Twelfth Edition

Scientific Farm Animal Production

An Introduction to Animal Science

Tom G. Field

SCIENTIFIC FARM ANIMAL PRODUCTION

AN INTRODUCTION TO ANIMAL SCIENCE

TWELFTH EDITION

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University of Nebraska

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This book is inspired by the men and women who make their living from the land and from applying not only the principles of science but the art of husbandry to their role as stewards of land, livestock, and communities. In the midst of the virtual age, there are those who turn their backs on the powerful visceral experience that characterizes agricultural endeavors across the globe but there are no more worthy caretakers of culture and humanity than those who spend their lives feeding others. I am honored to offer this work to the use of the next generation of people who find their calling in production agriculture. The book is offered as a resource to those who daily invest their time, energy, and talent into the process of improving animal agriculture in the hope that one day humanity might be free of hunger.

This work is dedicated to the greatest blessings in my life – my wife Laura and children Justin, Sean, Trae, Kate, and Coleman who have contributed their talent and support in its creation.

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Preface

Scientific Farm Animal Production is distinguished by an appropriate coverage of both breadth and depth of livestock and poultry production and their respective industries. The book gives an overview of the biological principles applicable to the animal sciences with chapters on reproduction, genetics, nutrition, lactation, consumer products, and other subjects. The book also covers the breeding, feeding, and management of beef cattle, dairy cattle, horses, sheep and goats, swine, and poultry. Although books have been written on each of these separate topics, the author has highlighted the significant biological principles, scientific relationships, and management practices in a condensed but informative manner.

Target Audience

This book is designed as a text for the introductory animal science course typically taught at universities and community colleges. It is also a valuable reference book for livestock producers, vocational agriculture instructors, and others desiring an overview of livestock production principles and management. The book is appropriate for the urban student with limited livestock experience, yet challenging for the student who has a livestock production background.

Key Features

Chapters 1 through 9 cover animal enterprises and products; Chapters 10 through 22 discuss the biological principles that are utilized to improve livestock and poultry production and the issues facing animal agriculture; while livestock and poultry management systems are presented in Chapters 23 through 34.

The glossary of terms used throughout the book has been expanded so that students can readily become familiar with animal science terminology. Many of the **Key Terms** in the text are included in the glossary. Additionally, key words are provided at the end of each chapter as an aid to student learning.

Photographs and figures are used throughout the book to communicate key points and major relationships. The visual aspects of the text should help students expand their global and macro view of the livestock industry as well as better understanding how theory is put into practice.

At the end of each chapter, a set of questions are provided that are designed to facilitate an in-depth understanding of the material. Students are encouraged to utilize the questions to assist them in making connections between concepts and to better integrate relationships to allow for not only listing the facts but creating a framework for the application of knowledge.

New to This Edition

This text continues to blend the various disciplines of science with contemporary management practices and industry trends to build a cohesive discussion of animal agriculture. The following improvements have been made to this edition:

- The input of reviewers was utilized to assure accuracy, clarity, and effective delivery of material.
- Demographic, industry data, and consumer trends have been updated.
- Photos and illustrations have been upgraded to enhance the reader experience.
- Management chapters have been revised to reflect the most current protocols and technologies used by the industry.
- More attention has been given to the issues and challenges confronting the livestock and poultry industry.
- Significant revision has been accomplished to provide a comprehensive but more clear communication of science based principles and relationships.
- Financial and enterprise-based cost and return data has been integrated to facilitate better understanding of the economic consequences of management decisions.
- The text effectively balances science and practice as it applies to the livestock and poultry industry.

Instructor's Resources

Instructor's Manual with Test Bank. Includes content outlines for classroom discussion, teaching suggestions, and answers to selected end-of-chapter questions from the text. This also contains a Word document version of the test bank.

TestGen. This computerized test generation system gives you maximum flexibility in creating and administering tests on paper, electronically, or online. It provides state-of-the-art features for viewing and editing test bank questions, dragging a selected question into a test you are creating, and printing sleek, formatted tests in a variety of layouts. Select test items from test banks included with TestGen for quick test creation, or write your own questions from scratch. TestGen's random generator provides the option to display different text or calculated number values each time questions are used.

PowerPoint Presentations. Our presentations offer clear, straightforward. Photos, illustrations, charts, and tables from the book are included in the presentations when applicable. To access supplementary materials online, instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc, where you can register for an instructor access code. Within 48 hours after registering, you will receive a confirming email, including an instructor access code. Once you have received your code, go to the site and log on for full instructions on downloading the materials you wish to use.

Alternate Versions

eBooks. This text is also available in multiple eBook formats. These are an exciting new choice for students looking to save money. As an alternative to purchasing the printed textbook, students can purchase an electronic version of the same content. With an eTextbook, students can search the text, make notes online, print out reading assignments that incorporate lecture notes, and bookmark important passages for later review. For more information, visit your favorite online eBook reseller or visit www.mypearsonstore.com.

About the Author

Dr. Thomas G. Field serves as the Director of the Engler Agribusiness Entrepreneurship Program and holder of the Engler Chair in Agribusiness Entrepreneurship at the University of Nebraska–Lincoln.

He is also a noted agricultural author and a frequent speaker at agricultural events in the United States and abroad. He has consulted with a number of agricultural enterprises and organizations, and has served on numerous boards related to education, agriculture, and athletics. He is the co-owner of Field Land and Cattle Company, LLC in Colorado.

Dr. Field was raised on a Colorado cow–calf and seedstock enterprise. He managed a seedstock herd of cattle after completing his B.S. degree. A competitive horseman as a youth, he has had practical experience with seedstock cattle, commercial cow–calf production, stockers, and horses. He has a B.S., M.S., and Ph.D. in animal science from Colorado State University.

Dr. Field has received teaching awards from the USDA National Excellence in Teaching program, the National Association of Colleges and Teachers of Agriculture, the American Society of Animal Sciences, Colorado State University, and the University of Nebraska.

He is married to Laura and father to Justin, Sean, Trae, Kate, and Coleman.

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Animal Contributions to Human Needs

INTRODUCTION

In many ways the history of civilization is told in the application of human creativity to the task of feeding, clothing, and raising the standard of living for the world's various societies via animal agriculture. Over the ages, the relationship between humans and domesticated animals have shaped history, impacted economies, altered the outcomes of war, sped the exploration and settlement of new territories, revolutionized agriculture and transportation, provided entertainment through sport, and etched itself into nearly every aspect of civilization. For example, the domestication of horses transformed the range of land movement for human beings. And with the stability that agriculture provided human communities came time for intellectual and cultural pursuits. Livestock have been incorporated into the telling of the human story through expression in the form of art, literature, and music.

Domestication of livestock depends on the animal reproducing within the management decisions of human beings and the creation of a complex mutually beneficial relationship founded on the ancient concept of the good shepherd. This "contract" offers the animal protection from predators and a more consistent supply of nutrients, to name a few of the benefits, in exchange for food, fiber, draft power, and companionship as contributions to the well-being of humans. This relationship in which domesticated species and humans seem to have chosen each other is still the basis for sound management and husbandry of livestock and has allowed domesticated animals far greater survival rates than those in the wild. The timeline of livestock and poultry domestication provides context for the relationship between humans and animals of agricultural importance (**Fig. 1–1**).

Table 1–1 outlines the major domesticated livestock species, their approximate numbers, and their primary uses. Chickens are the most numerous (22.8 billion), followed by cattle (1.49 billion), sheep (1.2 billion), ducks (1.1 billion), and swine (967 million).

Learning objectives

1. Describe the global distribution of livestock.
2. Quantify the role of animal products in the global food supply.
3. Evaluate differences in food production and agricultural productivity between developed and developing nations.
4. Compare food expenditures for at-home and away-from-home consumption in the United States.
5. Compare food consumption across diverse nations and cultures.
6. Describe changes in the U.S. agricultural productivity.
7. Describe the nonfood contributions of livestock.

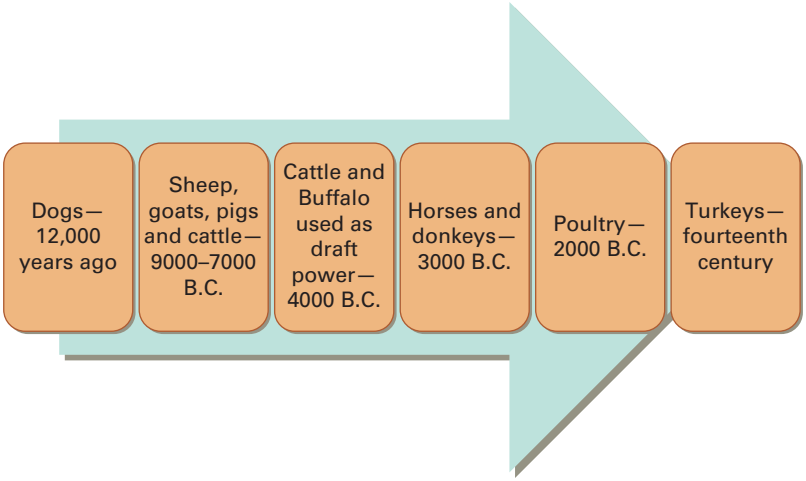


Figure 1–1
Timeline for the domestication of livestock and poultry.

Table 1–1
MAJOR DOMESTICATED ANIMAL SPECIES—THEIR NUMBERS AND USES IN THE WORLD

Animal Species	World Numbers (mil)	Leading Countries or Areas with Numbers[a] (mil)	Primary Uses
Ruminants			
Cattle	1,491	Brazil (215), India (185), United States (94), China (83), Ethiopia (61)	Meat, milk, hides
Sheep	1,202	China (161), Australia (72), India (63), Nigeria (42), Sudan (40)	Wool, meat, milk, hides
Goats	1,034	China (142), India (130), Nigeria (78), Pakistan (72), Bangladesh (60)	Milk, meat, hair, hides
Buffalo	200	India (113), Pakistan (37), China (23)	Draft, milk, meat, hides
Camels	35	Chad (7), Somalia (7), Sudan (5)	Packing, transport, draft, meat, milk, hides
Nonruminants			
Chickens	22,847	China (4,877), Indonesia (2,275), United States (1,971), Brazil (1,426), Iran (1,030)	Meat, eggs, feathers
Swine	967	China (435), United States (73), Brazil (41), Spain (30), Germany (27)	Meat
Turkeys	459	United States (248), Brazil (33), Chile (26), Italy (25), France (19)	Meat, eggs, feathers
Ducks	1,150	China (713), Vietnam (75), Bangladesh (54), Indonesia (50), Russian Federation (49)	Meat, eggs, feathers
Horses	60	United States (10), Mexico (6), China (5.5), Brazil (5), Mongolia (4)	Draft, riding, sport, occasionally meat
Donkeys and Mules	55	Ethiopia (9), China (6), Mexico (7), Pakistan (5)	Draft, transport

Source: Adapted from USDA and FAO.

CONTRIBUTIONS TO FOOD NEEDS

When opportunity exists, most humans consume both plant and animal products (**Fig. 1–2**).

The contribution of animal products to the per-capita calorie and protein supply in food is shown in **Figure 1–3**. Animal products constitute approximately 18% of the calories, 40% of the protein, and 45% of the fat in the total world food supply. Large differences exist between developed countries and developing countries in total daily supply of calories, protein, and fat.

For example, consumers in developed nations derive 26% of their calories from animal products with just over one-half of their total protein and fat supply from animal products. Consumers in developing nations derive 8% of their calorie supply,

Figure 1–2

Meat, milk, and eggs are nutrient dense foods that meet the needs of both domestic and global consumers. The livestock industry and food supply chain must align with consumer demand to assure continuation of a successful business model. Source: Milles Studio/Fotolia.

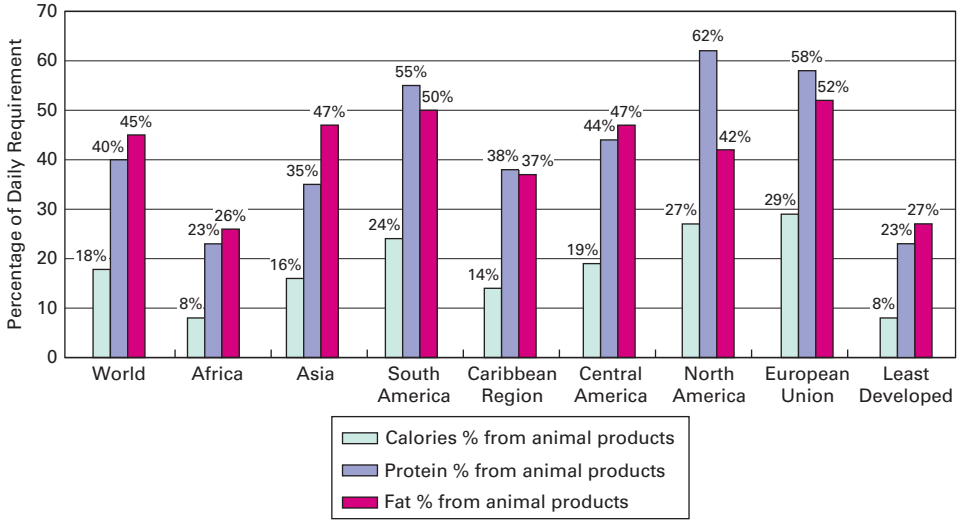


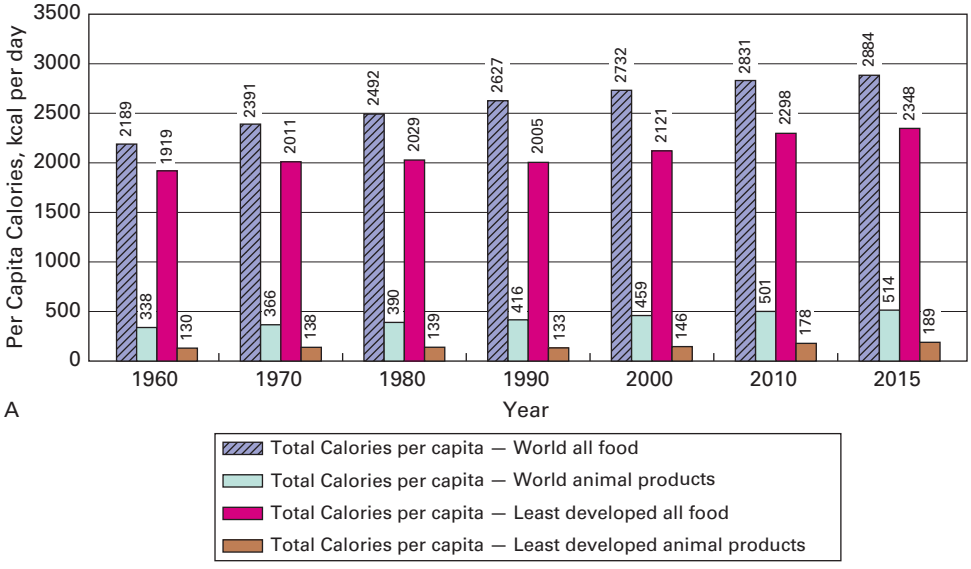
Figure 1–3

Caloric, protein, and fat intake from animal products. Source: Adapted from USDA and FAO.

23% of their protein, and 27% of their fat from animal products. The United States ranks higher than the world average for percent of calories and protein from animal sources but about average for percent of fat from animal products.

Changes in **per-capita calorie supply** and protein supply during the past 55 years are shown in **Figure 1–4a** and **b**. Per-capita caloric supplies of both calories and protein have increased in most areas of the world. The contribution of animal products to the **per-capita protein supply** has increased in most of the world. The large differences among countries in the importance of animal products in their food supply can be partially explained by available resources and development of those resources.

The percent of population involved in production agriculture varies dramatically when comparing regional and national data (**Fig. 1–5**). Least developed nations have a significantly higher proportion of their population making a living from farming. Countries with only a small percentage of their population involved in agriculture have higher standards of living and a higher per-capita consumption of animal products than their peer nations with lower economic performance.



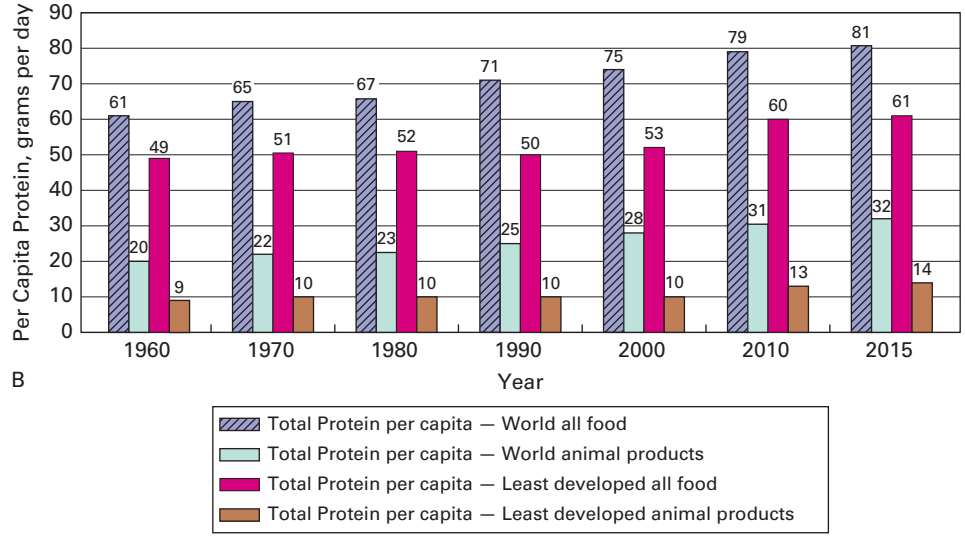


Figure 1–4

Comparison of average per capita supply of total calories (a) and protein (b) for the world and least developed economies.

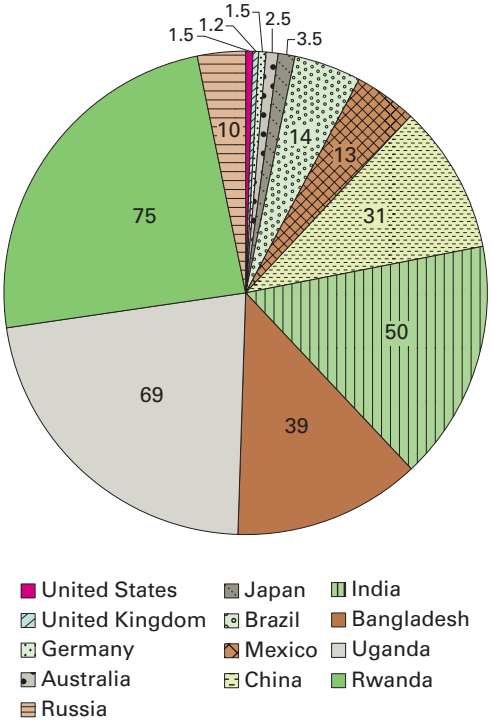


Figure 1–5

Percentage of population employed in production agriculture.

Agriculture **mechanization** (**Fig. 1–6**) has been largely responsible for increased food production and allowing people to turn their attention to professions other than production agriculture. This facilitates the provision of many goods and services, raises standards of living, and allows for the creation of more diverse economies. Note that 50% of the people in developing nations are engaged in agriculture while only 7% of the citizens in developed countries are active in the agricultural sector.

The tremendous increase in the productivity of U.S. agriculture (**Table 1–2**) has lowered the relative cost of food as vividly demonstrated in **Table 1–3**. Historical data show that agricultural productivity doubled in the 100-year span of 1820–1920. For example, at the turn of the century a team of horses, one handler, and a moldboard plow could plow 2 acres per day. Today, one tractor pulling three plows, each with five moldboards, plows 110 acres per day, accomplishing the work that once required 110 horses and 55 workers.

Livestock productivity since 1925 has progressively increased to extraordinary levels. The mix of animal enterprises on U.S. farms has shifted from a typical situation involving a vast number of species being raised on an average farm in the 1920s to contemporary scenarios where animal agriculture is considerably more specialized. These improvements in productivity have occurred primarily because people had an incentive to progress under a free-enterprise system.

Figure 1–6

The mechanization of agriculture has enabled a relatively small proportion of the human population to provide for a growing world market. Source: Tom Field.

Table 1–2
PRODUCTIVITY CHANGES IN SEVERAL FARM ANIMAL SPECIES IN THE UNITED STATES

Species and Measure of Productivity	1925	1950	1975	2000	2016
Beef cattle— Average liveweight at finishing (lb)	955	976	1,039	1,210	1,365
Sheep— Average liveweight at finishing (lb)	86	94	102	133	137
Dairy Cattle— Milk marketed per breeding female (lb)	4,189	5,313	10,500	17,192	22,774
Swine— Average liveweight at finishing (lb)	235	243	245	259	282
Broiler chickens[a, b]— Liveweight at marketing (lb)	2.8	3.1	3.8	5.0	6.2
Turkeys[a, b]— Liveweight at marketing (lb)	13.0	18.6	18.4	25.8	30.7
Laying hens[a]— Eggs per hen per year (no.)	112	174	232	257	279

[a]Feed required per lb of weight gain or per dozen eggs was reduced by more than half over the same time period.
[b]Time to market was reduced by more than half over the same time period.
Source: Adapted from USDA Annual Agricultural Statistics.

Table 1–3
EXPENDITURES FOR FOOD IN THE UNITED STATES (GROSS DOLLARS AND AS PERCENT OF PERSONAL DISPOSABLE INCOME)

	At Home		Away from Home		Total	
Year	($ bil)	(%)	($ bil)	(%)	($ bil)	(%)
1930	15.8	21	2.3	3	18.1	24
1940	13.5	18	2.4	3	15.9	21
1950	35.7	17	7.6	4	43.3	21
1960	51.5	14	12.6	3	64.0	17
1970	75.5	10	26.4	4	102.0	14
1980	180.8	9	85.2	4	266.0	13
1990	314.5	7	175.2	4	489.6	11
2000	431.6	6	292.9	4	724.4	10
2010	622.3	6	454.9	4	1,077.2	9.9
2015	714.1	6	804.6	4	1,518.	10
2017	747.8	5	869.3	5	1,617.1	10

Source: USDA.

In the United States, releasing people from producing their own food has given them the opportunity to improve their per-capita incomes. Increased per-capita income associated with an abundance of animal products has resulted in reduced relative costs of many animal products with time. Consumers in developed economies allocate a smaller share of their disposable income for food than do people in many other countries. For example, per-capita expenditures for food as a percent of household expenses in the United Kingdom, Canada, and Australia are 8%, 9%, and 10%, respectively. In poorer economies such as Nigeria, Kazakhstan, and Guatemala, 56%, 43%, and 41% of income is spent on food.

Table 1–4 shows that cereal grains are the most important source of energy in world diets. The energy derived from cereal grains, however, is twice as important in developing countries (as a group; there are exceptions) as in developed countries. Table 1–4 also illustrates that meat and

Table 1–4
CONTRIBUTIONS OF VARIOUS FOOD GROUPS TO THE WORLD FOOD SUPPLY

Food Group	Calories (%)	Protein (%)
Cereals	50	45
Roots, tubers, pulses	8	7
Nuts, oils, vegetable fats	11	4
Sugar and sugar products	8	2
Vegetables and fruits	7	5
All animal products	16	37
Meat	7	16
Eggs	1	3
Fish	1	7
Milk and dairy	5	10
Other	2	1

Source: Adapted from USDA and FAO.

milk are the major animal products contributing to the world supply of calories and protein.

Most of the world meat supply comes from cattle, swine, sheep, goats, chickens, and turkeys. There are, however, 20 or more additional species that collectively contribute about 6.5 billion pounds of edible protein per year or approximately 10% of the estimated total protein from all meats. These include the alpaca, llama, yak, horse, deer, elk, antelope, kangaroo, rabbit, guinea pig, capybara, fowl other than chicken (duck, turkey, goose, guinea fowl, pigeon), and wild game exclusive of birds. For example, the Russian Federation cans more than 110 million pounds of reindeer meat per year, and in Germany the annual per-capita consumption of venison exceeds 3 pounds. Peru derives more than 5% of its meat from the guinea pig.

Meat is important as a food for two scientifically based reasons. The first is that the assortment of amino acids in animal protein more closely matches the needs of the human body than does the assortment of amino acids in plant protein. The second is that vitamin B12, which is required in human nutrition, may be obtained in adequate quantities from consumption of meat or other animal products but not from consumption of plants.

Milk is one of the largest single sources of food from animals. In the United States, 99% of the milk supply comes from cattle, but on a worldwide basis, milk from other species is important. Domestic buffalo, sheep, goat, alpaca, camel, reindeer, and yak supply significant amounts of milk in some countries. Milk and products made from milk contribute protein, energy, vitamins, and minerals for humans.

Besides the nutritional advantages, a major reason for human use of animals for food is that most countries have land areas unsuitable for growing cultivated crops. Approximately two-thirds of the world's agricultural land is permanent pasture, range, and meadow; of this, about 60% is unsuitable for producing cultivated crops that would be consumed directly by humans. This land, however, can produce feed in the form of grass and other vegetation that is digestible by grazing ruminant animals, the most important of which are cattle and sheep (**Fig. 1–7**). These animals can harvest and convert the vegetation, which is for the most part indigestible by humans, to high-quality protein food. In the United States, about 385 million acres of rangeland and forest, representing 44% of the total land area, are used for grazing. Although this acreage now supports only about 40% of the total cattle population, it could carry twice this amount if developed and managed intensively.

Ruminant **animal agriculture** therefore does not compete with human use for production of most land used as permanent pasture, range, and meadow. On the contrary, the use of animals as intermediaries provides a means by which land that is otherwise unproductive for humans can be made productive (**Fig. 1–8**).

People are concerned about energy, protein, population pressures (**Fig. 1–9**), and land resources as they relate to animal agriculture. Quantities of energy and protein present in foods from animals are smaller than quantities consumed by animals in their feed because animals are inefficient in the ratio of nutrients used to nutrients produced. More acres of cropland are required per person for diets high in foods from animals than for diets including only plant products. As a consequence, animal agriculture has been criticized for wasting food and land resources that could otherwise be used to provide persons with adequate diets. Consideration must be given to economic systems and consumer preferences to understand why agriculture perpetuates what critics perceive as resource-inefficient practices. These practices relate primarily to providing food-producing animals with

A B C D

Figure 1–7

Ruminant animals produce food for humans by utilizing grass, crop residues, and other forages from land that cannot produce crops to be consumed directly by humans. (a) Cattle grazing stubble in New South Wales, Australia. (b) Cattle grazing hillsides in Georgia. (c) Cattle grazing native range in Arizona. (d) Sheep grazing native range. Source: (a–c): Tom Field; (d): Dalajlama/Fotolia.

feed that could be eaten by humans and using land resources to produce crops specifically for animals instead of producing crops that could be consumed by humans.

Hunger continues to be a challenge in some regions of the world. The factors that contribute to the hunger problem are varied and complex. Hunger takes two forms—chronic persistent hunger and famine. **Chronic persistent hunger (CPH)** results from a combination of poverty, climatic change, political instability, water shortages, loss of soil fertility, poor infrastructure (transportation, storage facilities, banking services, etc.), and illiteracy. Note that food scarcity is not a significant contributing factor to CPH. In fact, global food production has exceeded the population growth rate. **Famine**, unlike CPH, is typically a relatively short period of crisis resulting from the breakdown in food production and distribution infrastructure resulting from catastrophic events such as hurricanes, drought, or civil war. The international community is relatively adept at reacting to and minimizing the effects of famine.

The International Food Policy Research Institute suggests that while the number of malnourished children will decline from 1993 to 2020, there will still be 150 million babies and toddlers who will be insufficiently fed in 2020. An additional 500 million people will also suffer from hunger. Africa, Latin America, the Caribbean, and West Asia are the regions most likely to bear the brunt of the problem in the future. Of the 11 countries with daily per-capita consumption of less than 2,000 calories, 10 of these are located in Africa.

Per-capita food availability is estimated to increase by nearly 7% by 2020, with China and East Asia experiencing the greatest increase. Evidence

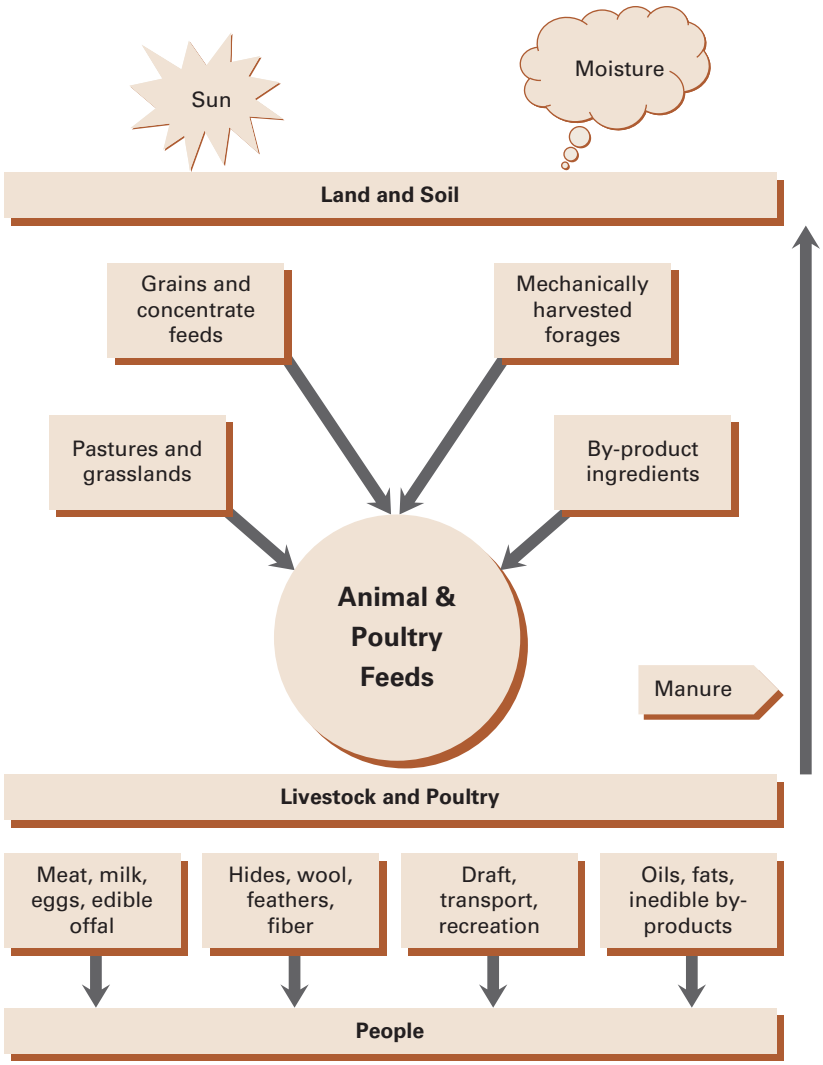


Figure 1–8
A graphic illustration of the land-plant-ruminant-animal-human relationship.

of a decline in global population increases is becoming apparent. However, slowing population increases is a gradual process, and for the next several decades approximately 80 million people will be added to the global population annually. Over 90% of this increase will occur in developing nations in or near urban areas. The 70 most susceptible countries to the effects of hunger are also the world's poorest nations. Sub-Saharan African nations have a per-capita income of approximately $380 per year.

Conquering hunger in developing nations involves a multifaceted strategy that includes increasing literacy rates, particularly in women; reducing poverty; improving health care; enhancing agricultural production; and improving the total food system infrastructure. As the demand for food increases, some regions of the world will become more import-dependent while others will become more export-focused.

Even developed nations are not immune to the effects of hunger for part of the population. For example, 88% of U.S. households are categorized as **food secure**, meaning all members of the household have access to enough food for a healthy lifestyle and sufficient financial resources to acquire food, as it is needed. Households deemed **food insecure** (12%) are further divided into categories of without hunger (7%) or with hunger (5%). Food insecure households without hunger are able to gain access to groceries via food assistance programs or community outreach programs. Fortunately, only 0.7% of children in the United States live in very low food insecure

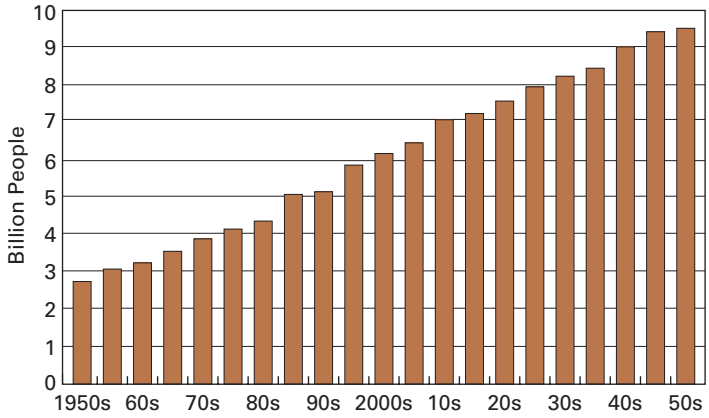


Figure 1–9

Past, present, and projected world population. Source: U.S. Census Bureau.

environments coupled with periods of hunger. Despite these low numbers, the impact of hunger is still significant. Those households considered food insecure typically have incomes below the poverty line of $19,000, and are comprised of single adults or single parents with children.

There will be annual demand increases of 1–1.5% for cereal grains, while worldwide demand for meat is expected to approach 2% per annum. Demand for meat will increase at the highest rate in developing countries (approximately 3%) with developed nations only accounting for less than 1% of annual demand growth. In the final analysis, the ability to pay will dictate food distribution. The need for economic growth in developing regions is of paramount importance.

Agriculture producers generate what consumers want to eat as reflected in the prices consumers are able and willing to pay. Nearly 90% of the world's population desires food of animal origin in its diets, perhaps because foods of animal origin are considered more palatable than foods from plants. In most countries, as per-capita income rises, consumers tend to increase their consumption of meat and animal products.

If many consumers in countries where animal products are consumed at a high rate were to decide to eat only food of plant origin, consumption and price of foods from plants would increase, and consumption and price of foods from animals would decrease. Agriculture would then adjust to produce greater quantities of food from plants and lesser quantities of food from animals. Ruminant animals can produce large amounts of meat without grain feeding. The amount of grain feeding in the future will be determined by cost of grain and the price consumers are willing to pay for meat.

Some people advocate shifting from the consumption of foods from animals to foods from plants. They see this primarily as a moral issue, believing it is unethical to let people elsewhere in the world starve when our own food needs could be met by eating foods from plants rather than feeding plants to animals. The balance of plant-derived foods could then be sent abroad. These people believe that grain can be shipped with comparative ease because a surplus of grain exists in many developed nations and because any surplus should be provided at no cost. Providing free food to other countries has met with limited success in the past. In some situations, it upsets their own agricultural production, and in many cases the food cannot be adequately distributed in the recipient country because transportation and marketing systems are poorly developed.

There are strong feelings that the United States has a moral obligation to share its abundance with other people in the world, particularly those in developing countries. It appears that sharing our time and technology can best do this. However, people need to have self-motivation to improve, access to knowledge and appropriate technology, and sufficient resources to develop agricultural productivity and infrastructure aligned to their own cultural values.

Advances in agricultural production and related topics must be shared to minimize the effects of hunger on civilization. These achievements have been built on knowledge gained through experience and research, the extension of knowledge to producers, and the development

of an industry to provide transportation, processing, and marketing in addition to production. Dwindling dollars currently being spent to support agricultural research and extension of knowledge may not provide the technology needed for future food demands. The next generation of agricultural leaders should view the decline in resources allocated to agricultural research, extension, and education as an emerging crisis.

About 20% of the world human population and 32% of the ruminant animal population live in developed regions of the world, but ruminants of these same regions produce two-thirds of the world's meat and 80% of the world's milk. In developed regions, a higher percentage of animals are used as food producers, and these animals are more productive on a per-animal basis than animals in developing regions. This is the primary reason for the higher level of human nutrition in developed countries of the world.

Possibly many developing regions of the world could achieve levels of plant and animal food productivity similar to those of developed regions. Except perhaps in India, abundant world supplies of animal feed resources that do not compete with production of food for people are available to support expansion of animal populations and production. It has been estimated that through changes in resource allocation, an additional 8 billion acres of arable land (twice what is now being used) and 9.2 billion acres of permanent pasture and meadow (23% more than is now being used) could be put into production in the world. These estimates, plus the potential increase in productivity per acre and per animal in developed countries, demonstrate the magnitude of world food-production potential. This potential cannot be realized, however, without coordinated planning and increased incentive to individual producers.

Fortunately, progress can be made in reducing hunger on both a global and regional scale. In 2005, 14.5% of the world's population was susceptible to hunger; by 2017, that number had been reduced to 10.9%. Regional examples include Asia reducing hunger (percent of population consuming less than 2,100 calories per day) by 30% in the 10-year period from 1994 to 2004. During the same time, Bangladesh reduced the number of hungry people by 70% by making significant strides in food production and distribution. This is particularly impressive given that Bangladesh was once considered the epicenter of famine and chronic persistent hunger. Interestingly, significant changes in governmental policy focused not only on increasing food production but also on enhancing exports as a means to infuse foreign exchange into the economy. Furthermore, government policy focused on private-sector investment in irrigation systems, seeds, and fertilizer to stimulate food production. These policies increased irrigated acreage by 50% from 1994 to 2004.

In the long run, each nation must assume the responsibility of producing its own food supply by efficient production, barter, or purchase and by keeping future food-production technology ahead of population increases and demand. Extensive untapped resources that can greatly enhance food production exist throughout the world, including an ample supply of animal products. The greatest resource is the human being, who can, through self-motivation, become more productive and self-reliant.

CONTRIBUTIONS TO CLOTHING AND OTHER NONFOOD PRODUCTS

Products other than food from ruminants include wool, hair, hides, and pelts. Synthetic materials have made significant inroads into markets for these products. For example, the world's production of wool peaked in 1990 but since has declined to 40-year lows. It is important to note that in more than 100 countries, ruminant fibers are used in domestic production and cottage industries for clothing, bedding, housing, and carpets.

Annual production of animal wastes from ruminants contains millions of tons of nitrogen, phosphorus, and potassium. The annual value of these wastes for fertilizer is estimated at more than $1 billion.

Inedible tallow and greases are animal **by-products** used primarily in soaps and animal feeds and as sources of fatty acids for lubricants and industrial use. Additional tallow and grease by-products are used in the manufacture of pharmaceuticals, candles, cosmetics, leather goods, woolen fabrics, and tin plating. The individual fatty acids can be used to produce synthetic rubber, food emulsifiers, plasticizers, floor waxes, candles, paints, varnishes, printing inks, and pharmaceuticals.

Gelatin is obtained from hides, skins, and bones and can be used in foods, films, and glues. Collagen, obtained primarily from hides, is used to make sausage casings.

CONTRIBUTIONS TO WORK AND POWER NEEDS

The early history of the developed world abounds with examples of the importance of animals as a source of work energy through draft work, packing, and human transport. The horse made significant contributions to winning wars and exploration of the unknown regions of the world.

A

B

Figure 1–10

Animals provide significant contributions to the draft and transportation needs of countries lacking mechanization in their agricultural technology. In developed countries, the use of draft animals is more oriented to recreation than necessity. (a) Donkey pulling a cart as an example of draft power. (b) Carriage horses provide a leisurely experience that harkens to times before widespread mechanization. Source: (a): Africa/Fotolia; (b): Pink candy/Fotolia.

In the United States during the 1920s, approximately 25 million horses and mules were used primarily for **draft purposes**. The tractor has replaced all but a few of these draft animals. In parts of the developing world, however, animals provide as much as 99% of the power for agriculture even today.

In more than half the countries of the world, animals—mostly buffalo and cattle, but also horses, mules, camels, and llamas—are kept primarily for work and draft purposes (**Fig. 1–10**). Approximately 20% of the world's human population depends largely or entirely on animals for moving goods. According to the Food and Agriculture Organization of the United Nations, in developing countries, animals provide 52% of the cultivation power, with an additional 26% derived from human labor. Developed countries, in contrast, use tractors for 82% of the cultivation, with animals and humans providing 11% and 7% of the power, respectively. There are more than three times as many tractors and harvesting machines and twice as many milking machines in use in developed nations as compared to developing countries. It is estimated that India alone would have to spend more than $1 billion annually for gasoline to replace the animal energy it uses in agriculture.

ANIMALS FOR COMPANIONSHIP, RECREATION, AND CREATIVITY

Estimates of the number of **companion animals** in the world are unavailable. There are an estimated 69 million family-owned dogs and 76 million family-owned cats in the United States, in addition to the animals identified in Table 1–1. Approximately one-third of all U.S. households have at least one pet dog or cat. The U.S. pet food industry annually processes more than 3 million tons of cat and dog food valued at more than $1 billion. Many species of animals would qualify as companions where people derive pleasure from them. The contribution of animals as companions, especially to the young and elderly, is meaningful, even though it is difficult to quantify the emotional value.

Animals used in rodeos, equestrian sports, livestock shows, and other venues provide income for thousands of people and recreational entertainment for millions (**Fig. 1–11**). Numerous people who have made money from nonagricultural businesses have invested in land and animals for recreational and emotional fulfillment.

Figure 1–11

(a) Many people enjoy the sport of horse racing. (b) Hunter jumpers are a key attraction in many equine shows and competitions. (c) Horse showing is a popular sport with increasing participation on the amateur and professional levels. (d) Horseback experiences provide high-quality recreational experiences for many. (e) Polo is an action-packed sport enjoyed by many. (f) Horses still play an integral role on many ranches. Source: (a) Donna/Fotolia; (b) Kseniya Abramova/Fotolia; (c) JJAVA/Fotolia; (d) Yanlev/Fotolia; (e) MrSegui/Fotolia; (f) PROMA/Fotolia.

A

B

C

D

E

F

Our livestock heritage involves the interactions of humans with animals over the centuries. Historically, animals have been highly respected, revered, and even worshiped by humans. Early humans expressed the sacred, mysterious qualities of some animals through art on cave walls between 15,000 and 30,000 B.C. Thus, through these early paintings and sculptures, animals found their way into an expression of the things of humans—the humanities. Several historians have noted that an extremely high form of art is the intelligent manipulation of animal life—the modeling and molding of different types through the application of breeding principles.

ADDITIONAL ANIMAL CONTRIBUTIONS

The use of livestock species in human health research is also of significance. Most human health research involving livestock is focused on smaller animals such as miniature pigs, swine, and sheep. Biomedical research using these species has focused on such topics as human aging, diabetes, arteriosclerosis, and development of replacement joints. This research is conducted under strict federal guidelines governing the care and use of animals in laboratory settings.

Transgenic technologies also offer significant potential in terms of utilizing livestock to produce specialized proteins for use in the creation of therapeutic drugs and other medical applications. This approach is often referred to as "pharming" or the use of agricultural animals to produce pharmaceuticals. Transgenic dairy cows and goats have been utilized to produce hepatitis B antigens, tissue plasminogen activator for treatment of heart disease, and the clotting agent antithrombin III for example.

CHAPTER SUMMARY

- Domesticated animals contribute to the well-being of humans throughout the world by providing food, clothing, shelter, power, recreation, and companionship.
- Animal products contribute significantly to the world's human protein needs and energy supply.
- As people increase their standard of living, the per-capita consumption of animal products also increases.
- Human health is improved via the continuing research utilizing domestic animals.

KEY WORDS

per-capita calorie supply
per-capita protein supply
mechanization
animal agriculture
chronic persistent hunger (CPH)
famine
food secure
food insecure
by-products
gelatin
draft purposes
companion animals

REVIEW QUESTIONS

1. Compare and contrast the global distribution of livestock and poultry.
2. Describe the role of animal products in the diets of consumers in developed and developing countries.
3. Describe the role of mechanization in changing agricultural practices, productivity, and the experience of consumers.
4. Discuss the trends in the livestock and poultry productivity.
5. How have expenditures for food purchased at-home, away-from-home, and on a per capita basis changed over time?
6. Describe the role of animal products to the global caloric and protein supply.
7. How does livestock production allow humans to capture value from land resources.
8. Compare and contrast chronic persistent hunger and famine.
9. Describe the hunger situation in the United States.
10. Define the value of nonfood values of the livestock and poultry industries.

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2

An Overview of the Livestock and Poultry Industries

Learning objectives

1. Quantify the economic impact of the U.S. livestock industry.
2. Describe the role of international trade in livestock and livestock products.
3. Overview the international and domestic beef, dairy, horse, poultry, sheep, goat, and swine industries.
4. Overview nontraditional livestock enterprises.

INTRODUCTION

It is important to see the broad picture of the livestock and poultry industries before studying the specific biological and economic principles that explain animal function and production. These industries are typically described with numbers of animals, pounds produced, production systems, prices, products, people (producers and consumers), and profitability. Products and consumers are covered in the next several chapters.

An understanding of the animal industries begins with basic terminology, especially the various species and sex classifications (**Table 2–1**). Refer to the glossary for definitions of many commonly used terms in the livestock industries.

U.S. ANIMAL INDUSTRIES: AN OVERVIEW

Historically, farms in the United States were highly diversified in both crop and livestock enterprises. For example, during the depression most farms had cattle, chickens, hogs, and horses. Over time, however, as fewer people chose to work in agriculture production, the industry had to develop more specialization in order to create the productivity required to meet consumer demand. The livestock and poultry industries in the United States must generate large volumes of output to meet the high animal product preference of more than 326 million U.S. consumers and also to supply the growing export market. **Table 2–2** shows the number of livestock and poultry producers and the inventory number for each species.

Cash Receipts

An evaluation of farm **cash receipts** from the sale of animals and animal products provides another perspective of U.S. animal industries. **Table 2–3** shows the cash receipts for animal commodities ranked against all agricultural commodities. The top five states for each commodity are also shown in this table. Note the cash receipts for all livestock products comprise 47% of all agricultural commodities in the United States.

Table 2–4 shows the farm cash receipts from livestock and poultry products for states that have annual cash receipts in excess of $4 billion.

Table 2–1
SEX AND SEX-CONDITION TERMINOLOGY FOR LIVESTOCK AND POULTRY

	Female		Uncastrated Male		Castrated Male	
Species	**Young[a]**	**Mature[b]**	**Young[a]**	**Mature[b]**	**Young[a]**	**Mature[b]**
Cattle	Heifer[c]	Cow	Bull[c]	Bull	Steer	Stag
Chicken	Chick/Pullet	Hen	Chick/Cockerel	Cock/Rooster	Capon	—
Goat	Doe	Doe	Buck	Buck	Wether	—
Horse[d]	Filly	Mare	Colt[e]	Stallion	Gelding	—
Sheep	Ewe[f]	Ewe	Ram[f]	Ram/Buck	Wether	Stag
Swine	Gilt	Sow	Boar[g]	Boar	Barrow	Stag
Turkey	Young Hen/Poult[h]	Hen	Young Tom/Poult[h]	Tom	—	—

[a]*Young:* generally prior to puberty or sexual maturity and before the development of secondary sex characteristics.
[b]*Mature:* generally after puberty and before the development of secondary sex characteristics.
[c]Referred to as a *bull calf* (under 1 year of age); *heifer* can be a heifer calf, yearling heifer, or first calf heifer (after the first calf is born and prior to the birth of the second calf).
[d]A close relative of the horse is the *donkey*, also known as an *ass* or a *burro*. The male ass is referred to as a *jack*; the female is known as a *jennet*. A *mule* is produced by crossing a *jackass* with a mare. A *hinny* is produced by crossing a stallion with a jennet. Mules and hinnys are reproductively sterile, although their visual sexual characteristics appear to be normal.
[e]Under 3 years of age.
[f]Referred to as a *ewe lamb* or a *ram lamb* (under 1 year of age).
[g]Referred to as a *boar pig* (under 6 months of age).
[h]Under 10 weeks of age. Chicks or poults are newly hatched or a few days old.

Table 2–2
NUMBERS OF PRODUCERS AND ANIMALS IN THE U.S. LIVESTOCK AND POULTRY INDUSTRIES

Species	Number of Producers (1,000)	Number of Animals (mil head)
Beef cows	728	31.7
Breeding sows	63	6.3
Dairy cattle	42	9.4
Broilers	NA	8,776.0
Layers	NA	376.6
Breeding ewes	88	3.0
Turkeys	NA	244.0
Goats—meat/milk/fiber	128	2.6[a]

[a]85% are meat-type.
Source: Adapted from USDA.

World Trade

International trade volumes are affected by a number of issues but are increasingly critical to the sustainability and profitability of American agricultural producers. The United States is an active importer and exporter of agricultural goods. **Table 2–5** shows the export and import markets for several animal commodities. While world trade for all U.S. products shows a deficit, agricultural and animal products show a positive trade balance. The leading destinations for U.S. agricultural exports are Canada ($20.5 bil), China

Table 2–3
LEADING U.S. STATES FOR FARM CASH RECEIPTS

Commodity	Rank[a]	Value ($ bil)	Five Leading States ($ bil)				
			1	2	3	4	5
All commodities		374.8	CA $50.2	IA $26.5	TX $22.9	NE $21.3	MN $17.1
Cattle and calves	1	66.4	NE 11.1	TX 8.8	KS 8.2	IA 4.0	CO 3.4
Milk	4	35.2	CA 6.5	WI 5.4	NY 2.7	ID 2.5	TX 2.2
Broilers	5	32.4	GA 4.4	AR 3.8	NC 3.6	AL 3.3	MS 2.6
Hogs	6	19.9	IA 7.1	MN 2.6	NC 2.3	IL 1.3	IN 1.2
Chicken eggs	7	7.5	IA 0.86	GA 0.58	IN 0.53	AR 0.48	OH 0.48
Turkeys	13	4.8	NC 0.74	MN 0.68	IN 0.51	MO 0.40	AR 0.34

[a]Ranking is in comparison to all agricultural commodities. Corn is #2 and soybeans #3.

Source: Adapted from USDA.

Table 2–4
LEADING STATES FOR CASH RECEIPTS FROM LIVESTOCK AND PRODUCTS SALES IN THE UNITED STATES

State	$1,000	Share of State's Cash Receipts from Livestock and Products (%)
Texas	14,377	62
Iowa	13,410	51
Nebraska	12,464	58
California	11,187	22
Kansas	9,529	61
Wisconsin	7,972	70
North Carolina	7,745	67
Minnesota	7,583	44
Georgia	5,837	66
Arkansas	5,316	60
Oklahoma	5,215	78
Colorado	4,612	68
Missouri	4,536	46
Alabama	4,393	80
Idaho	4,381	61

Source: USDA

Table 2–5
U.S. EXPORTS AND IMPORTS OF MAJOR ANIMAL PRODUCTS

	Exports	Imports
Commodity	Value ($ mil)	Value ($ mil)
Cattle and calves	68	1,533
Beef	7,200	5,600
Pork	4,700	1,600
Chicken	3,600	500
Dairy products	4,600	3,300
Variety meats	1,660	182
Hides and skin	1,888	178
Fats, oils, and greases	489	184
Total for agricultural products	138,397	121,014

Source: Adapted from USDA.

($19.6 bil), Mexico ($18.6 bil), Japan ($11.9 bil), and the EU-27 ($11.5 bil). The impact of agricultural trade is substantial and critical to the health of the U.S. economy.

Commodity Prices

The profitability of U.S. animal industries is partly influenced by the prices paid to producers for animals and animal products. Prices can fluctuate monthly, weekly, or even daily. These price changes are influenced primarily by supply and demand.

Those individuals interested in animal profitability should know the average prices of animal products. In addition, an understanding of the prices for specific classes and grades of animals, of what causes prices to fluctuate, and of how high prices are obtained is also necessary. **Figure 2–1** compares market prices of several livestock and poultry commodities. This overview shows average prices and variability in prices producers receive for the animals and products they sell. Details of how some factors influence prices are discussed in later chapters.

Biological Differences in Meeting Market Demand

Changes in consumer demand, feed prices, weather, and other factors dictate the need to increase or decrease animal numbers and amount of product produced. **Figure 2–2** shows the large differences between some farm animal species and how quickly or slowly inventories can change. Broiler numbers can be increased or decreased in a couple of months, while several years are needed to make significant changes in cattle numbers.

BEEF INDUSTRY

Global Perspective

Cattle were probably domesticated in Asia and Europe during the New Stone Age. Humped cattle (*Bos indicus*) were developed in tropical countries; the *Bos taurus* cattle were developed in more temperate zones.

Cattle, including the domestic water buffalo, contribute food, fiber, fuel, and draft animal power to the 6.8 billion people of the world. For most developed countries, beef (meat) is a primary product. For developing countries, beef is a secondary product as draft animal power and milk are the primary products. In some countries, cattle are still a mode of currency or a focus of religious beliefs and customs.

Table 2–6 shows the leading countries for cattle numbers, beef production, and beef consumption. India and Brazil have the largest cattle population; however, India's per-capita consumption is low because religious customs forbid cattle (considered sacred) from being slaughtered. The United States produces the most

Figure 2–1

Livestock and product commodity prices are cyclic over time and contribute significantly to the economic challenges faced by agricultural producers. Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

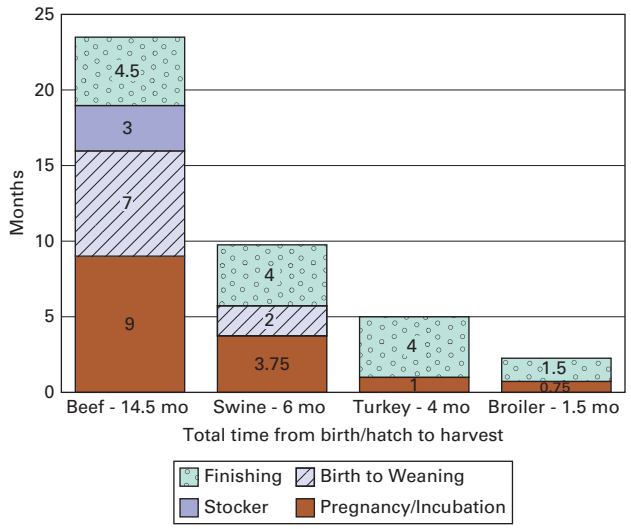

Figure 2–2

Production cycle in several species of livestock and poultry.

beef tonnage and has a distinct efficiency of production advantage. The United States produces approximately 20% of the world's beef with only 9% of the cattle. Brazil with more than 20% of the global cattle inventory produces 15% of the total beef while Australia accounts for 2% of the cattle inventory and 4% of the beef tonnage.

Countries with a high cattle population relative to their human population typically have a high per-capita consumption of beef and high export tonnage. For example, there are approximately 1.5 cattle per person in Australia and Argentina. Both countries rank high in per-capita consumption of beef. Leading export markets for U.S. beef include Canada, China, Japan, Korea, and Mexico (**Table 2–7**).

United States

The U.S. **beef industry** is made up of a series of producing, processing, and consuming segments that relate to each other but that operate independently.

Figure 2–3 shows historic trends for total cattle and amount of carcass beef produced in the United States. Interestingly, the U.S. beef industry has been able to retain high levels of beef production despite the recent cattle inventory losses. There are several reasons for this relatively high production of beef from fewer numbers of cattle: (1) the average carcass weight has increased by an average of 5 pounds per year over the last half century, (2) an increased number of cattle are fed per feedlot (2.4 times the feedlot capacity), (3) the market age of fed cattle has decreased, (4) more crossbreeding and faster-gaining European breeds (e.g., Simmental, Limousin, and Charolais) are being used in commercial breeding programs, and (5) more Canadian and Mexican calves are imported and fed in the United States when market conditions are favorable.

Cattle Production

Most commercial beef cattle production occurs in three phases: the **cow-calf**, **stocker-yearling**, and **feedlot** operations. The cow-calf operator raises the young calf from birth to 6–10 months of age (400–650 lb). The stocker-yearling operator then grows the calf to 600–850 lb, primarily on roughage. Finally, the feedlot operator uses high-energy rations to finish the cattle to a desirable finished weight, approximately 900–1,300 lb. Most fed steers and heifers are between 15 and 24 months of age when harvested.

Table 2–6
WORLD CATTLE NUMBERS, PRODUCTION, AND CONSUMPTION

Country	All Cattle (mil head)	Country	Production (1,000 tons) [a, b]	Carcass Weight (lb/hd)
1. India	305	1. United States	13,524	800
2. Brazil	232	2. Brazil	10,912	545
3. China	97	3. EU	8,658	641
4. U.S.	94	4. China	8,107	317
5. EU	88	5. India	4,739	227
World Total	1,007	**World Total**	70,132	480

[a]Does not include buffalo meat.
[b]Carcass weight.
Source: Adapted from USDA and FAO.

Table 2–7
U.S. BEEF TRADE

Exports		Imports	
Country	**($ mil)**	**Country**	**($ mil)**
1. Japan	1,890	1. Australia	2,469
2. South Korea	1,220	2. New Zealand	1,163
3. Mexico	980	3. Canada	1,102
4. Hong Kong	884	4. Mexico	1,002
5. Canada	796	5. Uruguay	238
World Total	7,269	**World Total**	6,200

Source: Adapted from USDA: FAS.

However, there are alternatives to the typical three-phase operation. In an integrated operation, for instance, the cattle may have a single owner from cow-calf to feedlot, or ownership may change several times before the cattle are ready for slaughter. Alternative production and marketing strategies are diagrammed in **Figure 2–4**.

Cow-Calf Production U.S. cow-calf production involves some 31.7 million head of beef cows that are distributed throughout the country. Most of the cows are concentrated in areas where forage is abundant. As **Figure 2–5** shows, 15 states each have over 700,000 head of cows (75% of the U.S. total), most of them located in the Plains, Corn Belt, and southeastern states. Approximately 80% of the beef cow operations have less than 50 cows per operation. Ten percent of cowherds have more than 100 cows, but this group controls 55% of the U.S. beef cow inventory (**Table 2–8**).

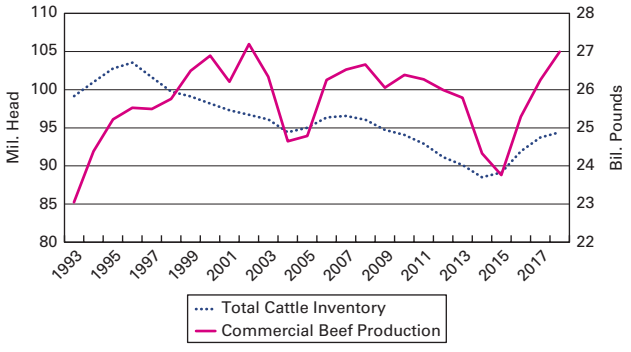

Figure 2–3
Total U.S. cattle inventory versus commercial beef production. Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

Cow numbers fluctuate over the years, depending on drought, beef prices, and land prices.

There are two kinds of cow-calf producers. Commercial cow-calf producers raise most of the potential slaughter steers and heifers. Seedstock breeders—specialized cow-calf producers—produce primarily breeding cattle and semen.

Stocker-Yearling Production Stocker-yearling producers feed cattle for growth prior to their going into a feedlot for finishing. Replacement heifers intended for the breeding herd are typically included in the stocker-yearling category. Our focus here, however, is on steers and heifers grown for later feedlot finishing.

Several alternate stocker-yearling production programs are identified in Figure 2–4. In some programs, a single producer owns the calves from birth through the feedlot-finishing phase, and the cattle are raised on the same farm or ranch. In other programs, one operator retains ownership, but the cattle are custom-fed during the growth and finishing phases. In still other programs, the cattle are bought and sold once or several times.

The primary basis of the stocker-yearling operation is to market available forage and high-roughage feeds, such as grass, crop residues (e.g., corn stalks, grain stubble, and beet tops), wheat pasture, and silage. Stocker-yearling operations also make use of summer-only grazing areas that are not suitable for the production of supplemental winter feed.

Stocker-yearling operations are desirable for early-maturing cattle. These cattle need slower gains to achieve heavier slaughter weights without being excessively finished. Larger-framed,

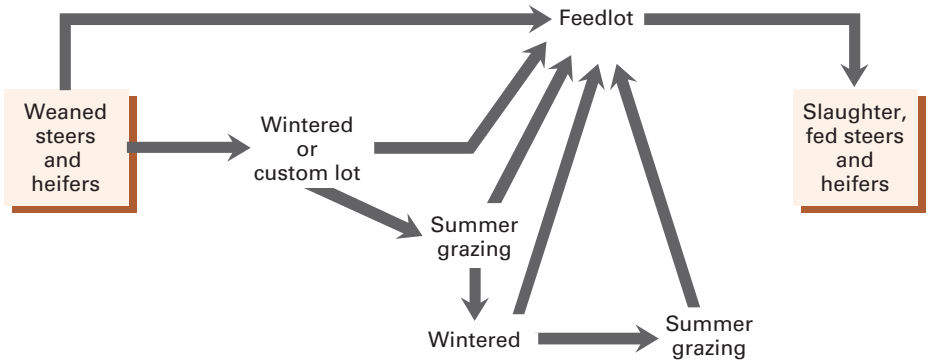

Figure 2–4

Alternative production and marketing strategies in the U.S. beef industry.

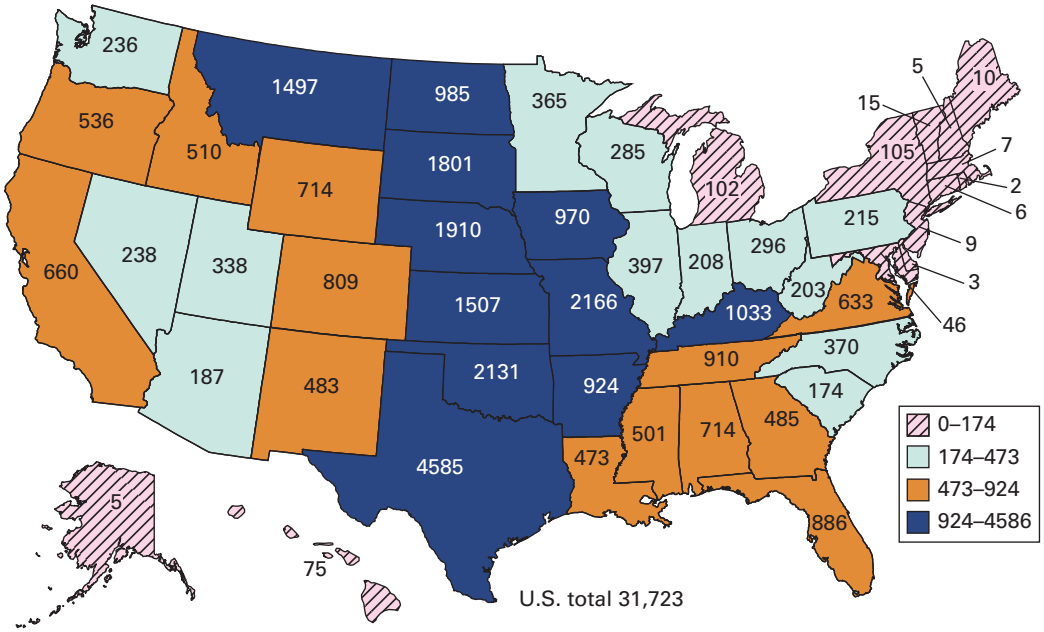

Figure 2–5

Beef cow inventory by state (1,000 head). Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

later-maturing cattle usually are more efficient and profitable if they go directly to the feedlot after weaning.

Feedlot Cattle Production Feedlot cattle are fed in pens or fenced areas, where harvested feed is brought to them. Some cattle are finished for market on pasture, but they represent only 10–15% of the slaughter steers and heifers. They are sometimes referred to as *nonfed cattle* because they are fed little, if any, grain or concentrate feeds. The cattle-feeding areas in the United States (**Fig. 2–6**) correspond to the primary feed-producing areas where cultivated grains and roughage are grown. These locations are determined primarily by soil type, growing season, and amount of rainfall or irrigation water. **Figure 2–6** shows where the approximately 25 million feedlot cattle are fed in the various states. The total number of fed cattle marketed in the leading states is shown in **Table 2–9**. Marketing by the leading 12 states represent 95% of the total fed cattle in all states. By contrasting **Figure 2–6** and Table 2–9, the number of cattle marketed for each state is considerably higher than the number on feed. This is because most commercial feedlots feed more than 1.7 times their one-time capacity in a given year.

Table 2–8
U.S. BEEF COW OPERATIONS AND INVENTORY

	Operations	Inventory
Herd Size (No. of Cows)	Percent of Total	Percent of Total
1–49	79	28
50–99	11	17
100–499	9	38
500+	1	17

Source: Adapted from USDA.

Cattle Feeding

The two basic types of cattle-feeding operations are (1) **commercial feeders** (**Fig. 2–7**) and (2) **farmer-feeders**. The two operations are distinguished by type of ownership and size of feedlot.

The farmer-feeder operation is usually owned and operated by an individual or a family and has a feedlot capacity of less than 1,000 head. An individual or partnership sometimes owns the commercial feedlot, but more often a corporation owns it, especially as feedlot size increases. It has a feedlot capacity of over 1,000 head. Approximately 82% of fed cattle are fed in feedlots with over 1,000-head capacity. A number of U.S. commercial feedlots have capacities of 40,000 head or higher, and a few have capacities of over 100,000 head. Some commercial feedlots custom-feed cattle; that is, the commercial feedlot provides the feed and feeding service to the cattle owner.

Each type of feeding operation has its advantages and disadvantages. What is an advantage to one type of feedlot is usually a disadvantage to the other type. The large commercial feedlot usually enjoys economic advantages associated with its size as well as professional expertise in nutrition, health, marketing, and financing. The farmer-feeder has the advantages of distributing labor over several enterprises by using high-roughage feeds effectively, creating a market of homegrown feeds through cattle, and more easily closing down the feeding operation

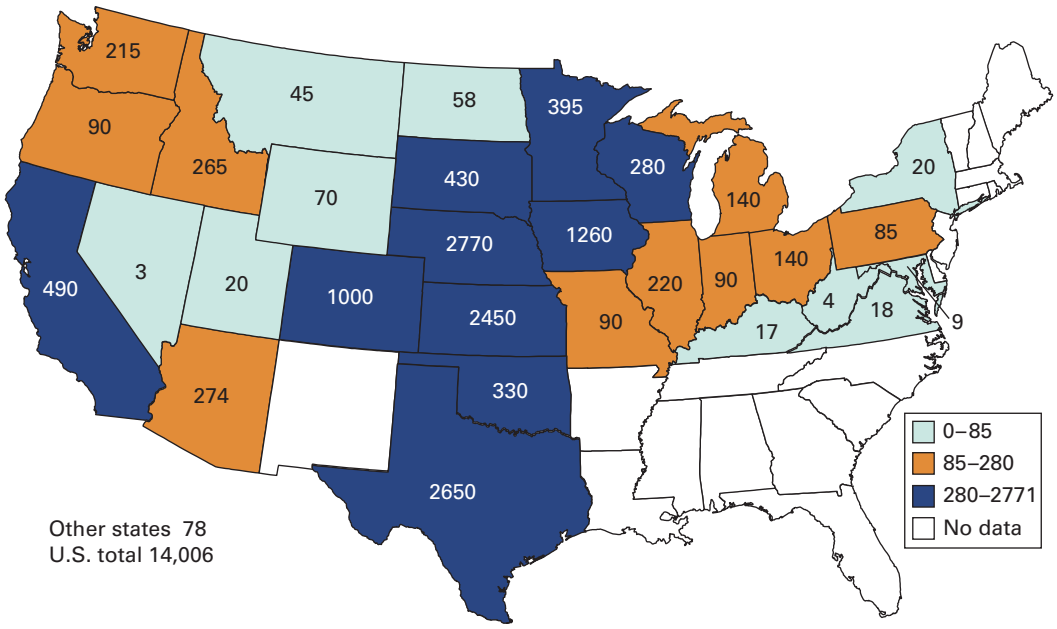

Figure 2–6

Cattle on feed by state (1,000 head). Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

Table 2–9
LEADING STATES FOR ANNUAL FED CATTLE MARKETINGS, 2018

State	Fed Cattle Marketings (1,000 hd)	State	Fed Cattle Marketings (1,000 hd)
Nebraska	5,455	California	591
Kansas	4,965	South Dakota	500
Texas	4,870	Idaho	485
Colorado	1,870	Washington	421
Iowa	1,583	Arizona	279
Oklahoma	653	Minnesota	241

during times of unprofitable returns. However, all feedyards are affected by feed price volatility (**Fig. 2–8**). The impact of alternate uses of feed grains such as ethanol production, weather, and changes in international trade are sources of disruption to grain markets.

THE DAIRY CATTLE INDUSTRY

Global Perspective

Milk and milk products are produced and consumed by most countries of the world. Although buffalo, goat, and other types of milk are important in some areas, our focus here is on cow's milk and its products.

Table 2–10 shows world dairy cattle numbers, fluid milk production, and per-capita consumption of milk. Of the 286 million dairy cows in the world, India leads all other countries with its 51 million. The average annual world production per cow is 5,244 lb, with production in Israel the highest at nearly 26,000 lb. Countries with high milk-production levels per cow have excellent breeding, feeding, and health-management programs.

World butter production is in excess of 23 billion lb. India, the European Union, the United States, New Zealand, and Russia are the leaders in total butter production, while New Zealand, the European Union, and Switzerland have the highest per-capita consumption of butter.

The leaders in cheese production are the European Union and the United States—jointly accounting for 78% of the world's

Figure 2–7
The feed mill associated with a large commercial cattle-feeding enterprise. Rations can be formulated and delivered to meet the needs of thousands of head of cattle. Source: Tom Field.

Figure 2–8
Ethanol production has created greater volatility in grain markets and thus impacts the feedyard profit margins of both commercial and farmer-feeder enterprises. Source: Tom Field.

Table 2–10
WORLD DAIRY CATTLE NUMBERS, MILK PRODUCTION, AND PER COW PRODUCTIVITY

Country	No. of Dairy Cattle (mil head)	Country	Fluid Milk Production (bil. lbs.)	Country	Production per Cow[a] (lb)
1. India	51	1. United States	221	1. Israel	26,061
2. Brazil	17	2. India	184	2. United States	23,055
3. Pakistan	13	3. Brazil	74	3. Republic of Korea	22,119
4. China	12	4. Germany	72	4. Denmark	21,492
5. Ethiopia	11	5. Russian Fed.	68	5. Estonia	20,229
World Total	286	**World Total**	1,438	**World Average**	5,244

[a]Whole and skim milk.

Source: Adapted from USDA and FAO.

cheese production. Consumers in Iceland, the European Union, Switzerland, and the United States have the highest per-capita consumption of cheese.

Fluid milk is produced worldwide but is rarely traded. Manufactured dairy products dominate dairy trade. Manufactured products traded internationally account for about 5% of the global fluid milk production on a milk-equivalent basis. Trade restrictions keep trade volume and prices lower than if trade was more liberalized. Most developed countries, including the United States, extensively regulate their dairy industries by subsidizing production and often exportation.

Table 2–11 shows the volume of U.S. export trade in dairy products. Cheese and nonfat dry milk are the most significant export items with cheese going to the Pacific Rim and NAFTA partners and dry milk to countries with minimal dairy production.

Table 2–11
VOLUME OF U.S. DAIRY PRODUCT EXPORTS

Product	Tons Exported
Condensed and evaporated milk	18,882
Nonfat dry milk	653,578
Dry whole milk and crème	35,818
Butter and milkfat	27,611
Ice cream	63,718
Cheese and curd	315,987
Fluid milk and crème	31.1 million gallons
Whey	1,656,348

Source: USDA.

United States

The U.S. **dairy industry** has changed dramatically since the days of the family milk cow. Today it is a highly specialized industry that includes the production, processing, and distribution of milk. A large investment is required in cows, machinery, barns, and milking parlors where cows are milked. Dairy operators who produce their own feed need additional investments for land on which to grow feed. They also require machinery to produce, harvest, and process the crops.

Although the size of a dairy operation can vary from less than 30 milking cows to more than 5,000 milking cows (**Fig. 2–9**), the average U.S. dairy has approximately 135 mature milking cows. Small sized dairies are declining in number while large and very large sized herds are increasing. Herds of less than 100 cows comprise nearly 75% of all dairy herds but only produce 14% of

Figure 2–9
Dairies in the United States continue to increase in herd size. Many dairy cow herds are intensively managed in excellent facilities. Source: Photo by Justin Field.

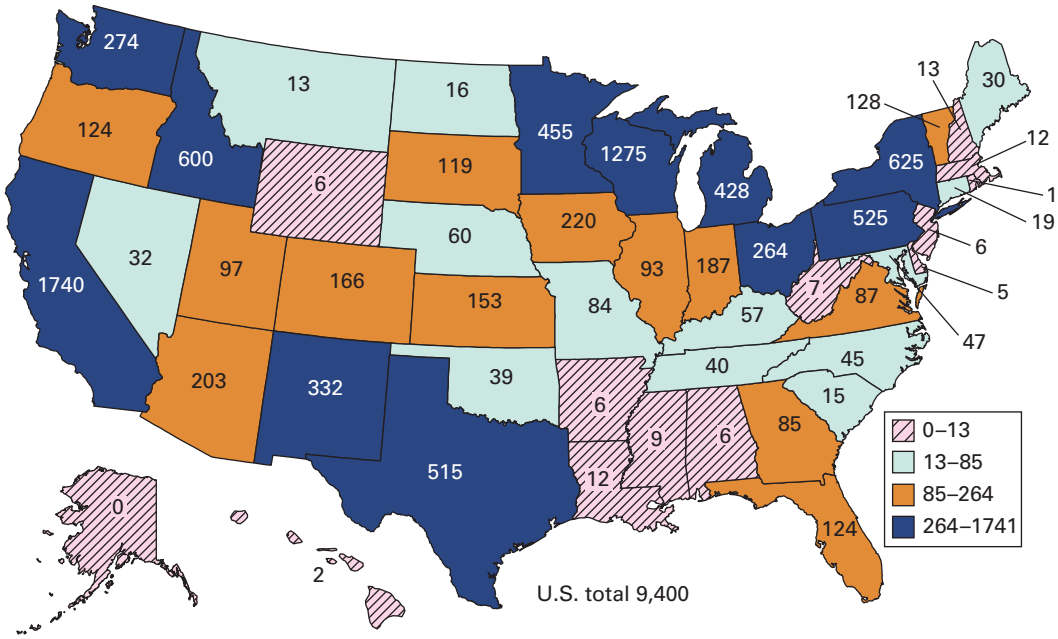

Figure 2–10

U.S. milk cow numbers by state (1,000 head). Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

U.S. milk production. Six percent of dairy herds have more than 500 cows and provide almost two-thirds of total domestic milk production.

New technologies have required extensive capital investment thus creating a competitive advantage for larger dairies capable of generating sufficient cash flow. Since 1977, farms with fewer than 100 milk cows have declined continuously as a share of all farms with milk cows. The share of farms having 500 or more milk cows is increasing in share of all farms with milk cows. The largest farms are typically found in the West and Southwest. The traditional milk-producing states of the Northeast and Great Lakes states have lost share of milk production.

One way to stress the importance of dairying in the United States is to examine the number of cows in the states (**Fig. 2–10**). The five leading states in thousands of dairy cows are, respectively, California, Wisconsin, New York, Idaho, and Pennsylvania. The five leading states in milk production per cow are, respectively, Colorado (25,733 lb), Michigan (25,250 lb), Arizona (24,402 lb), New Mexico (24,245 lb), and Idaho (24,126 lb). As **Figure 2–11** shows, today's 9.2 million dairy cows are approximately one-third the number of cows 50 years ago, yet total milk production continues to increase due to increased production per cow,

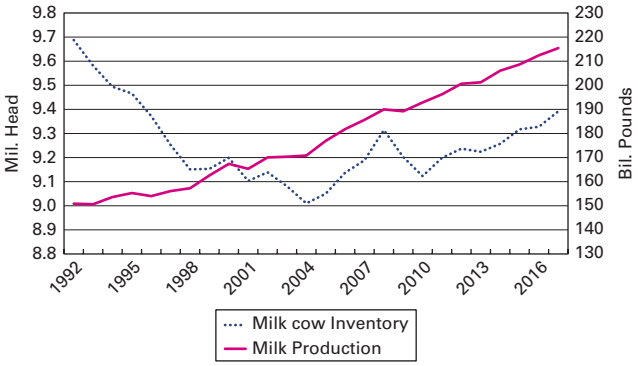

Figure 2–11

Trends in milk cow numbers and milk production. Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

which is 21,345 lb of milk per cow. This marked improvement is the result of effective breeding, feeding, health, and management programs.

THE HORSE INDUSTRY

Global Perspective

The horse was domesticated about 5,000 years ago. It was one of the last farm animals to be domesticated. Horses were first used as food, then for war and sports, and also for draft purposes. They

Table 2–12
WORLD HORSE, DONKEY, AND MULE NUMBERS

Horses		Donkeys and Mules	
Country	(mil head)	Country	(mil head)
1. United States	10	1. Ethiopia	9
2. Mexico	6	2. Mexico	7
3. China	5.5	3. China	6
4. Brazil	5	4. Pakistan	5
5. Mongolia	4	5. Egypt	1.5
World Total	60	**World Total**	55

Source: Adapted from FAO. These data are computational estimates and overestimate U.S. numbers.

were used for transporting people swiftly and for moving heavy loads. In addition, horses became important in farming, mining, and forestry.

The donkey, which descended from the wild ass of Africa, was domesticated in Egypt prior to the domestication of the horse. Donkeys and zebras are in the same genus (*Equus*), but are different species from horses. Horses mated with donkeys and zebras produce sterile offspring.

Table 2–12 shows the world numbers of horses (60 million) as well as donkeys and mules (55 million). The five leading countries are given for each of the three species, with the United States leading in horse numbers while Ethiopia leads in inventory of donkeys and mules.

Horses have been companions for people since their domestication. Once important in wars, mail delivery, farming, forest harvesting, and mining, the horse today is used in shows, in racing, in the handling of livestock, and for companionship, recreation, and exercise.

United States

There were no horses on the North American continent when Columbus arrived. However, there is fossil evidence that the early ancestor of the horse was here some 50–60 million years ago. The **Eohippus** (or dawn horse), a four-toed animal less than a foot high, is believed to be the oldest relative of the horse.

The early ancestors of the horse disappeared in pre-Columbian times, supposedly by crossing from Alaska into Siberia. It is from these animals that horses may have evolved in Asia and Europe. The draft horses and Shetland ponies developed in Europe, whereas the lighter, more agile horses developed in Asia and the Middle East. The Spaniards and colonists introduced modern horses to the Americas.

In the early 1900s, there were approximately 25 million horses and mules in the United States. Shortly after the World War I, however, horse numbers began a rapid decline. The war stimulated the development and use of motor-powered equipment, such as automobiles, trucks, tractors, and bulldozers. Railroads were heavily used for transporting people and for moving freight long distances. By the early 1960s, horses and mules had declined to a mere 3 million in the United States. As recreational experiences became more important to people's lifestyle, the **horse industry** was able to transform itself into an experience-based industry that put the horse in an entirely new light. With this new emphasis, numbers were rebuilt with the industry estimating total numbers between 7 and 10 million over the past 40 years.

An estimated 1.4 million Americans are employed by the equine industry and there are 2 million horse owners, and an additional estimated 5 million people acting as service providers, employees, and volunteers are involved in the industry. The U.S. horse business generates more than $122 billion in total economic activity with some $50 billion in direct economic impact according to the American Horse Council. The American Horse Council estimates that there are 7.2 million horses in the United States, with about 51% utilized in recreational activities, 20% as show animals, 20% involved in racing, and 9% as working horses. The leading states for horse numbers are identified in **Table 2–13**.

Table 2–13
HORSE POPULATION IN SELECTED STATES AND PRIMARY USE

State	Horses (N)	Racing (%)	Showing (%)	Recreation (%)	Other[a] (%)
Texas	1,000,000	11	19	27	44
California	700,000	11	30	43	17
Florida	500,000	12	52	18	14
Oklahoma	326,000	20	34	10	36
Kentucky	320,000	45	21	25	10
U.S. Total	7,200,000	10	28	43	18

[a]Includes agricultural, other sports, nonspecific breeding, etc. Source: Adapted from American Horse Council and USDA.

Involvement in the industry is varied with 85% of participants engaged as recreational riders, 30% competing at either the amateur or professional level, 11% in horse breeding, 10% in equine facility management, 9% as grooms and exercise riders, and 7% as professional trainers.

THE POULTRY INDUSTRY

Global Perspective

The term *poultry* applies to chickens, turkeys, geese, ducks, pigeons, peafowls, and guineas. Chickens, ducks, and turkeys dominate the world **poultry industry**. In parts of Asia, ducks are commercially more important than broilers (young chickens), and in areas of Europe, there are more geese than other poultry because they are more economically important.

Chickens originated in Southeast Asia and were kept in China as early as 1400 B.C. Charles Darwin concluded in 1868 that domestic chickens originated from the Red Junglefowl, although three other Jungle fowl species were known to exist.

Table 2–14 shows the leading countries in world poultry production. Poultry exports account for more than $5 billion (**Table 2–15**) with chicken exports accounting for $3.4 billion of the total. Approximately 16.5% of U.S. chick meat production and 11% of turkey meat production are exported annually.

World governments influence world poultry trade by controlling production and pricing and by placing **tariffs** on incoming goods—all barriers to free international trade. Trade liberalization by countries with industrial market economies would likely increase the trade of and decrease the price of poultry meat. Countries with efficient producers (such as the United States, Brazil, and Thailand), combined with consumers from countries with considerable trade protection (such as Japan, Canada, and the European Union), would benefit most from liberalized trade.

Poultry is the fastest-growing source of meat for people. The industrialized countries produce and export more than 50% of the poultry meat in the world.

Table 2–14
POULTRY AND EGG PRODUCTION

Broiler	(mil ton)	Turkey	(mil ton)	Eggs	(bil eggs)
U.S.	19.1	U.S.	2.9	China	529
Brazil	13.7	Brazil	0.64	United States	107
China	13.4	Germany	0.51	India	88
Russia	4.4	France	0.44	Mexico	55
India	3.5	Italy	0.34	Russia	51
World	109.1	World	6.5	World	1,420

Source: Adapted from USDA and FAO.

Table 2–15
PRIMARY CUSTOMERS OF U.S. CHICKEN AND TURKEY EXPORTS

Country	Chicken Exports (tons)	Country	Turkey Exports (tons)
Mexico	1,323,362	Mexico	384,722
Cuba	452,201	Hong Kong	30,075
Angola	382,193	Japan	21,195
Taiwan	338,343	Dominican Republic	16,437
Canada	334,607	Canada	13,326
World	3,500,000		293,000

Source: Adapted from USDA.

United States

The annual U.S. income from broilers, turkeys, and eggs exceeds $38 billion (broilers, $25.9 billion; eggs, $6.5 billion; and turkeys, $6.2 billion). **Figure 2–12** shows the leading states in broiler, turkey, and egg production. The U.S. poultry industry is concentrated primarily in the southeastern area of the country.

From 1900 to 1940, the primary concerns of the U.S. poultry industry were egg production by chickens and meat production by turkeys and waterfowl. Meat production by chickens was largely a by-product of the egg-producing enterprises. The **broiler** industry, as it is known today, was not yet established. Egg production was well established near large population centers, but the quality of eggs was often low because of seasonal production, poor storage, and the absence of laws to control grading standards.

Before 1940, large numbers of small farm flocks existed in the United States, but the management practices applied today were practically unknown. The modern mechanized poultry industry of the United States emerged during the late 1950s as the number of poultry farms and hatcheries decreased and the number of birds per installation dramatically increased. Larger cage-type layer operations appeared, and egg-production units grew, with production geared to provide consumers with eggs of uniform size and high quality. Large broiler farms that provided consumers with fresh meat throughout the year were established, and large dressing plants capable of dressing 50,000 or more broilers daily were built. The U.S. poultry industry was thus revolutionized.

One of the most striking achievements of the poultry industry is its increased production of eggs and meat per hour of labor. Poultry operations with 1 million birds at one location are not uncommon. Automatic feeding, watering, egg collecting, egg packing, and manure removal have accomplished significant labor reduction.

Dramatic changes came between 1955 and 1975 with the introduction of integration. It began in the broiler industry and is applied to a lesser degree in egg and turkey operations. Integration brings all phases of an enterprise under the control of one head, frequently the corporate ownership of breeding flocks, hatcheries, feed mills, raising, dressing plants, services, and marketing and distribution of products (**Fig. 2–13**). After 1975, poultry entered a new period of consolidation, in which vertically integrated companies purchased, acquired, or merged with each other, creating a small number of superintegrated companies.

The actual raising of broilers is sometimes accomplished on a contract basis between the person who owns the houses and equipment and furnishes the necessary labor, and the corporation that furnishes the birds, feed, field service, dressing, and marketing. Payment for raising birds is generally based on a certain price for each bird reared to market age. Bonuses are usually paid to those who do a commendable job of raising birds. An important advantage to the integration system is that all phases are synchronized to ensure the utmost efficiency.

Broiler production is concentrated in the southern and southeastern states. California and Texas are the only states with large production located outside the "broiler belt." The "broiler belt" includes Alabama, Arkansas, Georgia, Mississippi, North Carolina, and Virginia. This region produces two-thirds of U.S. broilers.

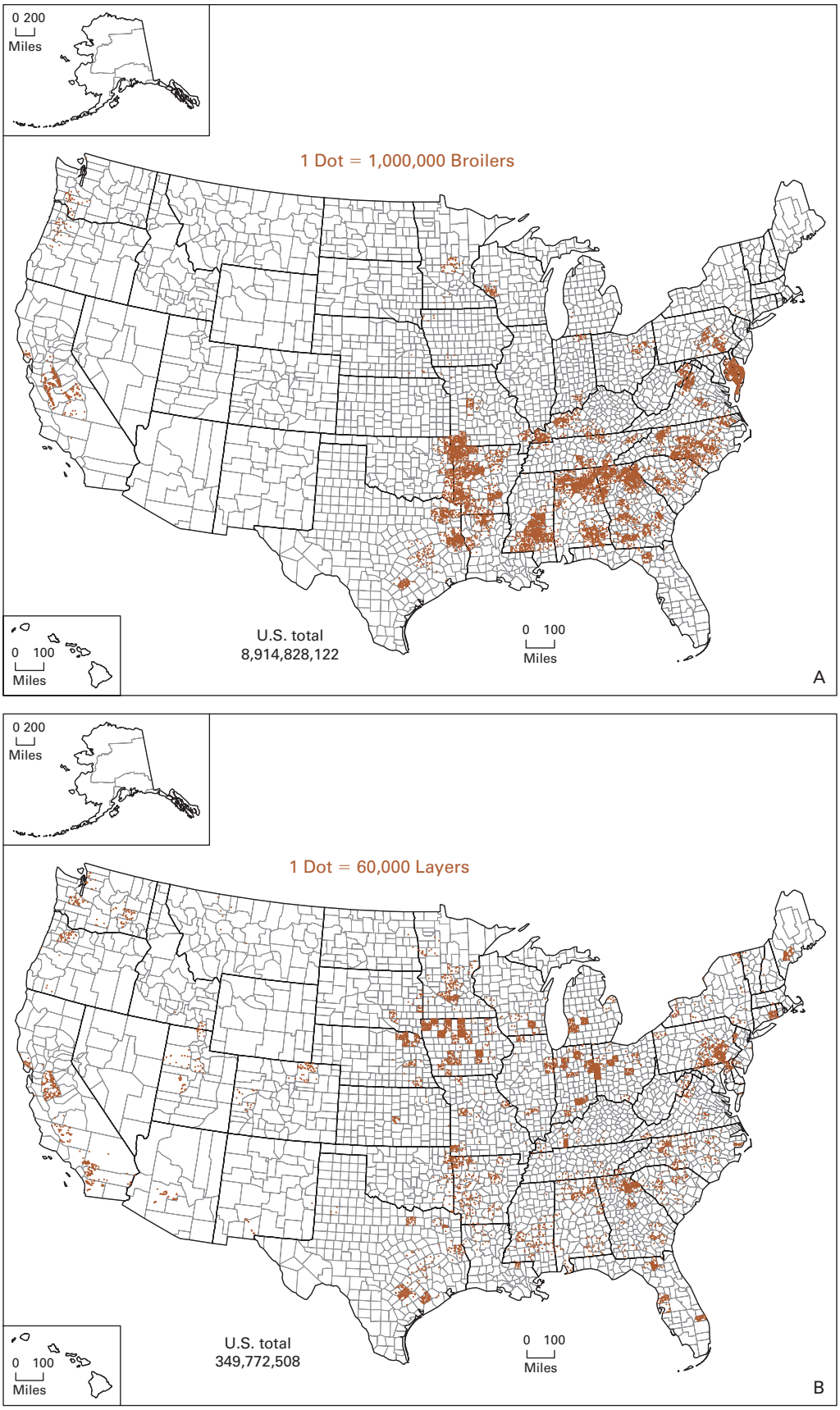

Figure 2–12

Concentration of broiler (a), egg (a), and turkey (c) production in the United States (million).

Source: Adapted from USDA.

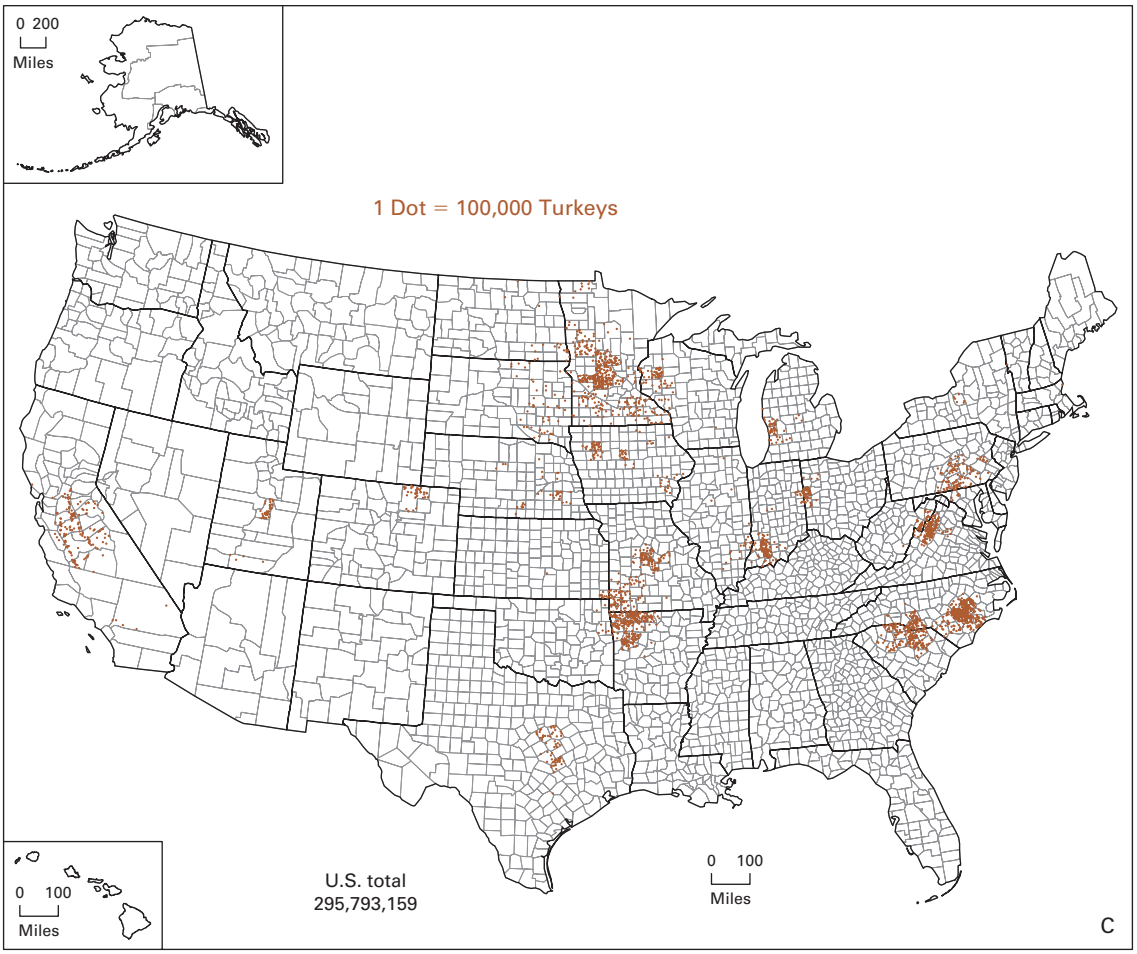

Figure 2–12
(continued)

Broiler production has increased tremendously over the past three decades, from 3.7 billion lb of ready-to-cook broilers in 1960 to more than 54 billion lb in 2018. The U.S. broiler industry is concentrating its grow-out operations into fewer but larger farms to take advantage of economies of scale, efficient supply chain logistics, and long-term marketing agreements.

Although the number of laying hens in the United States has declined over the years, egg production is higher because of improved performance of the individual hen. In 1880, for example, the average laying hen produced 100 eggs per year; in 1950, the average was 175; in 1986, it increased to 250; and in 2017, it was 279 eggs.

The United States Department of Agriculture (USDA) estimates that 85% of the market eggs produced in the United States originate from large commercial producers (those that maintain 1–11 million birds). The 45 largest egg-producing companies in the United States have more than 97 million layers, which is 35.5% of the nation's total.

Important changes have also occurred in U.S. turkey production. Fifty years ago, turkeys were raised in small numbers on many farms; today, they are raised in larger numbers on fewer farms. The average turkey farmer is producing well over 50,000 turkeys per year. The leading turkey-producing states are Minnesota, North Carolina, Arkansas, and Indiana.

Most of the turkeys produced today are the heavy or large, broad-breasted white type. At one time, the fryer-roaster-type turkey (5–9 lb) was popular; it bridged the gap between the turkey and the broiler chicken. Today, the broiler industry has taken over the fryer-roaster market because it can produce fryer-roaster chickens at a much lower price.

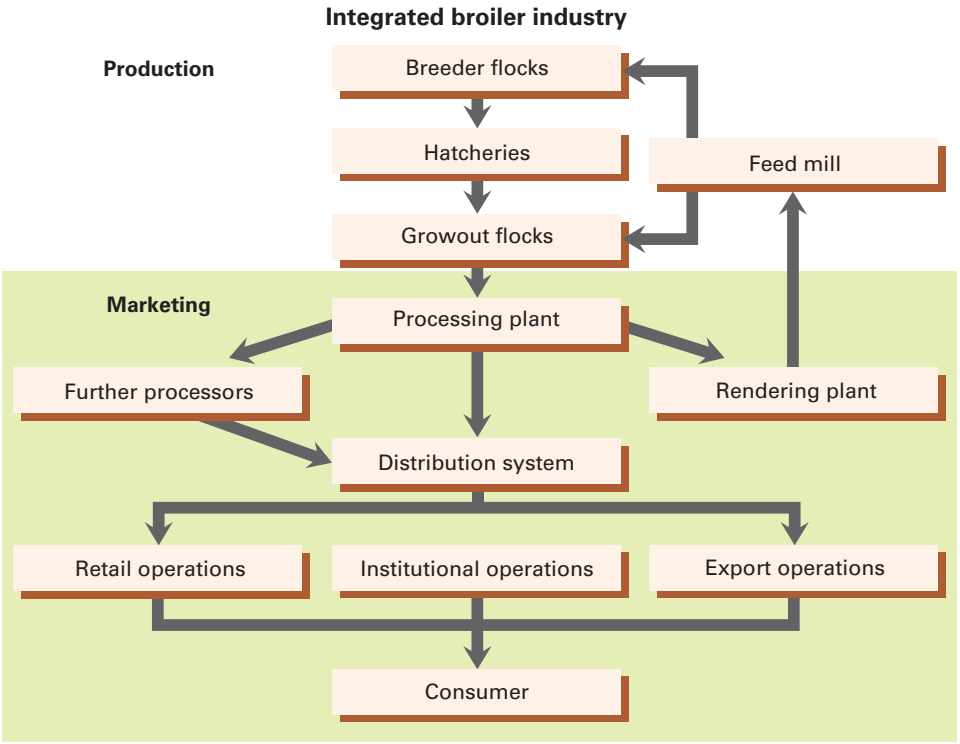

Figure 2–13
Structure of the integrated broiler industry.

It takes 16 weeks for turkey hens and 19 weeks for turkey toms to reach market size. Because there is a heavy demand for turkey meat in November and December, turkey eggs are set in large numbers in April, May, and June. However, eggs are set year-round because there is a constant, though lower, demand for fresh turkey meat throughout the year. The normal incubation period for turkey eggs is 28 days.

In the recent past, most consumers considered turkey a seasonal product, with consumption occurring primarily at Thanksgiving. Increasingly, turkey is consumed throughout the year, and consumers have available to them a large variety of turkey products. The greater demand for turkey has translated to an additional annual production of more than 1 billion pounds of ready-to-cook turkey as compared to the early 1980s.

THE SHEEP AND GOAT INDUSTRY

Global Perspective

Sheep and goats are closely related, with both originating in Europe and the cooler regions of Asia. Sheep are distinguished from goats by the absence of a beard, less odor (males only), and glands in all four feet. The horns are spiral in different directions; goat horns spiral to the left, while sheep horns spiral to the right (like a corkscrew).

Sheep and goats are important ruminants in temperate and tropical agriculture. They provide fibers, milk, hides, and meat, making them versatile and efficient, especially for developing countries. Sheep and goats are better adapted than cattle to arid tropics, probably because of their superior water and nitrogen economy. Cattle, sheep, and goats often are grazed together because they utilize different plants. Goats graze **browse** (shrubs) and some **forbs** (broad-leaved plants), cattle graze tall grasses and some forbs, and sheep graze short grasses and some forbs. Many of the forbs in grazing areas are broadleaf weeds.

More than 60% of all sheep are in temperate zones and fewer than 40% are in tropical zones. Goats, though, are mostly (80%) in the tropical or subtropical zones (0–40°N). Temperature and type of vegetation are the primary factors encouraging sheep production in temperate zones and goat production in tropical zones.

Table 2–16
WORLD SHEEP NUMBERS, PRODUCTION, AND CONSUMPTION

Country	No. of Sheep (mil head)	Country	Production (mil tons)[a]	Country	Carcass Weight (lb/head)
1. China	161	1. China	2.6	1. Syria	92
2. Australia	72	2. Australia	0.74	2. Montenegro	88
3. India	63	3. New Zealand	0.50	3. Barbados	78
4. Nigeria	42	4. Turkey	0.37	4. Poland	75
5. Sudan	40	5. United Kingdom	0.33	5. New Caledonia	71
World Total	1,202	**World Total**	10.5	**World Average**	37

[a]Carcass weight of lamb and mutton.
Source: Adapted from USDA and FAO.

Sheep originated in the dry, alternately hot-and-cold climate of Southwest Asia. To succeed in tropical areas, then, sheep had to adapt the abilities to lose body heat, resist diseases, and survive in an adverse nutritional environment. For sheep to lose heat easily, they require a large body surface-to-mass ratio. Such a sheep is a small, long-legged animal. In addition, a hairy coat allows ventilation and protects the skin from the sun and abrasions. In temperate areas, sheep with large, compact bodies, a heavy fleece covering, and storage of subcutaneous fat have an advantage. Sheep can also constrict or relax blood vessels to the face, legs, and ears for control of heat loss.

The productivity of sheep is much greater in temperate areas than it is in tropical environments. This difference is the result not only of a more favorable environment (temperature and feed supply) but also of a greater selection emphasis on growth rate, milk production, lambing percentage, and fleece weight. Sheep from temperate environments do not adapt well to tropical environments; therefore, it may be more effective to select sheep in the production environment, rather than introduce sheep from different environments.

World sheep numbers of nearly 1.2 billion head are the highest on record. China, Australia, India, Nigeria, and Sudan are the leading sheep producing countries (**Table 2–16**). Mongolia, Iceland, and New Zealand have the highest per-capita consumption of mutton, lamb, and goat meat.

The United States exports a relatively small amount of lamb and mutton with most of its export in the form of mutton from cull ewes. However, Australia and New Zealand provide a significant amount of lamb to the U.S. market. In fact, the U.S. imports more lamb than it produces domestically by more than 100 million pounds. The one billion head of goats in the world are most concentrated in China with nearly 139 million and India with 133 million goats on hand, with Pakistan, Bangladesh, and Nigeria have more than 50 million head of goats. In many countries, goats are important for both milk and meat production. **Table 2–17** shows countries with the greatest goat meat and goat milk production.

Table 2–17
WORLD GOAT NUMBERS, MEAT PRODUCTION, AND GOAT MILK PRODUCTION

Country	No. of Goats (mil head)	Country	Goat Meat Production (mil ton)[a]	Country	Milk Production (mil ton)
1. China	139	1. China	2.3	1. India	6.8
2. India	133	2. India	0.50	2. China	2.5
3. Nigeria	78	3. Pakistan	0.37	3. Bangladesh	1.3
4. Pakistan	72	4. Nigeria	0.27	4. Sudan	1.2
5. Bangladesh	60	5. Bangladesh	0.24	5. Pakistan	0.91
World Total	1,000	**World Total**	6.4	**World Total**	20.5

[a]Carcass weight.
Source: Adapted from USDA and FAO.

United States

The number of sheep in the United States reached a high of 56 million in 1942, thereafter declining to approximately 5.3 million today (**Fig. 2–14**). U.S. sheep are located on about 88,000 different operations. Because of the decline in sheep numbers, the United States is increasingly dependent on imports to supply the relatively limited demand for lamb.

The number of ewes on U.S. farms is shown in **Figure 2–15**. The five leading states in ewe numbers are, respectively, Texas, California, Wyoming, Utah, and South Dakota. The Midwest and West Coast areas are important in **farm-flock** sheep production, whereas other western states are primarily **range-flock** areas.

Table 2–18 shows average ewe flock sizes in selected states. Most of the decline in U.S. sheep numbers during the past 50 years has occurred in the West. However, this region, with its extensive public and private rangelands, still produces 80% of U.S. sheep production. Most U.S. sheep growers have small flocks (50 or fewer sheep) and raise sheep as a secondary enterprise. About 40% of the West's sheep producers maintain flocks of more than 50 sheep; these flocks contain about 93% of the sheep in that region. Only about one-third of the operators in the West who have flocks of 50 or more sheep specialize in sheep; the other two-thirds have diversified livestock operations.

The range operator produces some slaughter lambs if good mountain range is available, but most range-produced lambs are feeders (e.g., lambs that must have additional feed before they are slaughtered). Feeder lambs are fed by producers, sold to feedlot operators, or fed on contract by feedlot operators. Some feedlots have a capacity for 20,000 or more lambs on feed at one time, and many feedlots that have

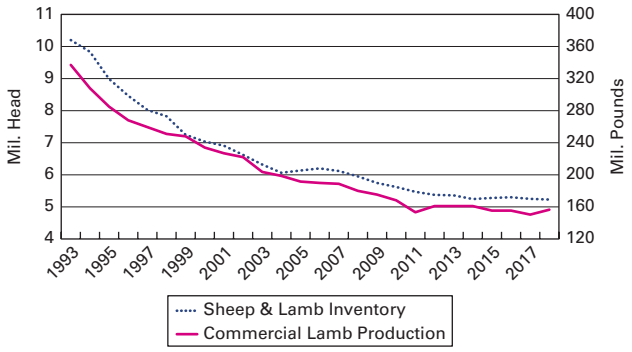

Figure 2–14

Total sheep and lamb population trends in the United States. Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

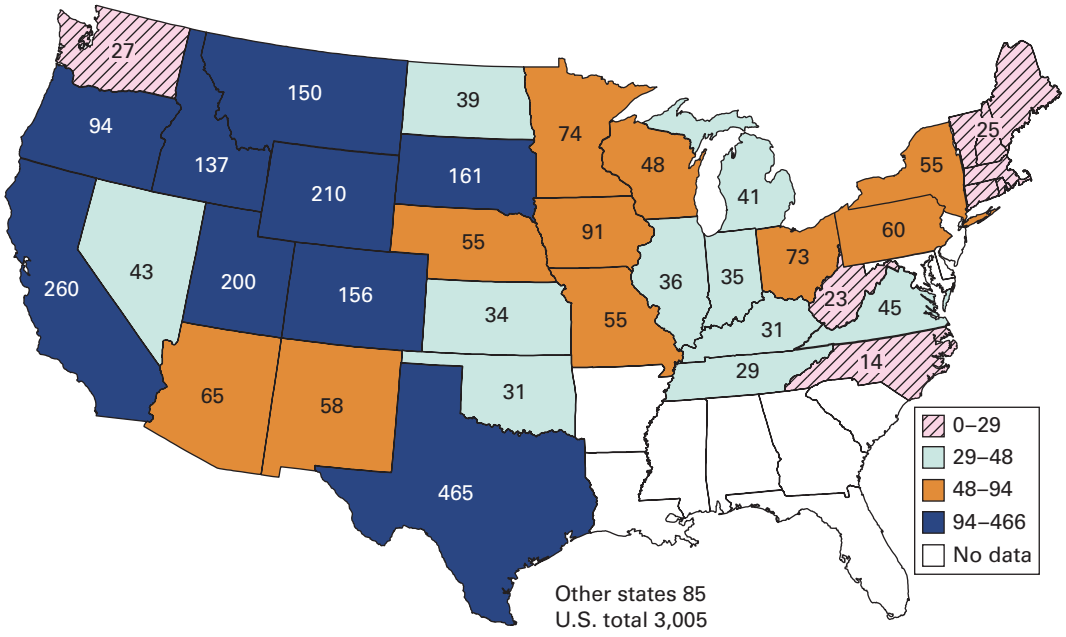

Figure 2–15

Breeding ewes, 1 year of age and older by state (1,000 head). Source: USDA-NASS. Data compiled by Livestock Marketing Information Center. Used by permission of Livestock Marketing Information Center.

Table 2–18
AVERAGE EWE FLOCK SIZE IN SELECTED STATES IN THE UNITED STATES

Range Flocks		Farm Flocks	
State	Ewes (N)	State	Ewes (N)
Wyoming	460	Iowa	60
Colorado	288	New York	40
Nevada	288	Kansas	34
Idaho	205	Virginia	32
Utah	162	Pennsylvania	26

Source: USDA.

a capacity of 5,000 are in operation. The leading lamb-feeding states are Colorado, California, Texas, Wyoming, South Dakota, and Kansas.

Purebred Breeder

Some producers raise purebred sheep and sell rams for breeding. **Purebred breeders** have an important responsibility to the **sheep industry**: They determine the genetic productivity of commercial sheep. The purebred breeder should rigidly select breeding animals and then sell only those rams that will improve productivity and profitability for the commercial producer.

Records are essential to indicate which ram is bred to each of the ewes and which ewe is the mother of each lamb. All ram lambs are usually kept together to identify those that are desirable for sale. The purebred breeder often retains the ram lambs until they are 1 year of age, at which time they are offered for sale.

Commercial Market Lamb Producers

Commercial lamb producers whose pastures are productive can produce market wether and ewe lambs on pasture, whereas those whose pastures are less desirable produce feeder lambs. Lambs that are neither sufficiently fat nor large for market at weaning time usually go to feedlot operators, where they are fed to market weight and condition. However, most feedlot lambs are obtained from producers of range sheep. The producer of market lambs, whose feed and pasture conditions are favorable, strives to raise lambs that finish at 90–120 days of age, weighing approximately 120–130 lb each.

Commercial Feedlot Operator

Lambs are sent to the feedlot if they need additional weight prior to slaughter. The feedlot operator hopes to profit by increasing the value of the lambs per unit of weight and by increasing their weight. Lambs on feed that gain about 0.5–0.8 lb per head per day are considered satisfactory gainers. Feeder buyers prefer feeder lambs weighing 70–80 lb over larger lambs because of the need to put 20–30 lb of additional weight on the lambs to finish them. A feeding period of 40–60 days is usually sufficient for finishing healthy lambs.

The inventory of goats in the United States is almost 2.6 million head (2.1 million meat goats, 380,000 dairy goats, and 142,000 Angoras). Nearly 510,000 meat goats are harvested annually under federal meat inspection. Texas is the leading producer of both meat and Angora goats while Michigan is the leading state for dairy goat production (**Table 2–19**).

THE SWINE INDUSTRY

Global Perspective

China far exceeds all other countries in number of pigs and total pork production. Swine are widely distributed throughout the world, even though approximately 40% of the world's pigs are located in China (**Table 2–20**). However, the swine herd in the United States is more productive on a per-head basis. Other swine numbers and production leaders are listed in Table 2–20.

The United States is second to the European Union in volume of pork exports. The United States