTEE ON NATIONAL WATER RESOURCES, UNITED STATES SENATE. WATER RESOURCES ACTIVITIES IN THE UNITED STATES. Com. Print No. 12, 86th Cong., 2d Sess., 1960.

cropped acres (exclusive of summer-fallowed land) in the 17 Western States.

Assuming a conservative estimate of 14 inches annual precipitation on 28 million fallow acres and a seasonal loss of 70 percent of this precipitation, the annual loss by evaporation would be about 23 million acre-feet of water, amounting to about $38,000,000 (table 44). Some of this loss is preventable.

Therefore, the total annual evapotranspiration loss of water from both cropped and fallowed acres would amount to $204,000,000.

Physical information to estimate surface evaporation losses from range, forested, and essentially nonvegetated (desert and alpine) lands is largely lacking. Grasses that provide complete cover should considerably reduce evaporation from the soil surface as compared to cultivated crops. However, in western range areas, complete cover is seldom attained because of sparse vegetative growth or the low growth habit of much of the vegetation. In addition, either natural or drought-induced dormancy occurs for extended periods on large acreages. Forested and brush-covered land similarly do not provide complete cover. Neither beneficial plants nor effective cover occurs on major western land areas. Thus, evaporation from the soil surface is undoubtedly a serious source of water loss from range, forested, and nonvegetated lands.

Evaporative losses from the 600 million acres of rangeland, 250 acres of forested land, and 100 million acres of desert and alpine land probably greatly exceed the combined losses from fallow and cropped land.

The relative magnitude of soil evaporation and transpiration cannot be established as a precise ratio, since the magnitude of each depends on the relative wetness of the surface.

In row crops, sufficient energy reaches the ground surface to account for a considerable portion of the water loss. The absolute amount of water loss, however, depends on the time the soil surface is wet and on the moisture-holding and transmitting capacities of the soil. It would be virtually impossible to predict the absolute amount of soil evaporation.

Unfavorable soil conditions

Losses due to unfavorable soil conditions have been estimated at $353,050,000 (table 44). Unfavorable soil conditions include salinity, alkalinity, acidity, low moisture-holding capacity, or some other condition that limits root development. Many of the losses due to these specific conditions are difficult to evaluate, but nevertheless they are large enough to be important economically.

Salinity.—Soil deterioration from the accumulation of deleterious salts may follow the application of salty irrigation water, inadequate development of drainage, or both. It is limited largely to the irrigated Western States. In a study of some 30 million acres, more than 8 million acres were affected by accumulations of saline elements. Saltiness ranges from a low level that allows most crops to grow well to levels so high that no crops can be grown. However, some plants can tolerate much more salt than others. Always present with salinity is an increase in osmotic pressure of the soil solution. This restricts water uptake by the plant and reduces growth. Toxic effects associated with specific ions also occur and cannot be neglected.

Qualitatively, the effects of salinity on crop yields are hard to measure. One index used widely is to relate crop response to the electrical conductivity of saturation extracts of soil water.

In addition to the toxic effects of salt concentrations on growth and yield of the plants, alkali accumulation frequently leads to deterioration of the physical structure of the soils; they become impermeable and untillable. This circumstance is usually accompanied by waterlogging of the soil. Furthermore, the actual waterlogging due to excess irrigation, even with relatively mineral-free water, often brings to the root zone toxic salts hitherto found only in the subsoils. Unlike losses due to severe soil erosion, losses arising from alkali accumulation and waterlogging are generally reversible.

Deterioration of Soil Structure.—While loss of favorable structure frequently accompanies soil erosion through the exposure of harsh, cloddy subsoils, it is also a widely prevalent consequence of cultivation even where no soil is lost. Yield reductions may be permanent in the absence of proper soil management, but generally the condition can be corrected through a shift to fewer and more careful cultivations and better rotations. Poor structure may develop at the surface (surface crusts), below the furrow slice (plow or tillage pans), or within the surface soil (puddling and compaction).

Hard surface crusts develop mainly from the beating of raindrops on unprotected soil. Adverse effects on crops arise from (1) impedence of water infiltration with consequent increase in runoff and erosion, (2) interference with seedling emergence, and (3) injury to young plants during cultivation.

Plowpan formation is a frequent result of overcultivation of moist, medium-textured soils with implements whose blades tend to compact the soil immediately below the furrow slice. Plowpans affect crop yields through resistance to root development and reduction in water permeability.

Puddling and compaction of the surface occur when soils are driven over or cultivated while still moist. The result is reductions in yield from the unfavorable seedbed produced. The hoofs of grazing livestock may also cause some compaction.

Structure deterioration occurs in varying degrees throughout the country. The most severe damage to crop production is generally on the medium-textured soils, particularly silt loams, but many areas of heavy soils are susceptible, such as the lake plain soils of northern Ohio. Damage is frequently less severe in regions where heavy frosts are common. Damage due to the formation of surface crusts is most pronounced in sandy loams and silt loams.

WEEDS IN AQUATIC AND NONCROP AREAS

Weeds in and along irrigation canals and ditches of the 17 Western States obstruct the flow of water; increase evaporation and seepage losses; cause sedimentation, canal breaks, and damage to structures; prevent timely delivery of water to crops; result in large losses of water through transpiration; clog sprinkler heads, valves, and structures; and interfere with efficient operation and maintenance of the irrigation systems. Weeds in drainage ditches cause similar losses and, in addition, result in damage to crops from inadequate drainage and infestation of farmland from weed seeds produced along the ditches. Weeds in farm ponds and reservoirs interfere with using the ponds for such things as water storage, irrigation, fish production, and recreation. The estimated average annual losses in value of irrigation water and related resources due to weeds in aquatic and noncrop areas are given in table 45.

Because of lack of suitable control methods for many weeds in aquatic and noncrop areas in the 17 Western States, losses from weeds have remained high. The losses would be much higher if the value of irrigation water lost were considered at its net productive value of $20 per acre-foot instead of the average cost of $2.09 per acre-foot. Also, the losses tend to increase every year as more farm ponds, drainage ditches, and irrigation canals are constructed and become infested with weeds, and as the needs for water and the movement of water through canals and streams become more critical for agriculture, navigation, industrial and urban development, and recreation.

TABLE 45.—IRRIGATION WATER AND RELATED RESOURCES: *Estimated average annual losses from weeds in aquatic and noncrop areas, 1951–60*

Kind of loss	Average annual loss
	1,000 dollars
Losses of water due to weeds in—	
Irrigation systems (17 Western States)	[1] 4,110
Farm ponds and reservoirs	27,320
Ditchbanks of drainage ditches (31 Eastern States)	8,550
Watershed and drainage basins (17 Western States)	9,750
Total losses due to aquatic plants	49,730
Losses on noncrop areas:	
Fencelines	650
Damage to canals, structures, and farms	2,110
Total losses due to weeds in noncrop areas	2,760

[1] Computed at an average cost of $2.09 per acre-foot of water. On the basis of data by Wollman and others (footnote 11), $20 per acre-foot is a very conservative figure for the cost of irrigation water. On this basis, the estimated loss of irrigation water would be $39,332,700.

Western irrigation systems

The most troublesome aquatic weeds in irrigation and drainage canals of the West are pondweeds, elodea, filamentous algae, cattail, and bulrushes. Bank weeds that cause the greatest losses include reed canarygrass, johnsongrass, Carex, Canada thistle, and many other rank-growing herbaceous and woody species.

A joint survey [12] in 1957 conducted by the Agricultural Research Service and the Bureau of Reclamation showed that aquatic and ditchbank weeds on irrigation systems in the 17 Western States cause annual losses of 1,966,000 acre-feet of irrigation water at a cost of $4,110,000 and result in other losses of $2,110,000 (table 45). This water, if available, would be enough to irrigate 330,000 to 780,000 acres of cropland, depending on the length of the growing season, evaporation losses, and other factors.

Eastern draniage ditches and water control canals

According to 1949 Bureau of Census estimates, there are nearly 190,000 miles of open drainage ditches and irrigation canals in the 31 Eastern States. The aquatic weed problems in these channels are similar to those in western irrigation systems, but bank weed problems are

[12] TIMMONS, F. L. WEED CONTROL IN WESTERN IRRIGATION AND DRAINAGE SYSTEMS. U.S. Dept. Agr., Agr. Res. Service, ARS-34-14, 1960.

often more serious because of denser and ranker growth resulting from greater rainfall and longer growing seasons. Weed species that are more troublesome in canals and ditches in Eastern States than they are in Western States include naiad, milfoil, waterhyacinth, waterprimrose, alligatorweed, paragrass, and phragmites.

Weed growth in and along drainage ditches and water control canals in the East is generally greater than along irrigation and drainage canals in the West, but estimated annual losses from weeds in the East were only $45 per mile as compared to annual losses of $43 per mile in the 17 Western States. The estimated average annual loss along drainage ditches of irrigation systems in 31 Eastern States is $8,550,000 (table 45).

Farm ponds and reservoirs

According to the 1954 Census of Agriculture, there are 1,768,000 farm ponds in the United States. These ponds average approximately 1 acre in size. Serious weed problems exist in 50 to 70 percent of these ponds. The weeds greatly reduce the storage capacity of water for livestock, irrigation, and fire protection, and interfere with fishing, boating, swimming, and other uses. Weeds that most commonly interfere wth economic utilization of ponds and reservoirs include naiad, milfoil, elodea, coontail, waterlilies, waterhyacinth, waterlettuce, waterprimrose, cottonball, and filamentous algae. The average annual loss from weeds in farm ponds for the period 1951–60 is estimated at $27,320,000.

Undesirable phreatophytes

Saltcedar, willows, cottonwoods, seepwillow, greasewood, and other undesirable phreatophytes that grow on river floodplains, along canals and streams, and around irrigation reservoirs are estimated by the U.S. Geological Survey [13] to result in water losses of 20 to 25 million acre-feet annually. That agency has estimated that more than 4.5 million acre-feet of this wasted water could be successfully and economically salvaged and delivered to farms and cities for irrigation and other uses. The value of this salvageable water at the average cost of $2.09 at the water user's headgate would be $9,750,000. In addition to the tremendous water losses, phreatophytes cause flood damage, sedimentation, and other losses not accounted for in this report.

Weeds in fencelines

The amount of farmland occupied by fencelines in the United States varies from 0.6 to 0.9 percent as much as the cultivated cropland in different sections of the country, and totals more than 2,000,000 acres or nearly 5,000,000 miles of fencelines. Weeds in fencelines include many that are hazardous to humans and livestock. Also, they harbor harmful rodents, insects, and plant diseases, and result in damage to fences when dry weeds are burned. Estimates of these losses have been included in other sections of this report, with the exception of losses in fencelines due to burning weeds. This is estimated to be $650,000.

[13] ROBINSON, T. W. PHREATOPHYTES. U.S. Geol. Survey Water-Supply Paper 1423, 84 pp., illus. 1958.

Chapter 12.—Costs of Controlling Losses and of Inspection and Quarantine Services

Diseases, insects, and pests not only reduce the quantity and quality of crops, livestock, and other agricultural products; they also increase the cost of production because of the need to apply measures for their control. The packer of meats and poultry and their products for interstate commerce must assure by Federal inspection that these products are wholesome.

Federal-inspection costs and the costs of controlling insects, pests, and weeds ultimately affect the consumer. These costs may be grouped under five major categories: (1) chemical control measures, (2) cultural and mechanical practices, (3) biological control measures, (4) large-scale cooperative control programs, and (5) inspection, quarantine, and regulatory measures. The first three categories relate to the production and marketing of crops and livestock.

Many losses that occur during the production and marketing of crops, livestock, and forest trees can be reduced or eliminated by agricultural chemicals. Other control measures include sanitation, management practices, and use of biologics.

Nationwide control, eradication, and regulatory programs protect agriculture from destructive insects, nematodes, and plant and animal pests. The Federal meat and poultry inspection programs assure that meat and poultry and their products will be clean, sound, and wholesome for human consumption, free from adulteration, and truthfully labeled.

Other efforts to control destruction or reduced quality of agricultural products include the inspection of plants and animals at ports of entry. This service is aimed at excluding the entrance of pests and diseases that affect both crops and livestock and that are not now in the United States.

All of these control measures and various services are costly. These costs affect the producer or marketer in some instances, but in the end all affect the consumer. It is the purpose of this chapter to record some of the costs of controlling pests of crops and livestock and the costs of maintaining the various Federal services for the inspection and protection of these commodities.

ANIMAL-DISEASE ERADICATION PROGRAMS

Nationwide animal-disease control and eradication programs to protect the livestock industry are conducted in cooperation with State and local agencies. These programs are administered to prevent the spread of diseases through interstate shipments of livestock and poultry.

The average annual cost of the cooperative animal-disease eradication programs is $47,577,693 (table 46). The federally sponsored part of these programs is $20,393,149.

TABLE 46.—COOPERATIVE ANIMAL-DISEASE ERADICATION PROGRAMS: *Average annual cost, 1951–60*

Program or activity [1]	Average annual cost		
	Federal	Non-Federal	Total
Brucellosis (7 years)	$13,052,369	$14,695,020	$27,747,389
Scabies (7 years)	172,035	557,893	729,928
Screw-worm (3 years)	1,755,787	1,637,685	3,393,472
Ticks (7 years)	408,477	358,376	766,853
Tuberculosis (7 years)	1,965,225	5,064,312	7,029,537
Vesicular exanthema (6 years)	1,594,105	1,136,151	2,730,256
Miscellaneous diseases (7 years)	323,078	2,682,547	3,005,625
Interstate movement (7 years)	1,122,073	1,052,560	2,174,633
Total	20,393,149	27,184,544	47,577,693

[1] Federal programs for the period 1951–60, except screw-worm (3 years) and vesicular exanthema (7 years); non-Federal programs as indicated.

ANIMAL INSPECTION AND QUARANTINE PROGRAMS

The primary objectives of the animal inspection and quarantine programs are (1) to prevent the introduction of foreign animal and poultry diseases into the United States through a system of inspections and quarantines at ports of entry to determine freedom from diseases of animals, poultry, animal products, and associated materials imported from many foreign countries; (2) to insure continuing export trade in livestock and products by health inspections and certifications at origin and at ports of embarkation; (3) to make certain that all veterinary biologics such as serums, vaccines, and related products used in the prevention and treatment of livestock and poultry diseases are pure, safe, and potent.

Animal quarantine measures

Inspection and Quarantine at Ports of Entry.—Animals and poultry, which each year are brought into the United States for various purposes from many foreign countries, can bring with them several diseases that presently do not exist in this country—foot-and-mouth disease, rinderpest, contagious pleuropneumonia, African swine fever, fowl plague, and many others. They can also harbor diseases already present—such as brucellosis, tuberculosis, hog cholera, and Newcastle disease—and thereby complicate nationwide control and eradication programs.

To provide for orderly importations of animals and poultry, the principal coastal cities and various points along international land borders are designated as ports of entry. At some ports inspection service is provided by resident inspectors while at others inspection service is on an appointment basis. Health inspection of import animals and poultry is mandatory by law. Adequate inspection and quarantine has taken on added significance with increased use of air transportation.

Each year thousands of tons of animal byproducts such as hides, wool, bones, animal glands, and dried blood are imported for pharmaceutical and industrial uses. Such products are potentially dangerous from a disease-introduction standpoint and must be inspected at ports of entry and released without restrictions if this can be safely done; otherwise, the products are sent under seal to approved industrial establishments for handling and processing under supervision in a manner designed to preclude spread of disease.

The purpose of regulatory controls over export livestock is to foster and maintain foreign trade by assuring that only healthy animals are shipped to foreign countries and in a manner that will assure their arrival in good condition. Thus there are health requirements to be complied with and requirements on transporting vessels and aircraft as to space, ventilation, feed, water, and attendants.

The average annual cost incurred in the administration of laws and regulations relating to the importation and exportation of animals and products and maintaining surveillance at ports of entry is $748,000 (table 47).

Operation of USDA Animal Quarantine Station, Clifton, N. J.—The station is maintained for quarantine or other detention of authorized importations of animals and poultry. Department veterinarians perform diagnostic tests, administer precautionary treatments for parasites as required, conduct daily health examinations, and supervise the care, feeding, and handling of animals and birds during their quarantine. Upon completion of minimum quarantine periods and if the animals are free from evidence of infectious or communicable diseases and exposure thereto, they are released to owners without further restrictions except for certain animals subject to permanent post-entry requirements at approved zoological parks. No charges are made for inspection services. Rates have been established for the care, feed, and handling of animals and poultry while in quarantine and for normal maintenance of the station. This represents an average annual cost to importers of $23,000 (table 47).

Inspection and Certification of Inedible Animal Products.—Regulations authorizing the Secretary of Agriculture to assist in the devel-

TABLE 47.—ANIMAL INSPECTION AND QUARANTINE SERVICES AND PRODUCTION AND MARKETING OF VETERINARY BIOLOGICS: *Average annual cost*

Nature of cost	Average annual cost
	1,000 dollars
Animal quarantine measures:	
Inspection and quarantine at ports of entry	748
Operation of USDA Quarantine Station, Clifton, N.J.	23
Inspection and certification of inedible products	[1] 15
Controls over the production and marketing of veterinary biologics:	
Licensing and inspection	540
Assessment fee for Control Agency	32
Total	1,358

[1] Service inaugurated July 23, 1955.

opment of new or expanded markets (foreign and domestic) provide for an inspection service whereby the Department, upon request, may issue and endorse certificates that meet certain specifications of contracts for the purchase or sale of animal byproducts, or to accompany shipments that meet the requirements of receiving foreign countries. Prior to July 1955, there were no provisions for such inspection and certification.

Numerous requests are received from independent processors, trade organizations, and others for certifications to accompany shipments of inedible animal products to meet the requirements of certain receiving countries. The average annual cost for these services is $15,000 (table 47).

Controls over production and marketing of veterinary biologics

Licensing and Inspection.—The Virus-Serum-Toxin Act of 1913 prohibits the production and marketing in interstate commerce of virus, serums, toxins, and related products except when produced under a U.S. Veterinary License issued by the Secretary. Such products must not be worthless, contaminated, dangerous, or harmful. Regulatory controls provide for a system of licensing, inspection, and testing. The program is one of consumer protection, assuring veterinarians and farmers that the products they buy and use for the diagnosis, prevention, and treatment of animal and poultry diseases are safe and potent. The average annual cost for these protective services is $540,000 (table 47).

Assessment Fee for Control Agency—The Control Agency for administration of a Marketing Agreement under the provisions of an Act of Congress regulating handling of anti-hog-cholera serum and hog-cholera virus consists of 12 members selected by the Secretary from nominations by the hog cholera industry. The Secretary has continuing right to disapprove Agency actions or decisions.

Funds collected from assessments against handlers of serum and virus are used to hire an Executive Secretary and his secretary, to maintain an office in Kansas City, Mo., and for travel expenses for members of the Control Agency and the Executive Secretary. The assessments amount to about $32,000 annually (table 47).

COOPERATIVE PLANT PEST CONTROL PROGRAMS

Under specific legislation, the U.S. Department of Agriculture cooperates with the States in certain extensive insect and plant disease control and regulatory programs. Current programs can be classified into three categories as follows:

(1) Eradication of incipient infestations of introduced agricultural pests. The programs in operation in 1960 were: golden nematode, imported fire ant, khapra beetle, and witchweed. Infestations of citrus blackfly, Mediterrean fruit fly, and of Hall scale have been eradicated. Surveys are conducted each year to confirm their eradication status.

(2) Prevention of spread of destructive pests of foreign origin that have become established in limited areas in this country. Regulatory programs are being carried on to prevent spread of the burrowing nematode, European chafer, gypsy moth, Japanese beetle, Mexican fruit fly, peach mosaic, phony peach, pink bollworm, soybean cyst nematode, sweetpotato weevil, and white-fringed beetle and including the programs mentioned in paragraph (1). Pests confined to limited areas by cooperative control and regulatory action do not normally cause the tremendous losses that they would cause if they were allowed to become distributed over their potential ecological range.

(3) Suppression of widely distributed insects and plant diseases that assume outbreak portions periodically, causing extensive agricultural losses that cannot be controlled effectively by individual effort. These programs include grasshoppers, Mormon crickets, and stem rust (barberry eradication). Each year Federal, State, and private groups spend considerable amounts to prevent the spread of these insect pests and plant diseases and to suppress outbreaks.

During 1951–60, the average annual expenditure for cooperative regulatory and suppressive programs was $12,522,116 from Federal sources and $11,998,599 from non-Federal sources (table 48).

CONTROLLING EROSION IN 17 WESTERN STATES

Nearly two-thirds of the acreage needing vegetation and more than nine-tenths of the land needing measures to control erosion are in the 17 Western States. Much of this land has a low value per acre. However, the benefits accrue not only to the actively eroding land but also to neighboring land covered by dunes and to other neighboring land to which erosion might extend. The cost of controlling erosion in this part of the United States is $238,080,000 (table 49).

According to the Great Plains Conservation Program Act, PL 1021, an estimated 6 million acres of privately owned land in the Great Plains is subject to erosion and the owner is

TABLE 48.—FEDERAL AND STATE COOPERATIVE PLANT PEST CONTROL AND QUARANTINE PROGRAMS: *Average annual cost, 1951–60*[1]

Program [2]	Average annual cost: Federal	Non-Federal	Total
Barberry (stem rust control)	$691,509	$301,333	$992,842
Burrowing nematode (5 years)	299,458	590,017	889,475
European chafer (6 years)	90,782	69,087	159,869
Golden nematode	340,454	237,796	578,250
Grasshopper and Mormon cricket	945,716	1,492,199	2,437,915
Gypsy moth	915,166	1,594,150	2,509,316
Hall scale	87,475	32,944	120,419
Hoja blanca (2 years)	76,910	21,098	98,008
Imported fire ant (3 years)	2,378,206	1,883,818	4,262,024
Japanese beetle	518,268	500,291	1,018,559
Khapra beetle (6 years)	666,441	663,247	[3] 1,329,688
Mediterranean fruit fly (6 years)	895,930	1,372,591	2,268,521
Citrus blackfly and Mexican fruit fly	323,485	835,928	[3] 1,159,413
Peach mosaic and phony peach	146,960	137,229	284,189
Pink bollworm and wild cotton	1,472,841	651,886	2,124,727
Soybean cyst nematode (5 years)	283,932	116,151	400,083
Sweetpotato weevil	227,262	684,914	912,176
Tropical termites (1 year)	56,551	40,000	96,551
White-fringed beetle	722,672	728,404	1,451,076
Witchweed (4 years)	1,382,098	45,516	1,427,614
Total	12,522,116	11,998,599	24,520,715

[1] All are introduced pests except grasshoppers, Mormon cricket, peach mosaic, and phony peach.

[2] For the period of 1951–60, except as indicated.

[3] Includes Republic of Mexico.

TABLE 49.—EROSION IN 17 WESTERN STATES: *Estimated average annual cost of control, 1951–60*

Kind of control	Average annual cost
	1,000 dollars
Private crop and grazing lands	117,162
Federal grazing lands	36,633
Handling excess irrigation water	84,285
Total	238,080

justified in spending $6.25 per acre for erosion control. Since 5 years is required to complete the average contract for this work, the annual cost to the owner would be $1.25 per acre. But this is a cost-sharing program; the actual cost would be $2.50 per acre. On this basis, the estimated annual cost of controlling erosion on the 46,850 acres of private crop and grazing lands in the 50 States, which is about three-fourths of the total grazing land, would total $117,162,000. For federally owned grazing land, at the estimated cost per acre, the estimate is $36,633,000.

Assuming that the reduction in water handled is a measure of a cost that is preventable by known methods, and that $1.50 per acre-foot is a reasonable cost-of-handling figure, the preventable cost of handling excess irrigation water amounts to $84,285,000 annually.

It should be emphasized that these are estimates of the annual cost of preventing or correcting deterioration. Thus, at the end of 5 years, after the expenditure of about 220 to 300 million dollars, the erosion may be controlled permanently under reasonable management, or at least for an indefinite period.

CONTROLLING FIRE, INSECTS, AND DISEASE IN FORESTS

The United States spends about $84 million annually to prevent or suppress forest fires (table 50). About 40 percent of these costs are

TABLE 50.—FIRE, INSECTS, AND DISEASE IN FORESTS: *Average anual cost of control, by source of funds, 1951–60*

Source of funds	Type of control: Fire	Insects	Disease	Total
	1,000 dollars	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*
Federal Government	34,400	3,200	3,050	40,650
State and county governments	32,200	150	650	33,000
Private agencies	17,400	100	50	17,550
Total	84,000	3,450	3,750	91,200

borne by States and counties, 40 percent by the Federal Government, and the remainder by private landowners.

Expenditures for controlling insects in the forests have averaged about $3,450,000 annually (table 50). About 90 percent of these funds have been provided by the Federal Government and the remainder by States and private agencies.

Expenditures for controlling disease in the forests have averaged about $3,750,000 annually (table 50), primarily for control of the white-pine blister rust. Most of these funds have been provided by the Federal Government, and the remainder from State and private sources.

CONTROLLING INSECTS AFFECTING CROPS, MAN, ANIMALS, AND HOUSEHOLDS

Insects that annoy man and transmit human diseases and that affect his homes, lawns, and gardens cost considerable to control. The estimated average annual cost of controlling these insect pests (exclusive of the enforcement of quarantine and regulatory measures and the operation of large-scale cooperative control programs) is about $425,000,000 (table 51).

The cost of these measures may be grouped under three major categories: (1) insecticidal control, (2) cultural, mechanical, and sanitation control, and 3) biological control. The measures are developed by research conducted by Federal and State agencies and by industry. The cost of this research is not included in the estimates.

Insecticidal control

Availability of new insecticides, changes in formulations and dosages, and improved methods of application make estimating the cost of control very difficult. The following procedure appears to be the most practical.

According to estimates, about 215,000,000 pounds of insecticidal chemicals are used each year to control insects affecting crops, man, animals, and households in the United States, excluding Alaska and Hawaii.[1] At an average price of $1.30 per pound, this material would be valued at approximately $280,000,000. If the cost of application is assumed to be one-half the price of the insecticide, about $140,000,000 should be added. Thus, the estimated total annual cost of controlling these insects with insecticides is about $420,000,000.

TABLE 51.—INSECTS AFFECTING CROPS, MAN, ANIMALS, AND HOUSEHOLDS: *Estimated average annual cost of control, 1951–60*

Type of control	Average annual cost
	1,000 dollars
Insecticidal control	420,000
Cultural, mechanical, and sanitation control	4,000
Biological control	1,000
Total	425,000

Cultural, mechanical, and sanitation control

Some of the cultural, mechanical, and sanitation practices used by the grower and the general public to control insect pests are clean cultivation, stalk and trash destruction, crop rotation, hand picking or hand worming, timing of planting dates, drainage, refuse disposal, and screening. These practices add appreciably to the cost of insect control. The amount expended for control has been estimated at $4,000,000.

Biological control

The expense of utilizing natural enemies such as insect parasites, predators, and diseases as a means of combating harmful insects and the expense of developing crop varieties resistant to insects is borne chiefly by Federal and State agencies. Only a few biological control agents have been available commercially for use by private individuals. Among these are lady beetles for use against mealybugs and certain scale insects on citrus, the egg parasite *Trichogramma* against several lepidopterous pests, and milky disease spore dust to control Japanese beetle grubs. It is estimated that $1,000,000 is expended annually in the biological control of insect pests, including the search for beneficial insects in foreign areas and importation of them into the United States.

CONTROLLING INSECTS IN STORED PRODUCTS

Damage by stored-product insects is in addition to the direct damage caused by insects to agricultural commodities after harvest and to the products derived from these commodities. Stored-product insects increase the cost of goods because of the expenditures required for their prevention and control. These costs affect farmers, warehousemen, millers, bakers, food processors, those engaged in transportation and marketing, and finally, the consumer.

The estimated average annual cost of controlling insects in stored products for the period 1951–60 is $279,302,000 (table 52). But this is not the total amount required to prevent and

[1] HALL, DAVID G. USE OF INSECTICIDES IN THE UNITED STATES. Ent. Soc. Amer. Bul. 8: 90–92. 1962.

TABLE 52.—INSECTS IN STORED PRODUCTS: *Estimated average annual cost of control, 1951–60*

Commodity	Average annual cost
	1,000 dollars
Apples	75
Apricots, dried	132
Corn	1,125
Dry corn milling products	1,200
Dry milk (nonfat)	1,162
Figs, dried	283
Macaroni and noodles	1,200
Peaches, dried	45
Peanuts	1,682
Pears, dried	19
Prepared flour and mixes	85,000
Prunes	3,035
Raisins	476
Rice	2,170
Sorghum (grain)	7,635
Tobacco (flue-cured leaf)	1,239
Wheat flour	84,824
Woolens and furs	88,000
Total	279,302

control stored-product insects. Costs considered are primarily for pesticides and the labor used to apply them. It was not possible to estimate the cost for purchase, maintenance, operation, and deterioration of equipment for applying pesticides or for carrying out sanitation and housekeeping operations directed primarily against stored-product insects. No attempt was made to estimate the additional cost of special packaging required to protect food products against insect infestation. The preventive and control measures used are developed by Federal, State, and industry research, the cost of which is not included in this estimate. Some of the cost of inspection, quarantine, and other regulatory measures is directed toward stored-product insects such as the khapra beetle, but the proportionate share has not been determined.

CONTROLLING NEMATODES

Direct expenditure by growers for nematode control is almost exclusively for soil nematocides and the machinery and labor needed to apply them. Two methods of applying nematocides are in general use: Field applications and row applications. By far the largest expenditure is for nematocides applied to soil in field applications. The average cost is about $30 per acre, including an allowance of $5 per acre for application. Many growers apply nematocides only to the rows in the field, leaving the middle untreated. Cost of row applications is about $15 per acre, including application.

A much smaller but still significant amount is spent for nematode control on seedbeds and in nurseries. The materials used usually combine weed seed control and control of soil insects, fungi, and bacteria with nematode control. Costs range up to $10 per 100 square yards, of which only about one-tenth should be charged to nematode control.

Exact figures on the production and use of nematocides are not available. They are extensively used on tobacco in the Southern United States, on sugarbeets in the West (particularly Utah), and on most pineapple fields in Hawaii. Use is rapidly increasing on cotton, peanuts, vegetables, fruit crops, and ornamental and forest nurseries, especially in the Atlantic and Gulf Coast States, and in California.

The best estimate is that nematocides were used on 50,000 acres of tobacco in 1951, on 750,000 acres in 1960, and on an average of 350,000 acres for the 10-year period. Estimates for other crops are cotton, 20,000 acres; sugarbeets, 75,000 acres; peanuts, 2,000 acres; peaches, 4,000 acres; vegetables, 135,000 acres; pineapples, 17,000 acres; and other crops, 100,000 acres. Thus, nematocides were used on a total of approximately 713,000 acres.

There is no way of knowing what percentage of this acreage was treated by field applications ($30 per acre) or row applications ($15 per acre). Assuming an average cost of $22.50 per acre for nematocide treatment, it is estimated that the annual cost of nematode control was about $16,000,000.

CONTROLLING PLANT DISEASES

Common methods of controlling plant diseases include (1) use of disease-resistant varieties; (2) cultural practices such as deep plowing to bury infested crop residues, rotating crops to avoid a buildup of disease inoculum, burning infested plant debris, shifting production areas to avoid diseases, removal of alternate hosts, controlled irrigation, use of fertilization and other management practices, and use of disease-free seed; (3) biological control, principally for soil diseases such as root rots and wilts; and (4) use of chemicals for treating seed, disinfesting soil, and as sprays and dusts applied to the plants to control diseases and insect vectors of plant diseases.

The total cost of controlling plant diseases is estimated at $115,800,000 annually for the period 1951–60 (table 53).

Estimates of control costs are difficult and are made only for chemical control ($100,000,000), and for the costs involved in producing disease-free planting materials ($8,800,000). Approximately $75,000,000 is paid for fungi-

TABLE 53.—CONTROLLING DISEASES IN THE PRODUCTION OF CROPS: *Estimated average annual cost, 1951–60*

Type of control	Average annual cost
	1,000 dollars
Chemical control:	
Fungicides	75,000
Application of fungicides	25,000
Total	100,000
Seed disinfectants	7,000
Production of disease-free planting stock:	
Ornamental plants	2,400
Sweetpotatoes	150
Potatoes	6,200
Fruit crops	50
Total	8,800
Grand total	115,800

cides by farmers and commercial pesticide applicators. It is estimated that 1,000,000 acres of fruit and nut trees are treated on an average of four times a year, 1,500,000 acres of vegetables are treated three times, and 1,000,000 acres of potatoes are treated four times. At an average cost of $2 per acre the total cost of application of fungicides is approximately $25,000,000.

The expense of controlling diseases in a particular crop varies considerably. For example, on potatoes grown in the arid West, foliage diseases are of little importance. In Maine, the 8 to 14 applications to control late blight cost $30 to $50 per acre. Growers of apples in the Pacific Northwest usually have to spray three to four times during the season; in the East, they have to spray 8 to 20 times. Each application costs approximately $8 per acre.

Approximately $7,000,000 is spent for seed treatment to control diseases (table 53). Most of the small grain seed treatment is done by custom treaters. Seedsmen or seed processors treat most of the corn, cotton, sorghum, peanuts, and vegetable seeds and the cost is included in the selling price.

An estimated $8,800,000 is spent to produce disease-free planting stock (table 53). For ornamentals, estimates were made of costs for indexing and isolating disease-free planting stock and the increased expenses of propagating chrysanthemums, roses, foliage plants, carnations, gladiolus, pelargoniums, and lilies. About 1 million pounds of certified sweetpotato seed stock were grown at an estimated cost of 15 cents per pound premium cost. Approximately 141,000 acres of certified and foundation seed potatoes were grown annually from 1951 to 1960 at an estimated extra cost of $44 an acre. The additional costs to the grower or nurseryman of providing virus-free strawberries, grapes, stone fruits, and citrus were estimated. Costs of administering these programs were not included unless they were recovered from the producer.

PLANT QUARANTINE AND REGULATORY MEASURES

The enforcement of quarantines affecting importation and interstate movement of plants, plant products, plant pests, soil, and miscellaneous nonagricultural importations found contaminated with pests cost approximately $4,162,000 annually during the period 1951–60. This estimate includes (1) Federal appropriations for foreign plant quarantines; (2) contributions by States and offshore possessions, particularly California, Hawaii, and Puerto Rico, to the plant quarantine program; and (3) costs to importers in connection with the inspection, treatment, cooperage, handling, and other incidentals to meet plant quarantine import requirements. The expense of fumigating or otherwise treating large quantities of imported cotton and cotton products, broomcorn, fruits, vegetables, used bagging, carriers, and contaminated nonagricultural cargoes is included in this last group. The fumigation of ships and cargoes found to carry the khapra beetle and injurious snails was especially heavy during the latter part of the 10-year period covered by this report.

CONTROLLING WEEDS

In addition to the losses caused by weeds (discussed in chapter 5), the costs of controlling them are a tremendous financial burden. One of the major objectives of weed control research is to develop weed control principles that not only will reduce losses in yield and quality caused by weeds but also will reduce the cost of weed control. Lower costs of controlling weeds will provide a better profit margin for farmers, improve the competitive position of American agriculture, and benefit the consumer by reducing the prices of food, feed, and fiber.

Methods of controlling weeds include hand pulling, hand hoeing, cultivating, disking, plowing, harrowing, rotary hoeing, mowing, crop rotation, fallowing, bulldozing, chaining, draglining, herbicide application, mulching, and use of biological control agents such as insects, snails, geese, fungi, and various animals. The method adopted and used by farmers depends largely on its cost and relative efficiency in

TABLE 54.—WEEDS: *Estimated average annual cost of control in various crop and noncrop areas by cultural and chemical methods, 1951–60*

Crop and noncrop areas	Average annual cost		
	Cultural methods	Chemical methods [1]	Total
	1,000 dollars	*1,000 dollars*	*1,000 dollars*
Field and seed crops	1,745,977	92,023	[2] 1,876,000
Horticultural crops	307,000	3,050	310,050
Hay crops, pastures, and rangelands	348,308	16,692	365,000
Aquatic and noncrop areas	----------	----------	55,637
Total	2,401,285	111,765	2,606,687

[1] Data are for 1959 only.
[2] Includes $21,000,000 for costs of cultural andchemical control of weeds in flax and $17,000,000 for these costs in sugarcane.

controlling weeds in a particular crop or situation. The estimated average annual cost of cultural and chemical control of weeds for various crop groups is given in table 54, and for individual crops in tables 55, 56, and 57. Estimates are based on experimental data and the judgment of plant scientists and other scientists concerned with weed control and other farm operations. Because adequate data were not available, estimates of the cost of weed control in some crops are not given. Estimates of costs of cultural and chemical control of weeds in aquatic and noncrop areas, chargeable to agriculture, are presented in table 58.

Field crops

The annual weed control operation in field crops is far greater than generally realized. Approximately 120 million acres of intertilled row crops receive intensive weed control practices each year. More than 200,000,000 acres of drilled field crops receive moderate weed control practices. The intertilled row crops usually receive from two to five tillage treatments for seedbed preparation and from one to as many as seven cultivations in a single growing season. More than half of the total tillage operations in agronomic crops are practiced for the sole purpose of controlling weeds, and no other advantage can be attributed to these practices. Weeds in agronomic crops are controlled by cultural, ecological, mechanical, chemical, and combination methods. Nonchemical methods were used on 87 percent of the total field crops planted in 1959.

Special equipment for controlling weeds includes tillage implements of all kinds, mowers, sprayers, and burners. Also, every grain elevator and commercial seed processor is equipped with expensive machinery for removing weed seed from crop seed.

A survey conducted by the U.S. Department of Agriculture in 1959 showed that farmers are rapidly accepting the use of herbicides for weed control in field crops. In that year field crops, not including pastures and rangelands, were grown and harvested on approximately 320,000,000 acres. Herbicides were used to control weeds on more than 45,000,000 acres, and nonchemical methods were used to control weeds on the remaining acreage. In 1959 about 13 percent of the total harvested acreage of field crops was treated with herbicides for weed control. Since 1959 the acreage has expanded rapidly.

There is little doubt that weed control is practiced on a wider scale than any other pest control operation in field crop production. The costs of weed control are high and represent a large proportion of the total cost of controlling pests. If control of weeds is neglected or ineffective, yields will be reduced accordingly. As a general rule, no other single operation under the control of the farmer may influence final yields and quality of crops so greatly.

The cost of weed control in field crops includes part of the cost of seedbed preparation, tillage, and cultivations necessary to control weeds, and all the cost of preemergence, postemergence, layby, and preharvest herbicidal treatments. Weeds are controlled in many crops by hand hoeing, hand pulling, flooding, mowing, burning, flaming, and mulching.

The cost of controlling weeds in field crops ranged from $3.15 per acre for oats to $33 per acre for sugarbeets. These costs ranged from 8 percent of the total per acre value of sugarcane to as much as 39 percent of the value of alfalfa grown for seed. The cost of controlling weeds in 39 major field crops averaged 15 percent of the total value of the crops produced and amounted to $1,876,000,000 per year (table 54). The loss in value to certain field crops is given in table 55.

Corn.—The average cost of weed control in corn is about $6.65 per acre, or more than $534,000,000 each year. This is about 12 percent of the value of the crop. Thorough seedbed preparation, rotary hoeing, and shallow cultivations, supplemented by some hand hoeing and hand pulling, are the most important cultural practices of weed control. However, more than 20,000,000 acres of the crop are being treated with herbicides each year at a cost of approximately $37,980,000 (table 55). The cost of preemergence herbicide treatments for weed control in corn averaged $3.68 per acre and the cost of postemergence treatments $1.67. Farmers applied herbicides on 82 percent of the total treated acreage with their own equipment; custom operators treated the remaining 18 percent.

The use of herbicides to control weeds in corn is expanding rapidly in an effort to reduce the cost of weed control and to increase the efficiency of controlling weeds in corn by eliminating the need for repeated cultivations and hand hoeing and to permit the use of minimum tillage practices.

TABLE 55.—FIELD CROPS: *Estimated average annual cost of controlling weeds by cultural and chemical methods, 1951–60*

Crop	Average annual cost		
	Cultural methods	Chemical methods [1]	Total
	1,000 dollars	*1,000 dollars*	*1,000 dollars*
Corn	496,020	37,980	534,000
Cotton	437,372	4,628	442,000
Beans, dry	33,000	-----	33,000
Sorghum, grain	53,489	6,511	60,000
Rice	23,112	888	24,000
Small grains:			
Barley	76,905	3,095	80,000
Oats	130,000	4,000	134,000
Wheat	293,000	30,000	323,000
Alfalfa (seeds)	16,225	775	17,000
Other grass and legume seed crops	39,907	1,093	41,000
Soybeans	99,687	2,313	102,000
Flax	---------	-----	21,000
Peanuts	19,884	116	20,000
Sugarbeets	27,376	624	28,000
Sugarcane	---------	-----	17,000
Total	1,745,977	92,023	1,876,000

[1] Calculated from average costs incurred by farmers and other land owners in States reporting. Alaska, California, Delaware, Hawaii, New Jersey, New York, Ohio, Oklahoma, and Washington not included. Costs based on data for one year, 1959.

Cotton.—The cost of controlling weeds in cotton with conventional methods averaged approximately $22 per acre. The cost represents about 19 percent of the total value of the cotton crop and amounts to $442,000,000 each year. The use of herbicides to control weeds in cotton is expanding at a rapid rate. In 1959, it is estimated that about 1,500,000 acres of cotton were treated with herbicides to control weeds, at a total cost of approximately $4,628,000 (table 55).

The cost of preemergence applications averaged $3.22 per acre, whereas postemergence herbicide treatments averaged $2.69 per acre. Farmers treated 92 percent of the total acreage with their own equipment; custom operators treated approximately 8 percent.

Conventional methods of weed control such as tillage, cultivation, and hand hoeing required an average of 27 man-hours per acre. By using herbicides to supplement cultural practices, the cost of weed control has been reduced from $22 to about $10 per acre and the labor from 27 to approximately 10 man-hours per acre.

Sorghum, Grain.—The average annual cost of weed control in grain sorghum is approximately $5 per acre, or more than $60,000,000 (table 55). This is about 17 percent of the value of the crop.

In 1959 more than 2,000,000 acres of grain sorghum were treated with herbicides as postemergence sprays. Improved preemergence herbicides have been developed recently, and their use is expanding. The total cost of treating 2,000,000 acres of grain sorghum for weed control in 1959 amounted to $6,511,000 (table 55). The average cost of preemergence treatments was $6 per acre, and postemergence treatments averaged $3.10 per acre. The cost of herbicide treatments for weed control in grain sorghum varied considerably. Postemergence treatments ranged from as low as 40 cents per acre to as much as $4.

Rice.—The average cost of controlling weeds in rice was $13 per acre, amounting to about $24,000,000 per year (table 55). This is about 9 percent of the total farm value of the rice crop.

Recent surveys indicate that practically the entire rice crop is treated with postemergence sprays of the phenoxy herbicides or 3[1],4[1]-dichloropropionanilide (propanil). The average cost of the phenoxy herbicides for the control of broadleaf weeds in rice amounted to about $1.77 per acre.

The use of herbicides represents only a fraction of the total cost of controlling weeds in the rice crop. Land leveling, levy construction, seedbed preparation, maintenance of excessive water depths, timing of fertilizer applications to avoid stimulating weeds, and other factors add greatly to the cost of controlling weeds in rice. Herbicides are used widely to improve the efficiency of weed control and to reduce costs.

Small Grains (Wheat, Oats, and Barley).—The average cost per acre for weed control in wheat is $5; oats, $3.15; and barley, $5.75. These costs amounted to 15 percent of the value of wheat; 15 percent of oats; and 21 percent of the farm value of barley. Farmers spend $80,000,000 per year to control weeds in barley; $134,000,000 in oats; and $323,000,000 in wheat (table 55). In 1959, the phenoxy compounds were used to control weeds in 21 million acres of these crops at a cost of more than $37,095,000 (table 55). Practically no herbicides are used as preemergence treatments to control weeds in small grains, so most of the acreage was treated postemergence with the phenoxy herbicides.

The average cost of postemergence herbicide treatments for controlling weeds in small grains was $1.79 per acre. Farmers purchased the herbicides and used their own equipment on 75 percent of the acreage treated; custom operators sprayed 25 percent.

The use of herbicides is essential for efficient weed control in small grains. Cultural practices for controlling weeds in small grains include thorough seedbed preparation and the choice of adapted varieties, properly fertilized and planted at optimum dates to insure vigorous stands of rapidly growing plants. Once the grain crops are planted, there are no other cultural practices of weed control other than hand pulling. The use of herbicides for weed control in small grains is expanding rapidly, and this trend is expected to continue.

Forage Grass and Legume Seed Crops.—The average cost of weed control in forage-seed crops ranged from $5 per acre for lupines to about $18 per acre for alfalfa. This is 39 percent of the value of the alfalfa seed crop. Farmers spend annually more than $17,000,000 for weed control in alfalfa and approximately $41,000,000 for weed control in other grass and legume crops grown for seed production (table 55). Cultural practices alone have proved only partially satisfactory. Preemergence and postemergence herbicide treatments to control weeds in these crops are expanding rapidly. Dodder is especially serious in alfalfa seed production, and the cost of controlling this parasite is considerable. No combination of cultural practices has controlled dodder, but supplementing cultural practices with chemicals is proving satisfactory.

Soybeans.—The average annual cost of weed control in soybeans is $5.50 per acre, which is about 11 percent of the total value of the crop. Each year farmers spend approximately $102,000,000 (table 55) to control weeds in soybeans.

Methods of controlling weeds in soybeans include thorough seedbed preparation and the establishment of excellent stands of vigorous varieties by planting at optimum dates to give rapid, early season growth, followed by rotary hoeing, shallow cultivation, some spot hand hoeing and hand pulling. The use of herbicides for emergence control of weeds in soybeans is expected to increase rapidly as improved herbicides are introduced.

Flax.—The average annual cost of weed control in flax is $4.50 per acre, or 19 percent of the value of the crop. Farmers spend approximately $21,000,000 (table 55) each year to control weeds in flax. Cultural methods of weed control, including thorough seedbed preparation, hand pulling, and other methods, have proved relatively inefficient in preventing serious losses from weed competition in this crop.

The use of herbicides for controlling weeds in flax is expanding rapidly. For example, in Minnesota in 1961, more than 400,000 acres of flax were treated with herbicides for weed control. This was approximately 90 percent of the total acreage of flax in the State. Use of herbicides in flax in all production areas is expected to expand.

Peanuts.—The average annual cost of weed control in peanuts is $13 per acre, or 12 percent of the value of the crop. Farmers spend approximately $20,000,000 (table 55) annually to control weeds in the crop. Approximately 300,000 acres of peanuts are treated each year with preemergence herbicides to control weeds, at an average cost of about $4.36 per acre.

The acreage of peanuts treated with herbicides as postemergence sprays for the control of weeds is expanding. The cost of postemergence treatments averages about $3 per acre. Cultural methods of weed control consist of thorough seedbed preparation, rotary hoeing, the use of finger weeders, frequent shallow cultivation, plus hand hoeing and hand pulling. Farmers are expanding the use of herbicides in order to reduce hand hoeing and other weed control costs in peanut production.

Sugarbeets.—The average cost of weed control in sugarbeets was $33 per acre, or 18 percent of the value of the crop. Farmers spend approximately $28,000,000 (table 55) each year to control weeds in sugarbeets. Cultural methods of weed control include thorough seedbed preparation, blocking, thinning, hand hoeing, hand pulling, and frequent cultivations.

The introduction of monogerm varieties of sugarbeets greatly increases the need for chemical methods of controlling weeds. If satisfactory chemical methods can be developed to control weeds, monogerm varieties will permit planting to a stand and eliminate the need for blocking and thinning.

The average cost of preemergence treatments is approximately $5.24 per acre; postemergence treatments average about $4.63 per acre. In 1959, $624,000 was invested in herbicides and their application for the control of weeds in the crop (table 55) and their use is expected to expand rapidly as more effective herbicides are developed.

Sugarcane.—The average cost of controlling weeds in sugarcane is approximately $22 per acre, or 8 percent of the value of the crop. Farmers spend approximately $17,000,000 (table 55) each year to control weeds in sugarcane. Methods of controlling weeds in sugarcane include fallow plowing, thorough seedbed preparation, frequent cultivations in some areas, and hand hoeing.

The use of herbicides to control weeds in sugarcane is expanding rapidly. The entire sugarcane crop on the mainland and in Hawaii receives phenoxy or other herbicides to control broadleaf weeds and grasses. For example, in Hawaii about 100 thousand acres of sugarcane are treated with herbicides four to five times each year—an accumulative half a million acres. The cost of chemical weed control in sugarcane in Hawaii alone amounts to about $7,000,000 annually.

Cultural practices alone have not been efficient in controlling johnsongrass and other annual and perennial broadleaf weeds and annual grasses in sugarcane. The use of herbicides is expanding rapidly as supplemental techniques for the control of weeds in combination with cultural practices.

Horticultural crops

Horticultural crop plantings total about 8,000,000 acres. Until very recently, repeated hand weedings and intensive cultivation with a variety of implements were necessary to control weeds in many of these crops. Effective chemical methods of controlling weeds have been developed for a number of these crops but grower acceptance varies from poor to excellent depending on the crop, location, cultural practices, and economic stresses. In most instances, herbicides are used in combination with mechanical cultivation and hand weeding. The net result of herbicide use is therefore a reduction in mechanical and hand weeding and not an elimination of these practices.

Methods of controlling weeds in horticultural crops include: (1) hand pulling; (2) hand hoeing; (3) mechanical cultivation; (4) disking; (5) plowing; (6) harrowing; (7) mowing; (8) crop rotation; (9) fallowing; (10) soil fumigation; (11) herbicide application; and (12) mulching.

Because of the many crops involved and the many methods and combinations of methods that are used in horticultural crops, it is difficult to accurately assess the extent of use of the various methods and their cost. Limited data have been reported and these combined with knowledgeable estimates constitute valuable information for charting the trends in weed control costs. The loss in value to horticultural crops as a group is $310,050,000 (table 56).

Vegetable Crops.—Many vegetable crops are planted at high seeding rates and the plants are very small at emergence and grow slowly for a period of time. Weeds that emerge between the crop plants in the row are difficult to remove by mechanical cultivation and much hand labor is necessary where effective herbicides are not available. Reports indicate a very limited use of herbicides in these crops in 1959 suggesting that mechanical and handweeding methods were generally used.

Approximately 4,900,000 acres of vegetable crops were grown commercially in 1959. The cost of weed control by all methods and combinations of methods is estimated at $70 per acre for 2,800,000 acres of general vegetable crops including melons; $14 per acre for 1,300,000 acres of potatoes; $20 per acre for 634,000 acres of sweet corn; and $70 per acre for 113,000 acres of onions. This amounts to a total cost for control of about $224,418,000 for all vegetables (table 56). This amounts to an average cost of about $45 per acre for vegetables.

TABLE 56.—HORTICULTURAL CROPS: *Estimated annual average cost of controlling weeds by cultural and chemical methods, 1951–60*

Commodity groups and crops	Average annual cost		
	Cultural methods	Chemical methods [1]	Total
	1,000 dollars	*1,000 dollars*	*1,000 dollars*
Vegetable crops	223,000	1,418	224,418
Tree fruits, nuts, and vineyards	40,000	43	40,043
Strawberries and cranberries	11,000	55	11,055
Ornamentals	33,000	45	33,045
Lawns	-----	1,489	1,489
Total	307,000	3,050	310,050

[1] Based on data for 1959.

Tree Fruit and Nut Crops and Vineyards.—Many annual and perennial weeds infest orchard and vineyard plantings. Methods of control include the use of mechanical tillage, organic chemical herbicidal oils, mowing, and various combinations of these methods. The method to use depends on topography, cultural practices, and climate. Many citrus growers are using herbicidal oils and organic chemical herbicides for controlling practically all weeds in these crops. Herbicides are used to a lesser extent in other orchard and vineyard plantings. The methods and cost of weed control used in orchard and vineyard plantings, therefore, vary widely.

Approximately 2,800,000 acres of tree fruit and nut crops and grapes were grown commercially in 1959. The cost of weed control by all methods is estimated at $35 per acre for about 779,000 acres of citrus; $5 per acre for 1,700,000 acres of deciduous tree fruits; $10 per acre for 248,000 acres of tree nut crops; and $20 per acre for 89,000 acres of miscellaneous plantings including grapes. The total annual cost of control is about $40,043,000 (table 56). This is an estimated average annual cost of about $14 per acre for all tree fruit and nut crops and grapes.

Strawberries and Cranberries.—Intensive weed control practices are necessary in strawberries and cranberries because they are perennials. Winter and summer annual weeds must be controlled and many perennial broadleaf weeds and weed grasses are critical problems. The matted bed culture of strawberries limits mechanical cultivation to the first few weeks after establishment of new plantings to permit runner plant rooting. Thereafter, hand weeding or herbicides, or a combination of these weed control methods, are used. Use of herbicides does not eliminate—but does reduce—hand weeding or cultivation.

The matted growth of cranberries prevents mechanical cultivation of any kind after establishment. Mowing, flooding, and herbicides are used in combination to control weeds.

Approximately 96,000 acres of strawberries and 21,000 acres of cranberries were grown commercially in 1959. The cost of weed control by all methods and combinations of methods is estimated at $105 per acre for strawberries and $40 per acre for cranberries for a total annual cost of about $11,055,000 for these crops (table 56).

Ornamentals.—Weed control in commercial nurseries involves propagating beds, cold frames, liner plantings, and long-term field plantings. Propagating beds and cold frames are often treated with soil fumigants to control weeds. Liner plantings must be hand weeded at frequent intervals, and general field plantings must be cultivated frequently with supplemental hand weeding unless herbicides can be used. Selective herbicides are used on a number of these crops in combination with hand weeding and mechanical weeding methods.

Preemergence herbicide treatments are being used to control some weeds in bulb crops. They are supplemented by hand weeding and mechanical cultivation. Other miscellaneous ornamental crop plantings including cut flowers and flower seed crops are weeded by hand and mechanical methods.

Approximately 191,000 acres of ornamental and nursery crops were grown commercially in 1959. The cost of weed control by all methods and combinations of methods is estimated at $200 per acre for about 139,000 acres of nursery crops and $100 per acre for about 53,000 acres of bulb and miscellaneous ornamental crops for a total cost of about $33,045,000 for all of these crops (table 56). The average cost of weed control for ornamentals, based on these estimates, is about $173 per acre.

Hay crops, pastures, and rangelands

Cost of spraying for weed control on pastures in 1959 in the 33 States that provided estimates was about $2.40 per acre, or a total cost in those States of $5,789,000. If these figures are projected to include the eight additional States that did not give estimates but that have appreciable pasture acreages, the total cost of spraying for weed control in pastures would be nearly $7,200,000 (table 57) for the United States.

Estimates of costs of chemical controlling of brush and weeds on rangelands were furnished in 1959 by 13 of the 19 States having extensive rangeland acreage. The average cost per acre was about $3, or a total cost in those States of $6,174,000. If the acreages sprayed in six other States were included, the total costs of spraying would be about $7,800,000 (table 57).

In 1959, States gave estimates of the costs of spraying for weed control in hay crops. The

TABLE 57.—HAY CROPS, PASTURES, AND RANGELANDS: *Estimated cost of controlling weeds by chemical methods, 1959*

Commodity	Cost
	1,000 dollars
Hay crops	1,692
Pastures	7,200
Rangelands	7,800
Total	16,692

cost per acre was estimated to be about $6.25, or a total cost of $1,692,000 (table 57) for the acreage treated.

Thus, the total estimated cost of weed control on pastures and rangelands by use of herbicides in the United States was about $16,692,000 in 1959 (table 57).

Total cost of controlling weeds and brush in pasture and forage crops in the United States is not available because the extent of use for some of the methods of control is not known. The estimated annual cost of mowing, herbicides, grubbing, root plowing, chaining, controlled burning, clearing, cutting and burning, and bulldozing is $365,000,000 (table 54).

Hand grubbing of small brush plants such as mesquite, cactus, and other species is still practiced on a considerable acreage. The cost per acre varies with the number of plants per acre and their size. In one operation in New Mexico, costs were reported as 67 cents per acre for grubbing 25 plants per acre of mesquite having a crown spread of 36 inches or less. This left 16 larger mesquite plants per acre to control by more expensive methods. Therefore, the cost of removing all these trees would be more than double the 67 cents per acre.

"Root plowing" for control of brush is used extensively in the Southwest. Costs per acre in Texas were reported as $10 to $17 per acre. Cost of plowing sagebrush in the Western States is reported to vary from $3 to $4 per acre.

Chaining is also used for partial control of brush. Even aged juniper and other woody plants may be pulled down where terrain and freedom from obstructions permit. Cost of chaining varies with size of trees and terrain. A study in Texas gave costs of $2 to $3 per acre with $10 as the cost if the uprooted brush was raked into windrows. In Texas chaining did not kill much brush but gave enough control that a fair increase in grass production resulted.

Cost of sagebrush beating in the Western States is about $4 per acre, but data are not available on the acreage of rangeland treated in this way.

Cost of controlled burning used for control of chaparral, sagebrush, and some other types of brush vary greatly with area to be burned, size of standby crew required for safety, amount of preparation necessary for burning, and other variables. In California costs of burning ranged from $3.60 per acre for areas of about 50 acres to 40 cents for large areas up to 5,000 acres. Cost of burning sagebrush in Oregon was reported to be 45 cents per acre.

Clearing brush by cutting and burning the cut brush in Missouri cost $37 per acre. When the stumps were also sprayed with 2,4,5,-T in diesel fuel to prevent resprouting, the total cost was $43 per acre. Where the trees were allowed to remain standing and the base of the trunks sprayed with 2,4,5-T in diesel oil for control, the cost was $19 per acre. Use of heavy bulldozers for clearing and piling brush costs from $10 to $50 depending on size and density of the woody plant cover.

Aquatic and noncrop areas

Costs of weed control usually are considerably higher per unit of area in aquatic and noncrop areas than in cultivated crops and in pastures and rangelands. However, in most aquatic and noncrop areas the costs of weed control are much less than the losses caused by weeds in untreated areas. The estimated annual loss due to weeds in aquatic and noncrop areas is $55,637,000 (table 58).

Western Irrigation Systems.—Based on a survey conducted in 1957, the annual total cost of weed control for aquatic sites and ditchbanks in irrigation systems in the 17 Western States is approximately $8,113,000 (table 58). The cost per acre or per mile varies widely—from less than $10 to more than $400, depending on the chemical or mechanical method used. The average cost of weed control was $56.20 per mile of canal in 1957. The estimated annual saving through weed control was $15,860,000, or a net saving of approximately $7,747,000. In this instance, the ratio of losses caused by weeds to cost of weed control was nearly 2:1.

TABLE 58.—AQUATIC AND NONCROP AREAS: *Estimated annual cost of controlling weeds by cultural and chemical methods*

Location	Estimated annual cost
	1,000 dollars
Aquatic sites:	
Irrigation systems, 17 Western States	1,592
Farm ponds and reservoirs	5,496
Total	7,088
Ditchbanks:	
Irrigation systems, 17 Western States	6,521
Drainage ditches, 31 Eastern States	12,349
Total	18,870
Noncrop areas:	
Highway rights-of-way	19,415
Railroad rights-of-way	2,074
Fencelines	8,190
Total	29,679
Grand total	55,637

Eastern Drainage Ditches and Water Control Canals.—Costs of weed and brush control in drainage and water control canals of the 31 Eastern States ($12,349,000, table 58) are considerably higher than on irrigation systems of the West, but the proportion of canals and ditchbanks treated in Eastern States is considerably less. The estimated costs of control were $65 per mile of ditch or canal treated. No reliable estimates are available on the relative amount of weed losses prevented by weed control on drainage ditches and water control canals in Eastern States.

Farm Ponds and Reservoirs.—The development of effective, economical, and safe methods of controlling weeds in farm ponds and irrigation reservoirs has not progressed as far as the development of improved methods for weed control in canals and ditches. While chemical control of algae in ponds and reservoirs is a rather common practice, new methods of controlling submersed aquatic weeds have had only limited use. As a result the annual cost of weed control in ponds and reservoirs is only about $5,496,000 (table 58), which is about 20 percent as much as the estimated annual losses caused by weeds in ponds and reservoirs (table 45 of chapter 11).

Highway Rights-of-Way.—Costs of weed control on 3,000,000 miles of Federal, State, county, and township roads through rural areas total $97,074,000 annually. It is estimated that 80 percent of this cost is chargeable to highway safety and beautification; and 20 percent, or $19,415,000 (table 58), is chargeable to the protection of adjacent farms from weed infestation and other losses caused by weeds.

Railroad Rights-of-Way.—Actual costs of treating noxious weeds on railroad rights-of-way to protect adjacent farmland in 1961 were obtained from Idaho, Kansas, and Minnesota. By extrapolation of these figures, the total annual cost of controlling weeds on railroad rights-of-way was estimated at $2,074,000 (table 58). This represents 6.91 percent of the $30,000,000 total annual expenditure for vegetation control on railroads in the United States.

Fencelines.—Definite figures on the total cost of weed control in fencelines are not available. Average cost per acre was $8.83 for foliage sprays and $95.45 for soil sterilant treatments. On the basis of estimates from State weed supervisors and Extension weed specialists in different regions, the total annual cost of weed control in fencelines in the United States is approximately $8,190,000 (table 58).

Chapter 13.—Summary

A summary of the estimated annual losses to agricultural commodities from various hazards, the costs of controlling these losses, and the cost of various inspection and quarantine programs is given in table 59.

Losses during production to crops, due to diseases, air pollutants, nematodes, insects, weeds, fire, inefficient farm operations, and inadequate harvesting operations amount to $11,230,353,000. Loss to the honeybee industry due to insect pests is estimated at $500,000 annually. Fire, insects, diseases, and other causes reduce the value of forest trees and forest nurseries by $253,920,000 annually. The average losses to livestock, poultry, and their products during production amount to $2,787,414,000 each year. Therefore, the average annual loss to crops, forest trees and forest nurseries, and livestock, poultry and their products during production is estimated at $14,272,187,000 (table 59).

After the crops and livestock are produced, they are subject to losses in storage, marketing, and processing. During storage of crops, insects and other causes reduce the value by $1,042,063,000. Losses during transit and unloading of fruits and vegetables are estimated at $121,793,000 and the losses to these two commodities in retail stores is estimated at $67,841,000 annually. Thus, the losses for fruits and vegetables during various marketing stages are $189,634,000. The losses of animal and livestock products because of condemnations during inspection amount to $60,302,000 annually. Average annual losses to field, fruit, and vegetable crops during processing is estimated at $85,131,000. During the marketing and processing of poultry and poultry products the estimated annual loss is $77,644,000. Values for losses in forest products are estimated at $825,000,000 annually. The total loss during storage, marketing, and processing of agricultural commodities and forest products is estimated at $2,279,774,000.

Soil-deterioration losses and flood damage on croplands, ranges, and watersheds amount to an estimated $2,956,329,000 annually. Water losses through irrigation, evapotranspiration, and aquatic weeds (including some loss due to weeds on noncropped areas) are estimated at $918,730,000.

The losses resulting from weeds in fencelines and damage to canals, structures, and farms are estimated at $2,760,000.

The total cost of controlling losses in agricultural commodities and forests and forest nurseries, and the cost of the State and Federal inspection and quarantine programs amounts $3,849,688,000 annually.

TABLE 59.—SUMMARY: *Estimated average annual losses to agricultural commodities from various hazards, and cost of controlling these losses and of inspection and quarantine programs, 1951–60*

Kind of loss and control programs	Loss in value	Cost of control
	1,000 dollars	*1,000 dollars*
CROPS, PASTURE AND RANGE PLANTS, AND LIVESTOCK LOSSES:		
During production:		
Diseases of crops and pasture and range plants	3,251,114	115,800
Loss to crops from air pollutants	325,000	--------
Nematode damage	372,335	16,000
Injurious insects	3,312,906	[1] 425,000
Loss to honeybee industry by insect pests	500	--------
Weeds in crops and pasture and range plants	2,459,630	2,551,050
Fire and inefficient farm operations	510,887	--------
Forest trees and nurseries	253,920	91,200
Losses during harvesting of crops	998,481	--------
Livestock, poultry, and their products:		
Infectious and noninfectious diseases and nutritional disorders	1,569,358	--------
Internal parasites	340,206	--------
Insect pests	877,850	(1)
Total	14,272,187	--------
After production:		
During storage (due to insects and other than insects)	1,042,063	279,302
During marketing of fruits and vegetables and losses in retail stores	189,634	--------
Meat and poultry condemnations	60,302	--------
During processing of field, fruit, and vegetable crops	85,131	--------
Marketing and processing losses in poultry and poultry products	77,644	--------
Forest products	825,000	--------
Total	2,279,774	--------
SOIL AND WATER LOSSES:		
Losses to erosion and water	2,956,329	[2] 238,080
Water losses due to—		
Irrigation	665,000	--------
Evaportranspiration	204,000	--------
Aquatic weeds	[3] 49,730	[4] 55,637
Total	3,875,059	--------
Losses caused by weeds in fencelines and damage to canals, structures, and farms	2,760	--------
CONTROL PROGRAMS:		
Animal-disease eradication programs	---------	47,578
Animal inspection and quarantine programs	---------	1,358
Cooperative plant pest control programs	---------	24,521
Plant quarantine and regulatory programs	---------	4,162
Total	---------	3,849,688

1 Includes cost of controlling insects affecting crops, man, animals, and households.

2 Estimated average annual cost of controlling erosion in 17 Western States, 1951–60.

3 The value of irrigation water used in computing the loss was $2.09 per acre-foot instead of the value of $20 per acre-foot given by Wollman and others (ch. 12, footnote 11). On this basis, the estimated loss would be $39,332,700 instead of $4,110,000 as given in table 43.

4 Includes cost of controlling weeds in fencelines, canals, structures, and farms.

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