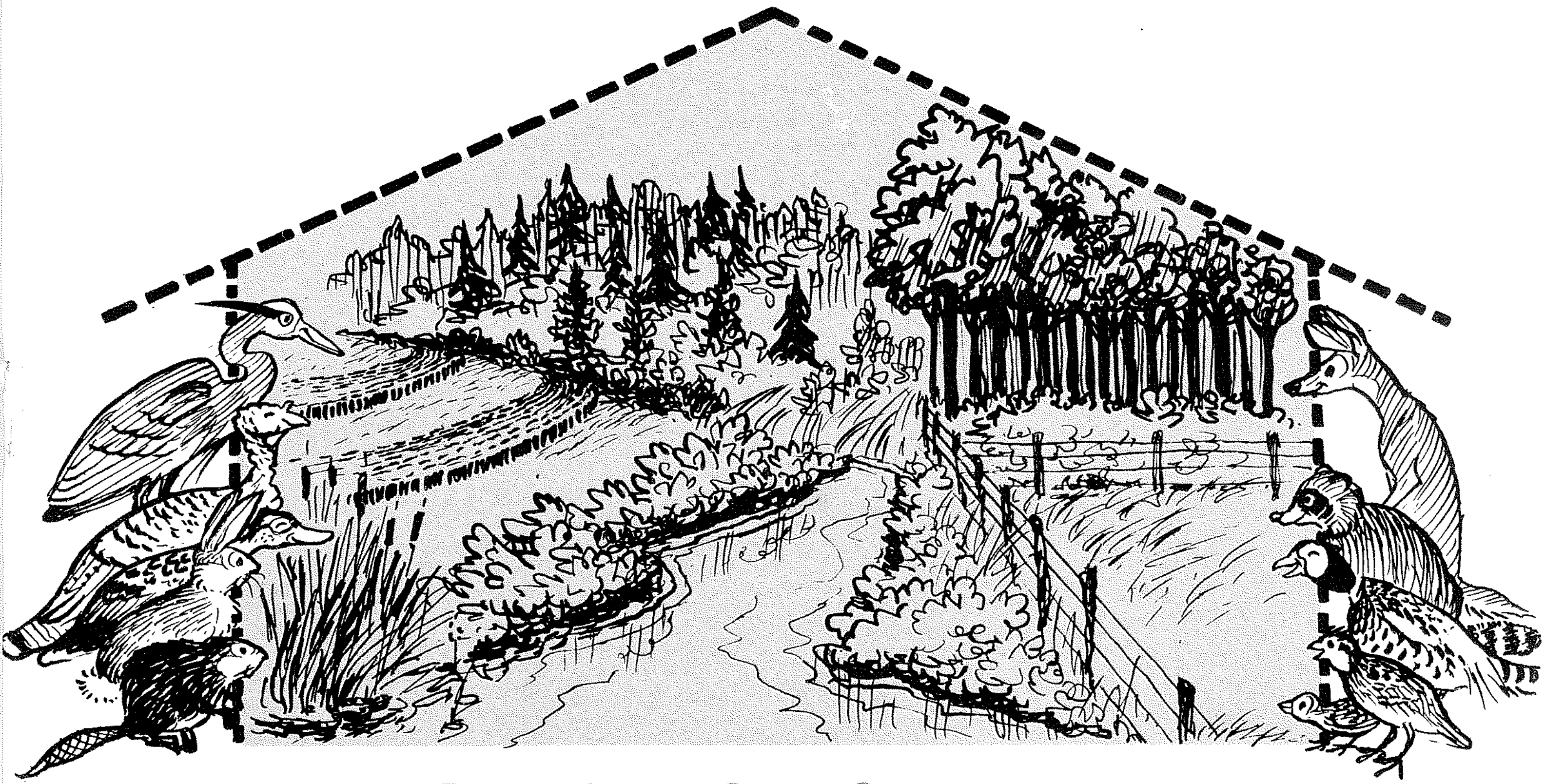
HELPING WILDLIFE:
Working With Nature



Pennsylvania Game Commission

HELPING WILDLIFE:

Working With Nature

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FOREWORD

Natural sciences involve the origin, evolution and composition of this planet's resources, including its plants and animals. Social sciences encompass changing conditions and behaviors of man. Environmental education concerns itself with both by focusing on the interlocking and frequently ignored relationships of man to his surroundings.

Environmental education has evolved from the consequences of man not fully understanding or appreciating the effects of his numbers and activities on the Earth that sustains him. Through environmental education, citizen understanding and action can be expanded to prevent further abuse of our natural resources. By such an educational process, the principles and objectives of natural resources conservation can be translated into helpful guidelines for human activities.

Prepared by Delwin E. Benson, Extension Wildlife Specialist at Colorado State University, in cooperation with the Wildlife Management Institute, this booklet is a guide for teaching some basic ecological concepts of natural resources and wildlife management. The objective of *HELPING WILDLIFE: Working With Nature* is to provide teachers, instructors and students with a useful tool for understanding and explaining the complexities of wildlife ecology and management to youngsters and others.

The information presented here is intentionally simplified. Instructors should supplement the text with local examples to illustrate the principles and objectives of wildlife ecology and management. This approach will help assure interest in and understanding of the subject in all geographic locations.

We hope this booklet will stimulate public involvement in deciding the future of wildlife resources.

Daniel A. Poole, *President*
Wildlife Management Institute

Nature is the ever-changing characteristics and conditions of our physical ***environment***, or surroundings. Because it is complicated and because it is part of our everyday lives, Nature often is taken for granted. We have become so numerous and so technologically advanced that nearly everything we do either harms or helps the quality and quantity of natural things. So, by studying, understanding and working with Nature, we help to improve the quality of our environment and, therefore, our own lives.

Ecology is the study of Nature. It deals with interrelationships, or the dependence of all living things on all other living things and their surroundings. The word ecology comes from the Greek words ***oikos*** which means "house," and ***logos*** which means "discussion or study." Nature, then, is like a house. Each item that goes into the construction of a house serves a unique function. By themselves, these items—such as boards, bricks, shingles, wires, cement, lights, plumbing fixtures and so forth—are not particularly useful. But when put together carefully, they form a livable house. That house can continue to be a comfortable place in which to live if each item that went into building it is kept in place and in good condition. And so it is with Nature. Each item, or component, of our natural surroundings serves a useful, but not always apparent purpose. Together, natural things combine to make a livable home for all of us—a home we call the Earth.

This booklet will examine some of the Earth's natural components. We will study their interlocking relationships. Particular attention will be given to wildlife, because this ***natural resource*** frequently is misunderstood and, consequently, ignored or abused when we seek to do things that alter our environment.

From Grass to Coyote to Grass: The Energy Flow

Our natural environment is composed of soils, water, plants, animals, minerals, gases and sunlight (Figure 1).

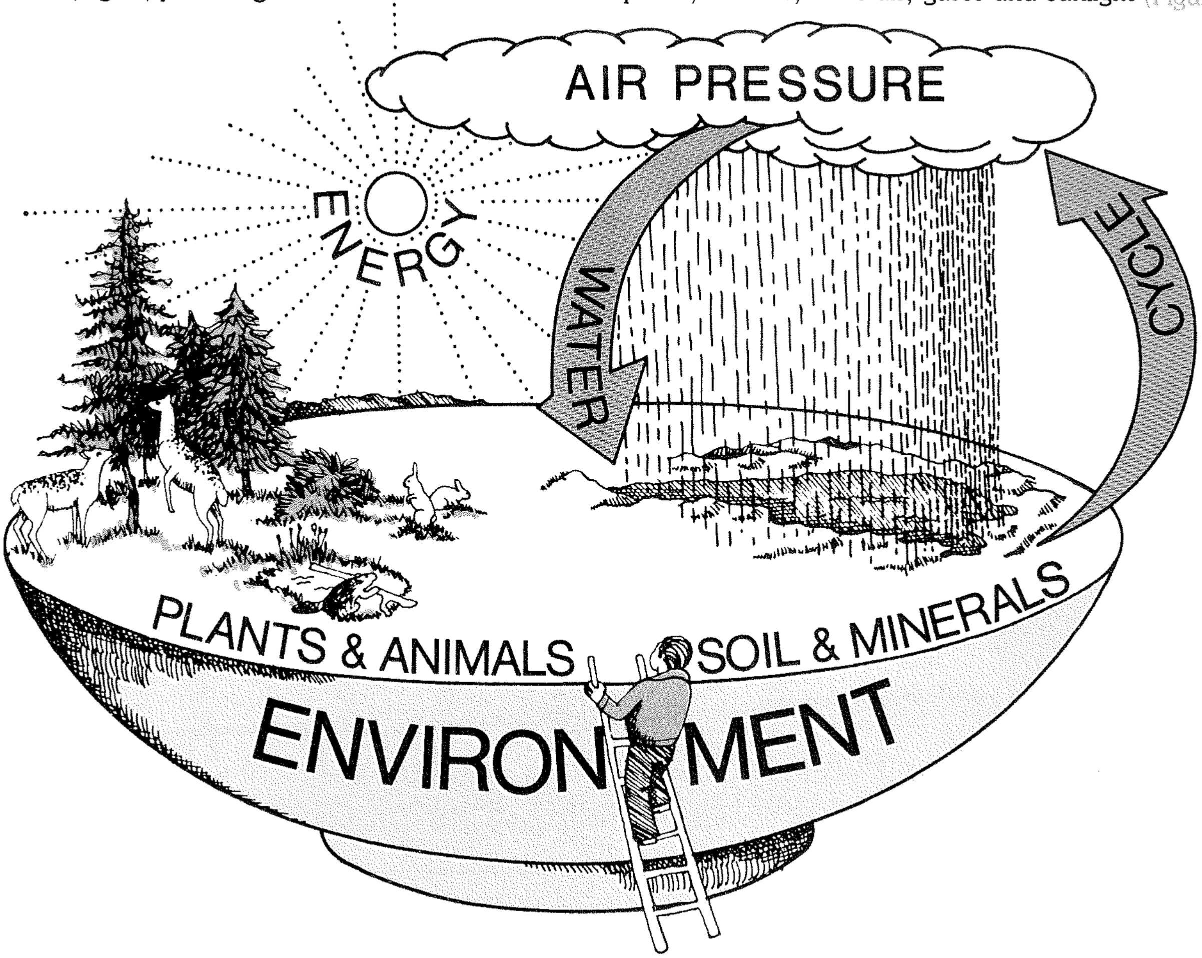

Figure 1. An environment is composed of many things, including light, heat, gases, soil, minerals, air, plants, water and animals. Each of these components interacts with and depends on all others.

The interrelationships of these components may be as subtle as the effect of one plant giving shade to another, or as dramatic as one animal eating another. The basis for all interrelationships is energy, one of the most fundamental of physical concepts.

Energy is the power by which anything acts to move, grow or cause change. It is necessary for all plant and animal life. The major distinction between plants and animals is the way they obtain nourishment or energy to grow. Most plants ***(flora)*** are stationary and convert radiant energy from sunlight into chemical energy that produces cells and tissues, and permits growth. This process of energy conversion, which allows plants to manufacture their own food, is known as ***photosynthesis***. Animals ***(fauna)*** move about and obtain their energy by eating plants or other animals.

Plants are known as ***primary producers*** because they utilize the sun's energy and chemical nutrients in soil and water to manufacture their own food. They produce energy that then is consumed by plant-eating animals ***(herbivores)***. The energy eventually is transferred to all other animals, including those that eat other animals ***(carnivores)*** and those that eat plants as well as animals ***(omnivores)***. Herbivores are ***primary consumers*** because they get their energy directly from primary producers—plants. Carnivores and omnivores are ***secondary consumers*** because they get their energy by eating other animals, thus indirectly from the primary source.

The transfer of energy from one living organism to another often is referred to as a ***food chain*** (Figure 2). One organism uses another for food and, in turn, is consumed as food by a different organism. Every living thing in an environment gets its energy from something else. The process sounds simple, but it is not. For example, one food chain begins with a single blade of grass. That blade is consumed by a grasshopper, which is eaten by a prairie deer mouse. The mouse then is eaten by a coyote.

Of course, there are millions of food chains because there are many ***species*** of plants and animals. Most animals eat more than one kind of food, depending on what is available to them when they need energy. In any environment, a number of food chains forms a complex, interrelated system known as a ***food web*** (Figure 3).

Within a single food chain, such as the grass-to-coyote example, the actual transfer of energy from the organism being eaten to the consumer is not very efficient. Each time an organism is eaten, only about 10 percent of its energy is transferred to the consumer in the process of converting food to body tissue. Unlike many materials in the environment, energy cannot be used over again, so an organism must continually obtain its energy needs from

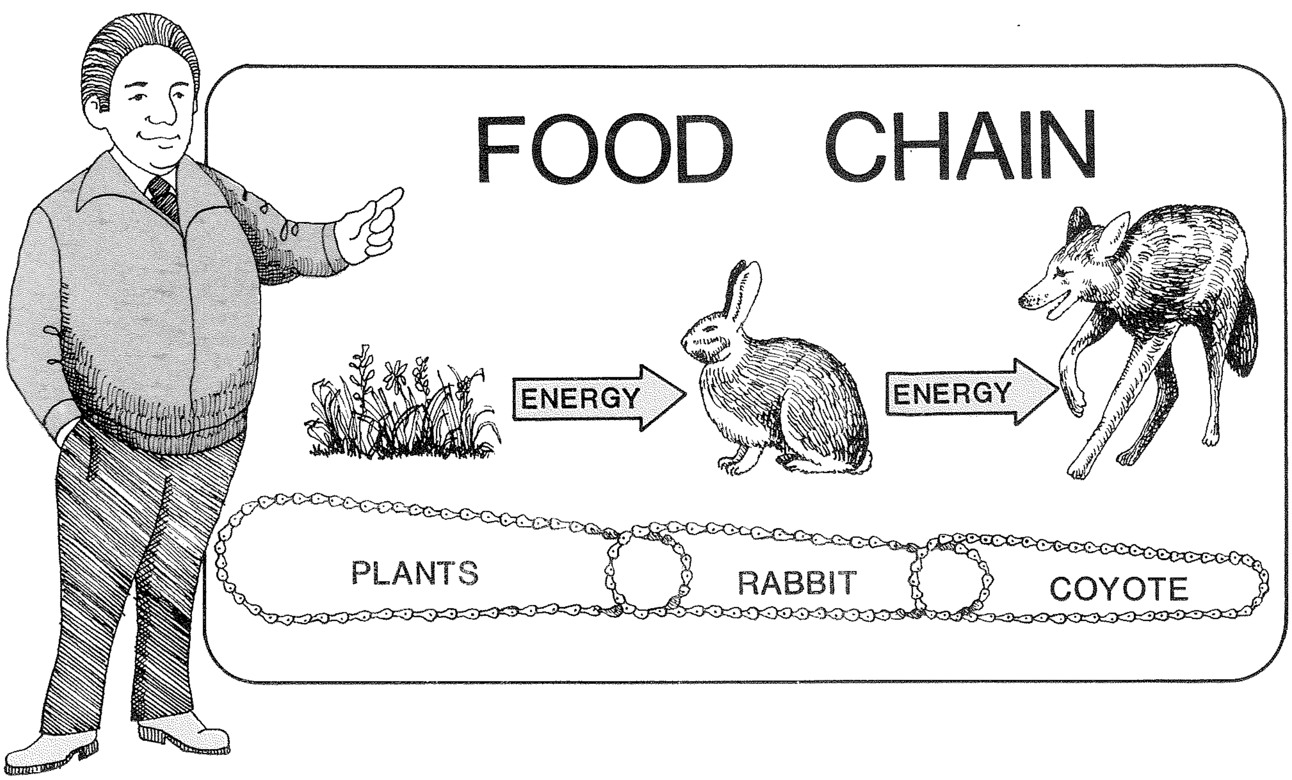

Figure 2. Energy for life is transferred along food chains.

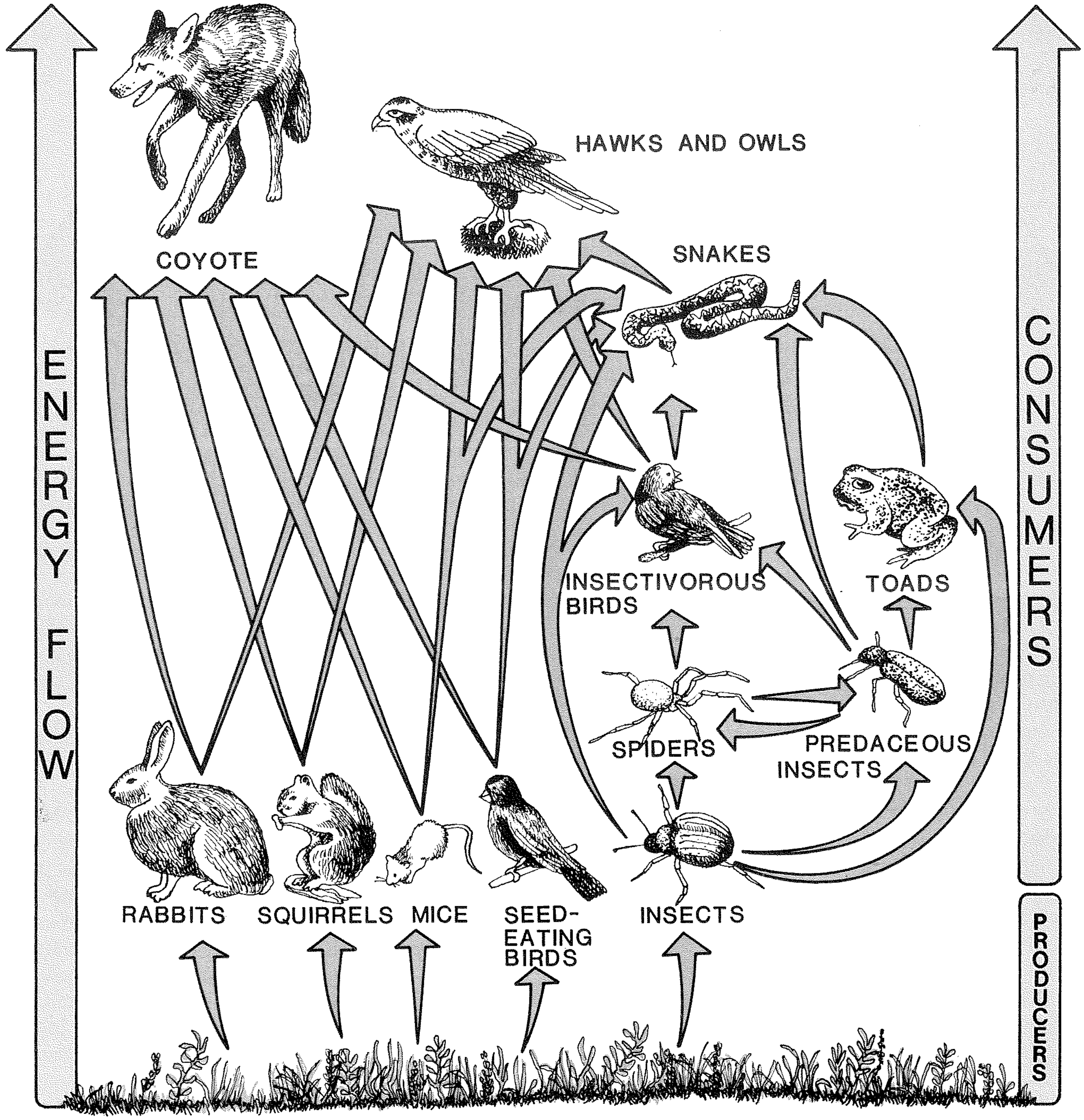

Figure 3. Food web. The many food chains in a given area form a complex food web.

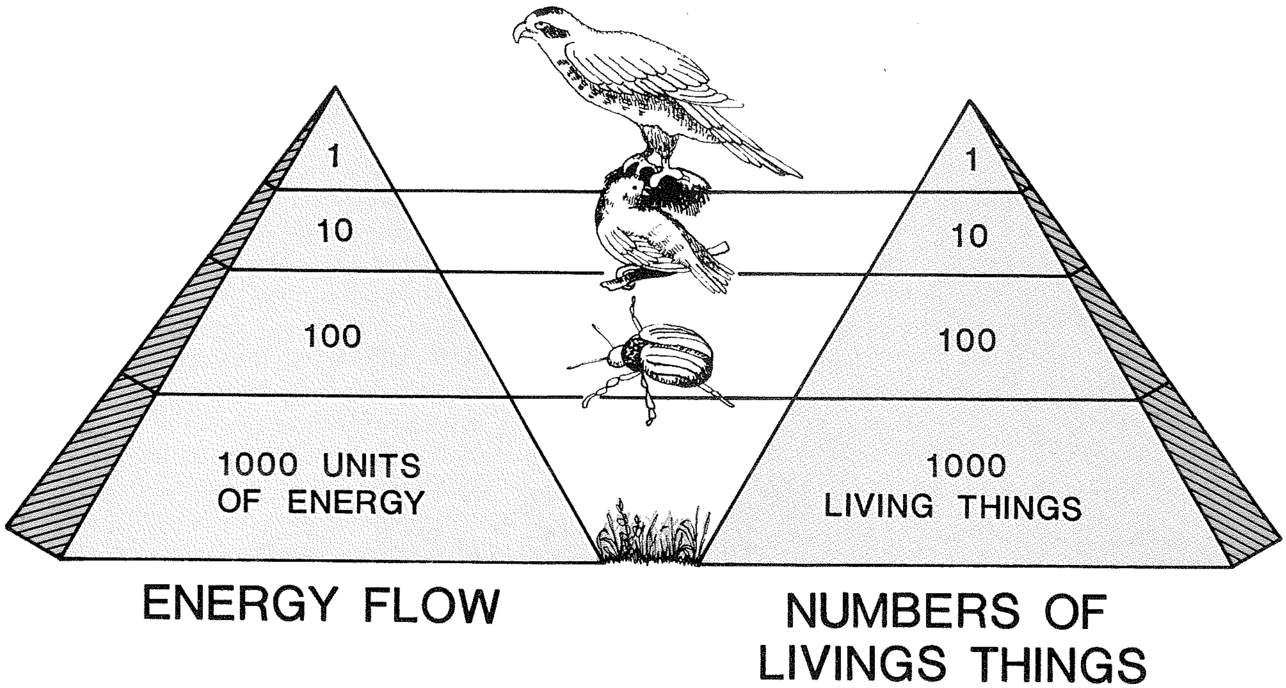

Figure 4. Ecological pyramid. The numbers and energy relationships of plants and animals in a given area form pyramid. Total stored energy and, usually, the number of living organisms are greatest at lower levels, and both decrea at each successive level upward.

outside sources. Therefore, at least 10 times more organisms are required at lower levels in a food web than in successive, higher levels. Supply of energy is illustrated by an ***ecological pyramid*** (Figure 4). When an animal consumes a plant or another animal, energy used to heat and build its own body system is unavailable to higher levels in the pyramid. Likewise, energy also is dissipated into the atmosphere as heat and is lost through the discharge of body wastes.

When plants and animals die without being eaten by other animals, they gradually decompose with the aid of tiny, living organisms such as fungi, bacteria and protozoa. These ***decomposers*** break down excrement and dead plant and animal tissue into simple forms of ***nutrients*** that are absorbed as food by plants. So, energy that begins with plants and eventually gets to the coyote ultimately is returned to the soil for new plants. This pattern of events is the way life is sustained on Earth. It is known as life's ***energy flow***.

Within the energy flow, there also is a ***mineral cycle*** that is very important to life. Minerals are formed by chemical elements that combine in soil, water, air and living organisms. Minerals are a major source of nutrients needed for growth of plants and animals. Chemical elements, chemical compounds and minerals taken from the soil or air by plants are passed along food chains a eventually return to the air or soil when plants and anim die. Decomposers convert animal wastes and plant a animal tissues to mineral nutrients that plants and ev tually animals can use.

Some elements, such as oxygen, come primarily f the air. Others, such as phosphorous, come from r (Figure 5). Rocks are formed by changes in the Ea heat and internal pressure over millions of years. Min in rocks become available to plants when rocks ch to soil through the process of ***weathering***. This pr breaks rock into small particles through temper changes, chemical reactions with water, and other ences. The materials in rock particles and other soil r are dissolved by water and carried into plant roots cycling through plants, animals and soil, minerals tually may become rock again if deposited in lo and compressed by the weight of sediments or materials.

Unlike energy, chemicals and minerals can b over and over again—a process known as ***rec*** Energy for people comes from recent meals, chemicals and minerals in our bodies may on been in the bodies of dinosaurs!

Figure 5
transfer

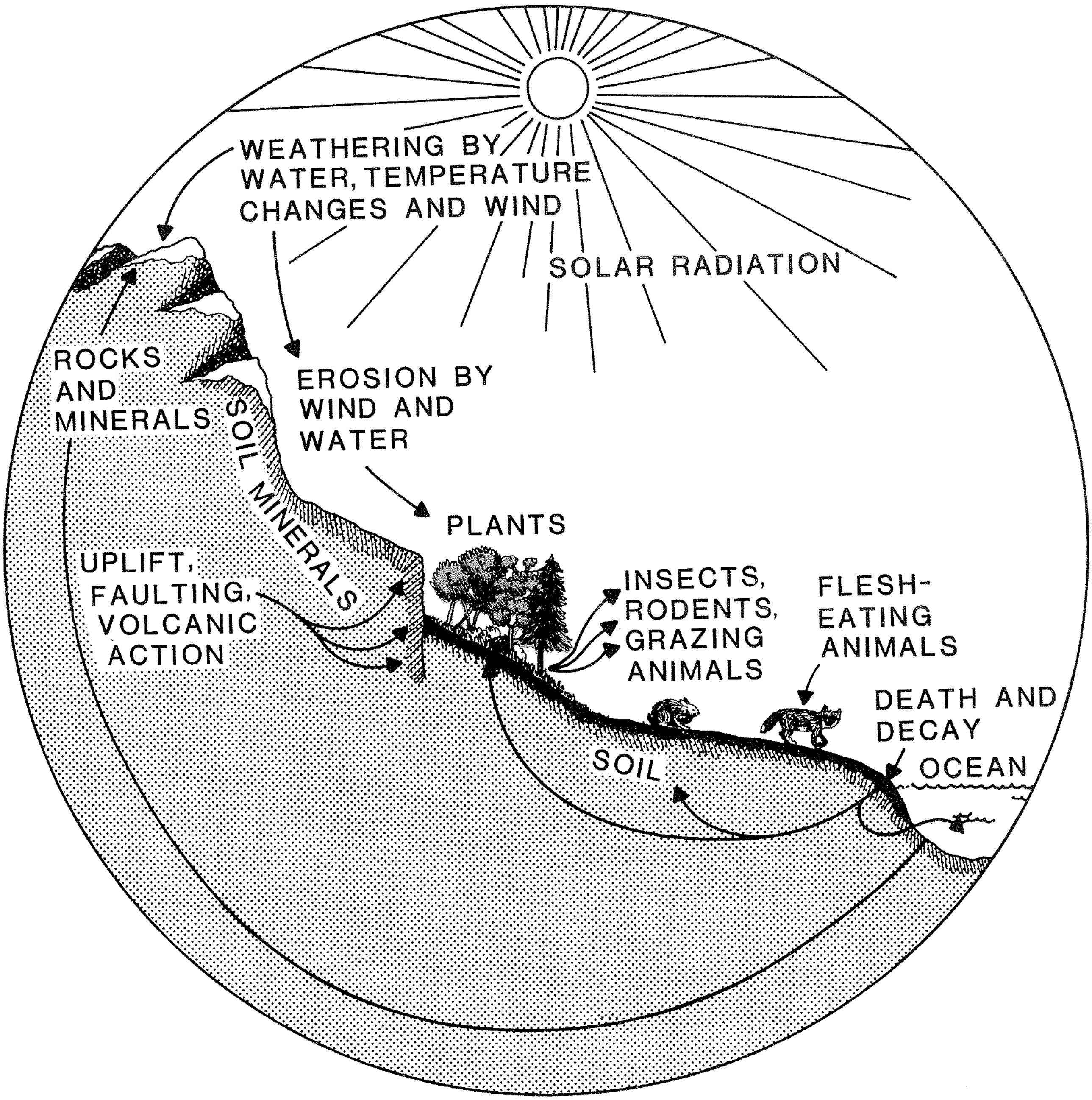

Figure 5. The mineral cycle. Weathering and erosion release minerals from rocks for use by plants. Minerals then are transferred along food webs and eventually return to the soil by decomposition of dead plant and animal tissues.

Soil

Soil is made up of matter that is ***organic*** (living, once alive, or produced by a plant or animal) and ***inorganic*** (nonliving, never alive and not the product of a living organism). It contains minerals, air and water needed by all plants, the primary producers of energy from sunlight. Soil also provides an anchoring place for many plants and a home for small organisms.

Quality of life in any environment, to a great extent, depends on soil characteristics. From one area to the next, soil differs in depth, water-holding capacity and mineral content. Loamy soil, for instance, with its high percentage of organic particles (***humus***) is more fertile and holds water much longer than does sandy soil. More plants grow in loam than in sand. Generally, the greater the variety and number of plants, the more diverse and abundant are the wildlife populations.

Climate and Weather

Extremely important to any environment is the amount of light, heat and water received from the atmosphere. Living organisms require a certain amount of heat and water. Each kind of plant also needs a definite amount of sunlight as well. How much light, heat and water an environment receives is a function of daily and yearly movements of the Earth, location of the environment on the Earth, weather and climate.

Weather refers to short-term (hourly, daily or weekly) atmospheric conditions of a given area. For example, outside your home right now the weather may be sunny, hot and humid. In an hour or perhaps tomorrow, it may change to rainy, cool and windy.

Climate is the total, average and extremes of weather in a given area over a longer period of time (months, seasons or years). The climate of a given area is determined by the long-term combined effect of all atmospheric factors, such as solar radiation, wind, precipitation, barometric pressure, humidity and cloud cover. However, we tend to classify areas as having a certain climate according to the long-term combined effect of only three factors—solar radiation, precipitation and humidity. This is done because these three are the most important to the growth of plants and, therefore, other forms of life as well.

Sunlight and Heat

Heat and light received from the sun, collectively known as ***solar radiation***, do not reach all parts of the Earth in equal amounts or for equal lengths of time. Heat and light vary in intensity during the course of a day as the Earth rotates on its axis, and throughout the year as it revolves in an orbit around the sun. Polar regions receive much less solar radiation than do tropical regions because the sun is farther from the poles than from the equator, and because of the Earth's tilt on its axis, which prevents direct sunlight from reaching the poles for long periods each year. As a result of the daily, seasonal and annual distributions of solar radiation, the Earth has specific ***climatic zones***—ranging from polar to temperate to tropic—which relate primarily to temperature differences.

Solar heat is a form of energy measured in degrees of relative warmth called ***temperature.*** Plants and animals have certain high and low limits of temperature that they can tolerate. Beyond those limits, each organism cannot survive. Temperature also influences rates of reproduction, growth and survival of living things. For example, in a temperate climate, if cold weather persists late in the spring, most plants will not develop properly, nor will the insects and rodents that feed upon them. A poor supply of insects and rodents then will decrease the well-being of hawks, foxes and other animals. Therefore, temperature—as a component of weather—influences the strength or weakness of food chains and webs.

Warm-blooded animals, such as birds and mammals, have insulated bodies and regulated internal temperatures regardless of the amount of heat in their environments. ***Cold-blooded animals***, such as reptiles, fishes, amphibians and insects, have no way to regulate their own body temperatures. So, their bodies usually are the same temperature as their environments.

Tolerance of most warm- and cold-blooded animals to external temperature extremes is influenced by the amount of moisture in the air, known as ***humidity.*** Hot or cold temperatures in dry climates generally are easier for most animals to cope with than similar extremes in wet climates.

Water

Water takes many forms in the environment: water vapor is a gas; standing water is a liquid; and frozen water or ice is a solid. In the atmosphere, it is humidity. It is precipitation when it falls to the ground as snow, sleet, rain, hail and other forms. In oceans, lakes and streams, it is surface water; and it is part of every cell making up the bodies of plants and animals. No matter where or in what form it occurs, water eventually is recycled through processes of evaporation from streams, lakes and oceans, transpiration from plants, and respiration from animals (Figure 6)

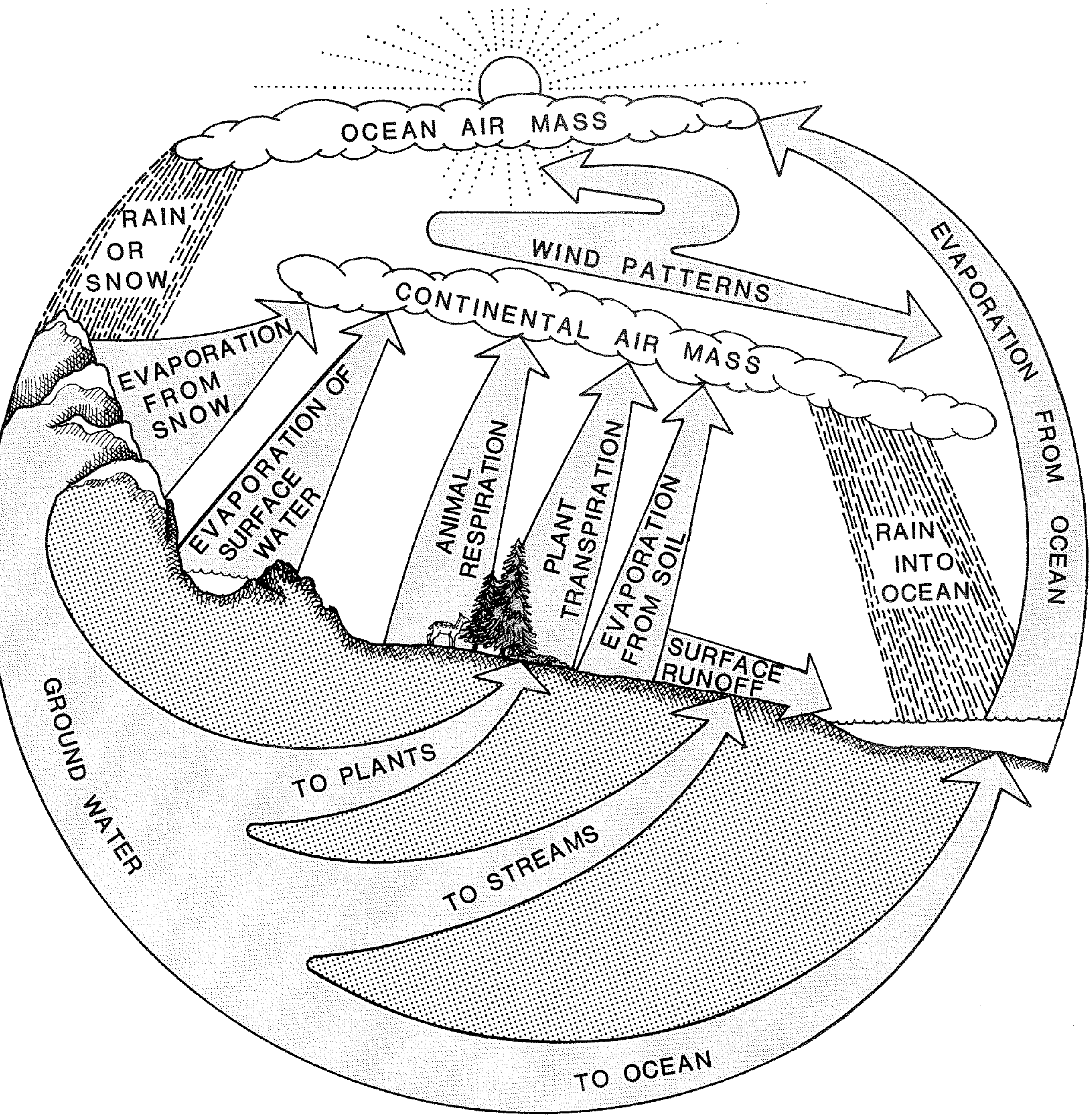

Figure 6. The hydrologic cycle. Water is recycled continually between earth and sky by many different but important processes.

Similar to solar radiation, water differs in amount and availability from place to place throughout the world. For example, deserts are almost always dry. Tropical forests tend to be very wet. There are many other climatic zones—such as humid, subhumid, semiarid and others—determined by annual precipitation.

Air

Air is another essential element of climate and condition of the environment. It affects all life in many ways. ***Oxygen*** is a gas in the air that is especially vital to animal and plant life. Oxygen given off by plants and from other sources is taken in by animals through lungs, gills and other specialized breathing mechanisms. It also is transported in blood to the many cells of the body to be used for every life-support process. At high elevations, air contains less oxygen, so animals' hearts must pump harder to get blood and, therefore, oxygen to all parts of the body. Animals must either adapt to different conditions of the air, move to a different environment, or perish. For example, animals living at high altitudes have larger hearts than do their relatives at lower elevations. Air also supplies plants with nitrogen and carbon dioxide as well as oxygen.

When traveling through the mountains or in an elevator you may notice an increasing or decreasing pressure in your head as you go up or down. Your ears probably pop. These occurrences are the result of rapid changes in ***atmospheric pressure.*** The atmosphere is denser close to the Earth, at sea level, than higher in the sky. Unlike water in oceans, which is nearly incompressible and weighs the same at the ocean floor as it does at the surface, air at sea level weighs more than air at the top of mountains. Although there is air in our atmosphere hundreds of miles above the Earth, more than one-half of our breathable air is located within 3½ miles (5⅗ kilometers) of its surface. Because it is highly compressible, the air at or near the Earth's surface is much heavier and less stable than air further up. This accounts for weather changes. Therefore, air pressure refers to the density of air at a given time in a given place.

Our weather is caused by high-pressure (fair weather) or low-pressure (inclement weather) air masses which move across the country. To a great extent, weather forecasters rely on high- and low-pressure information to make their predictions.

Biotic Zones

Plants and animals are distributed throughout the world according to ***biotic zones*** that are influenced in a general way by climatic zones. The geographic relationships of temperature and precipitation zones form climates that are favorable to some species and unfavorable to others. Biotic zones range from tropical rain forests near the equator to open tundra that spreads across the Arctic. Between the extremes are grasslands, deciduous forests, coniferous forests and other vegetative communities. Similar zones can be seen when one travels up a mountain (Figure 7).

All the components of Nature should be considered when thinking about where plants and animals live. When all the components are combined, they form different ***ecosystems***, each occupied by a characteristic ***community*** of organisms.

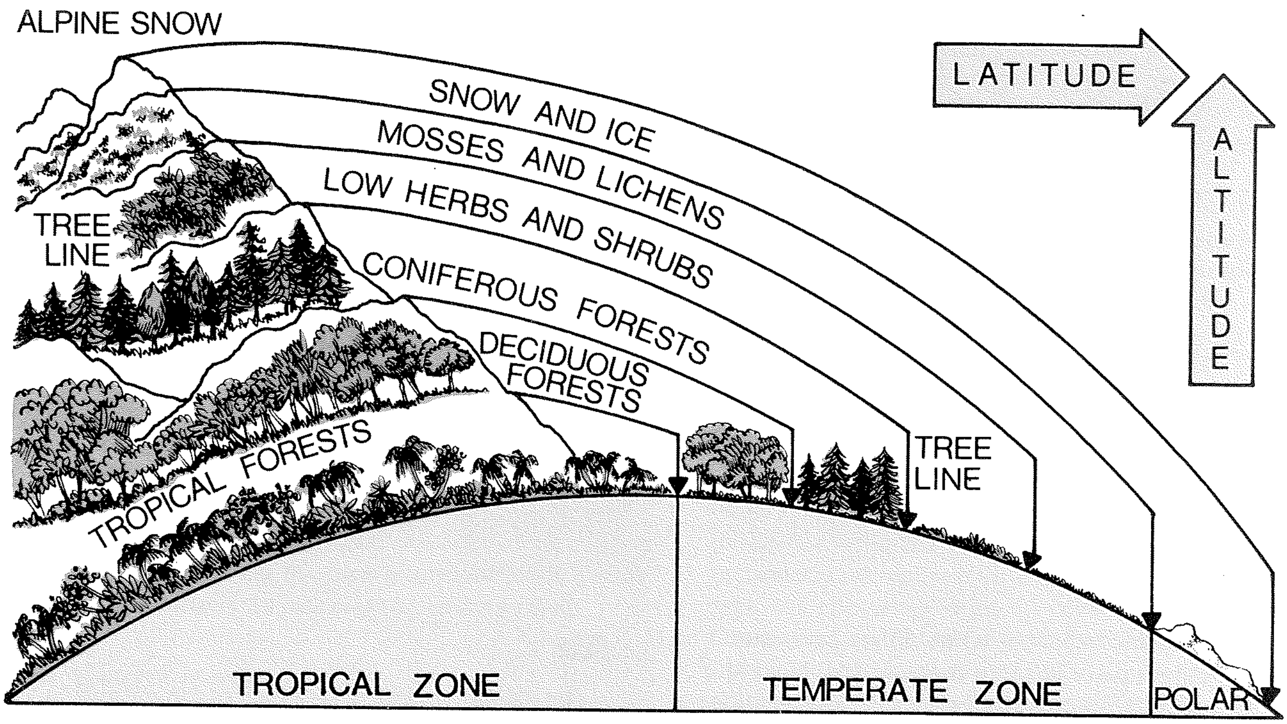

Figure 7. Altitudinal zones of vegetation (from sea level to mountain tops) are similar to latitudinal zones of vegetation (from the equator to the Earth's poles).

The term ***habitat*** is used to indicate where one or more animal species can live within a given environment. Essentially, habitat is the "home address" for a species. For example, the habitat of gray squirrels is hardwood forests, and the habitat of pronghorn antelope is the plains.

Habitat has three main ingredients—food, shelter and water—which form the ***habitat triangle*** (Figure 8). Both the amounts and qualities of those ingredients are important. Also, they must be available in the proper proportion and within accessible distance. For example, if shelter is not within easy access of food and water, it may remain unoccupied by animals that otherwise would use it.

Space is also an important ingredient. Some animals can live close to each other, while others must live far apart. In either case, if they become too crowded, problems arise as a result of competition and disease. So, for all animal populations, habitat must provide an ample amount of properly arranged and good quality food, shelter and water—with enough space to prevent excessive crowding.

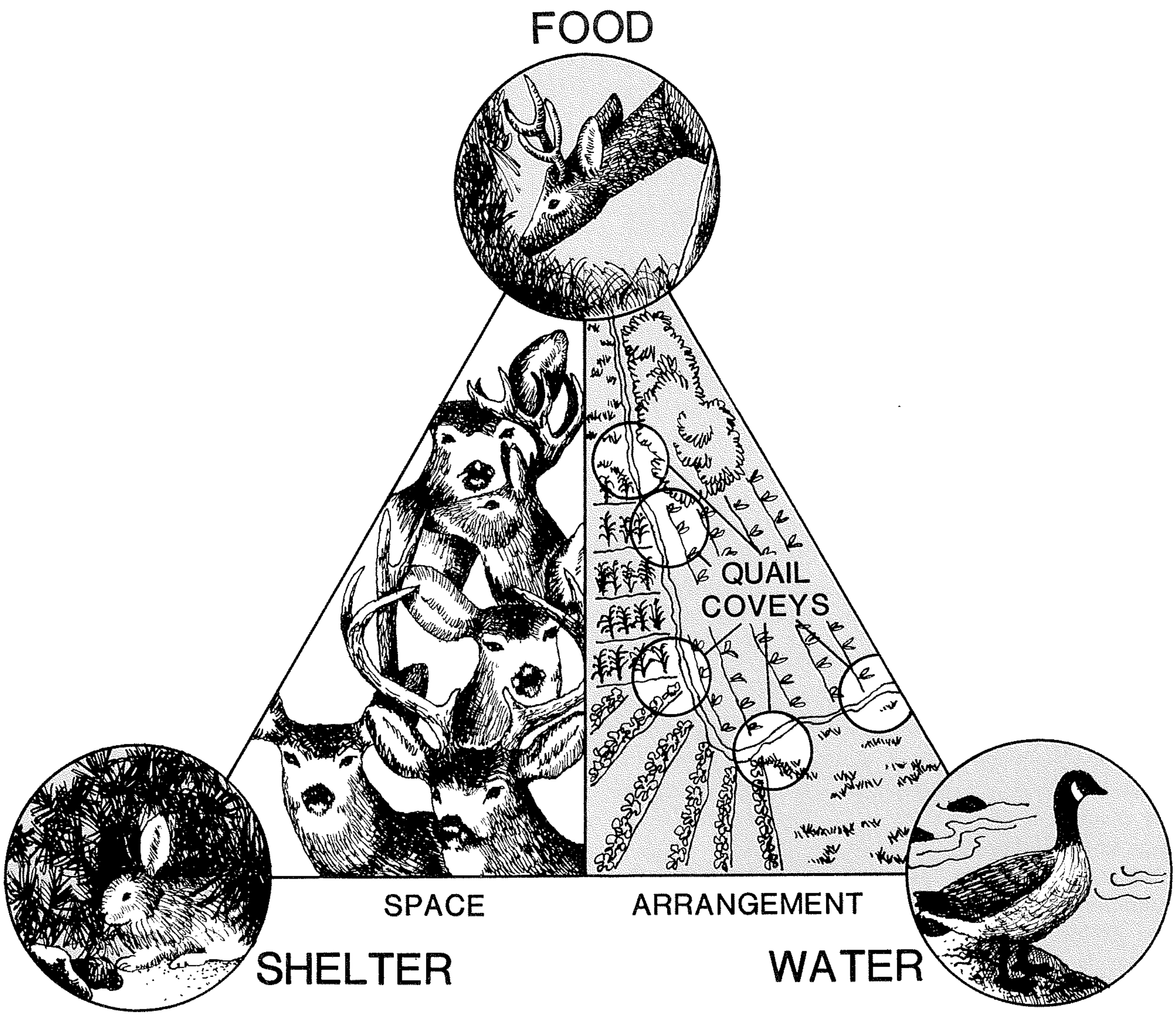

Figure 8. Habitat triangle. Food, shelter and water are the essential ingredients of any habitat. For animals to occupy a habitat, each ingredient must be of good quality, properly situated in relation to the other ingredients, and in ample supply.

The role or function that an animal carries out in its habitat is termed its ***ecological niche.*** A niche represents the "profession" of the animal. The profession of a squirrel is, in part, to eat nuts and seeds and then to be consumed by other animals. The pronghorn eats plants and then may be eaten by a coyote. If it dies instead of being killed as a source of food for other animals, its remains may decompose and recycle through soil as nutrients for plants.

Wildlife managers enhance potential survival of animals by managing habitat, and by controlling mortality in order to maintain desirable numbers of animals. When all the main habitat ingredients are present, wildlife is capable of thriving.

Food

Food is any material taken into an animal's body that provides energy to carry out necessary functions. Lack of food causes malnutrition, which makes animals more susceptible to disease and vulnerable to predation and adverse weather. Lack of the proper quantity and quality of food often causes limited production of young.

Food requirements for any animal depend on that animal's location, age, size, sex, behavior and the season of the year. In the North, winter snow and ice sometimes cover nutritious plant foods. The arid Southwest may not get enough moisture during hot spring and summer months for certain plants to grow. In both examples, deer may die because their food supply is inadequate in terms of quality, quantity or both. Diets of animals also change with age and season. For example, young birds eat many insects because they require relatively large amounts of protein. The nutritional needs of these same birds at an older age may allow them to consume mostly seeds or berries, which have less protein than do insects. Wildlife managers must learn the different food requirements of animals and then help maintain proper quantities and qualities of food through land and water management practices.

Shelter

An animal's ***shelter*** serves five functions. It provides: living space—a place to feed, play and loaf; a place to raise and care for young; a place of protection from adverse weather; a place to rest and sleep; and a place to escape from predators.

One usually thinks of shelter as vegetation, but shelter requirements also may be provided by a rock pile, hole in the ground, hill, cliff or hollow in the soil. Vegetation, however, is what managers often manipulate to provide shelter for animals.

Water

Water is necessary for many purposes. It keeps cells in body tissue alive; it is used for cleansing the body; it is vital to the production of food supplies; and it also serves as shelter for some animals. Some species need to consume water daily, others need it weekly. Some animals have body chemistries that extract and use water from plants they eat. In an area that receives 50 inches (128 centimeters) or more of precipitation per year, the availability of water may not be a problem for wildlife. However, in dry climates with only 6 inches (approximately 15 centimeters) or less of annual precipitation, water shortage can be critical to animals.

Space

The area within which an animal normally must travel to secure its needs is called its ***home range.*** This area reflects an animal's requirement for ***space*** and the arrangement of its other main habitat ingredients.

Home range for one species of animal may be much different from the home range for others. A rabbit may live its entire life within 1¼ acres (½ hectare) of land, while a wolf may travel over an area of 25 square miles (64 square kilometers). Generally, small animals have small home ranges and big animals have large home ranges. Most waterfowl have a combination of the two—a small home range in the breeding season and a large one in winter. Like waterfowl, some animals ***migrate*** or move great distances between their summer and winter ranges; thus, home ranges can be located in different habitats and may be temporary during migration. Inside the home range, an animal may have an area it defends against intruders of the same species and sometimes against other species. This is a ***territory***, where an animal spends most of its time and often raises its young (Figure 9).

In any habitat, animals cannot be overcrowded for two primary reasons. First, the health and reproductive success of wildlife are determined by the quality and quantity of habitat ingredients. Dense wildlife populations competing for those ingredients can have adverse effects on reproductive success, rates of death and the basic health of individual animals. Second, a social system within a particular species' population can limit the size of its numbers. Some species, such as Canada geese, tolerate many of their own kind; but others, such as wolves, tolerate only a few other wolves. Pressures within the social system can limit the number of animals on a home range even if the habitat has enough food, water and shelter for more animals.

Ecological Succession

On any area, habitat undergoes continual change. Where people do not interfere, this change usually is gradual and progressive. Known as ***ecological succession***, it simply is the process of natural aging. Even without

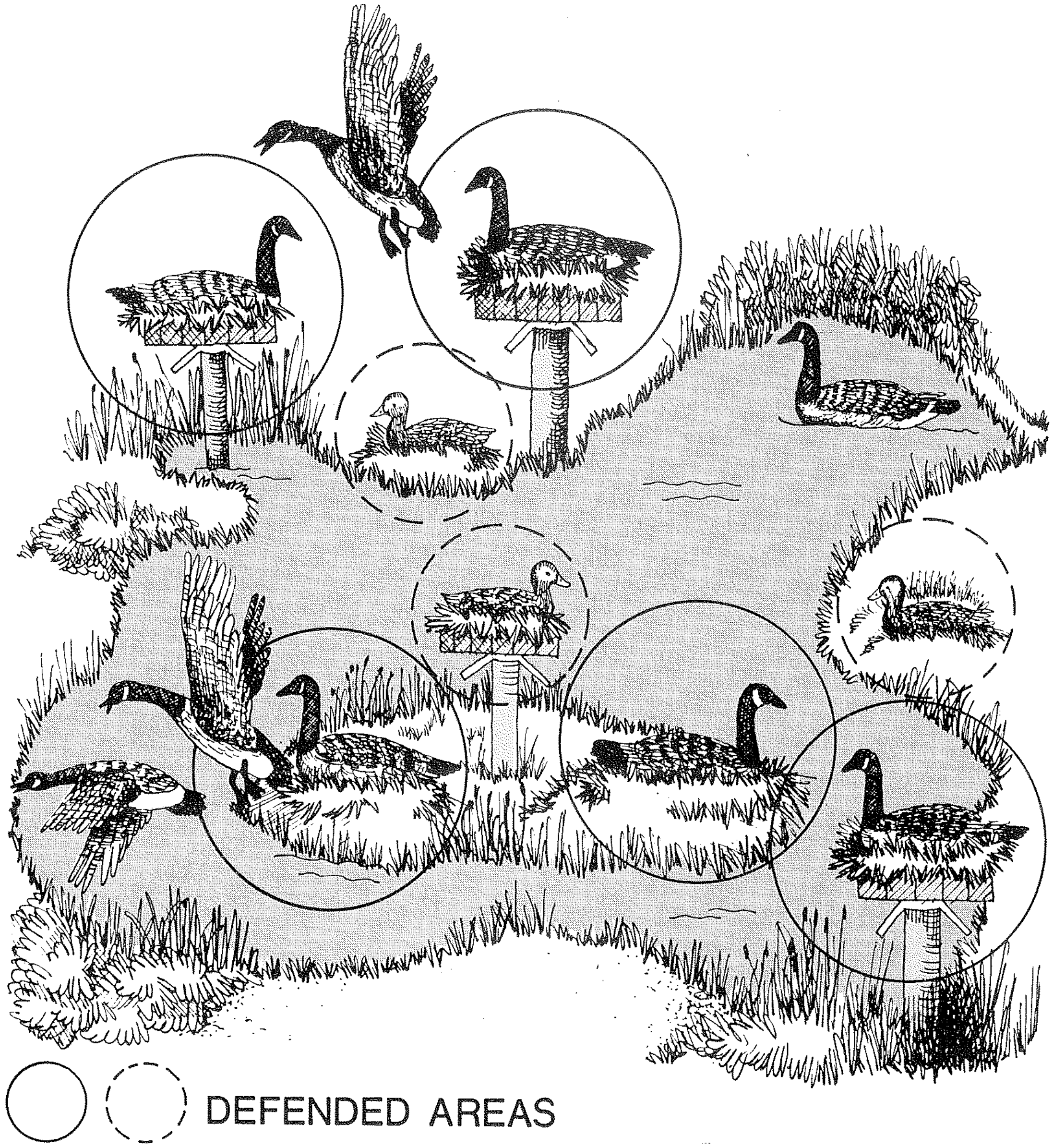

Figure 9. Nesting territory. Geese and other wildlife species normally defend portions of their home ranges against predators and other individuals of the same species.

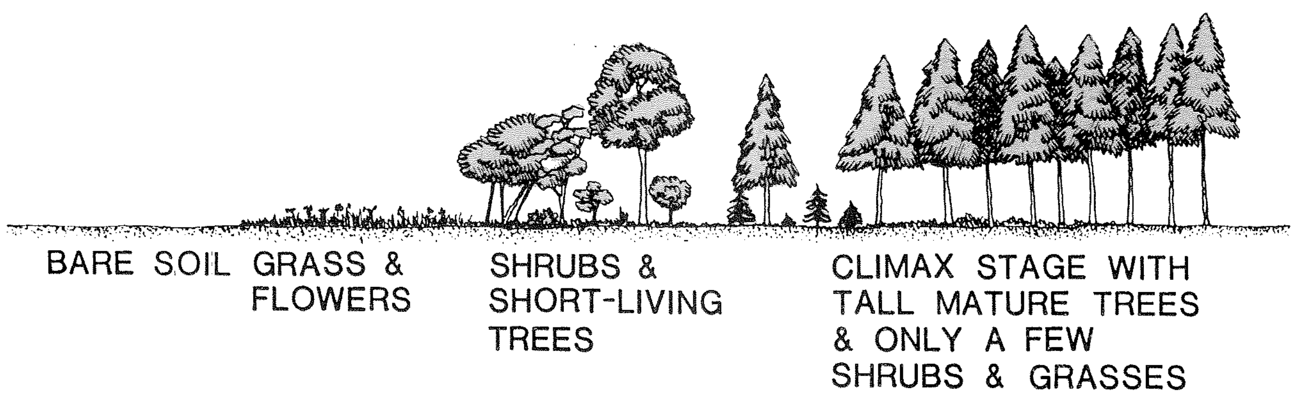

Figure 10. Ecological succession. Over time, bare soil may support a mature forest through stages of natural aging.

human interference, ecological succession can be set back by natural disturbances such as wildfires, insects and diseases.

Various stages in ecological succession occur in the transition of an area from bare ground to evergreen forest (Figure 10). You may have seen similar changes to a vacant city lot. Initially, one type of plant begins to grow, and then others appear. Over the years, the bare soil becomes covered with grasses and other small plants, then shrubs and finally trees. Wildlife managers usually speak of the grasses and shrubs as early stages in succession, and trees as the climax stage. But in some places, such as prairie grassland, vegetation does not progress to the tree stage because the environment is not suited for trees.

Just as vegetation in a particular area changes over time, so do the animals that live there. Different species and populations occupy different successional stages of vegetation on the same area, as shown in Figure 11.

Vegetation of early stages in succession, such as shrubby plants, often occur at the edges of ponds, fields and forests. Many animals can occupy this ***edge cover*** because it combines the food and shelter ingredients of several habitats. Diversity of habitat tends to encourage a diversity of wildlife.

Carrying Capacity

The quantity, quality and distribution of food, shelter and water in a habitat, plus the social system of the animals living there determine carrying capacity. ***Carrying capacity*** refers to the number of animals of one or more species that a particular habitat can support at a given time. That capacity may vary by seasons of the year, and it usually changes as a result of ecological succession. Any ingredient of habitat that is deficient and prevents an animal population from increasing is called a ***limiting factor.*** More than one factor may affect a population at the same time.

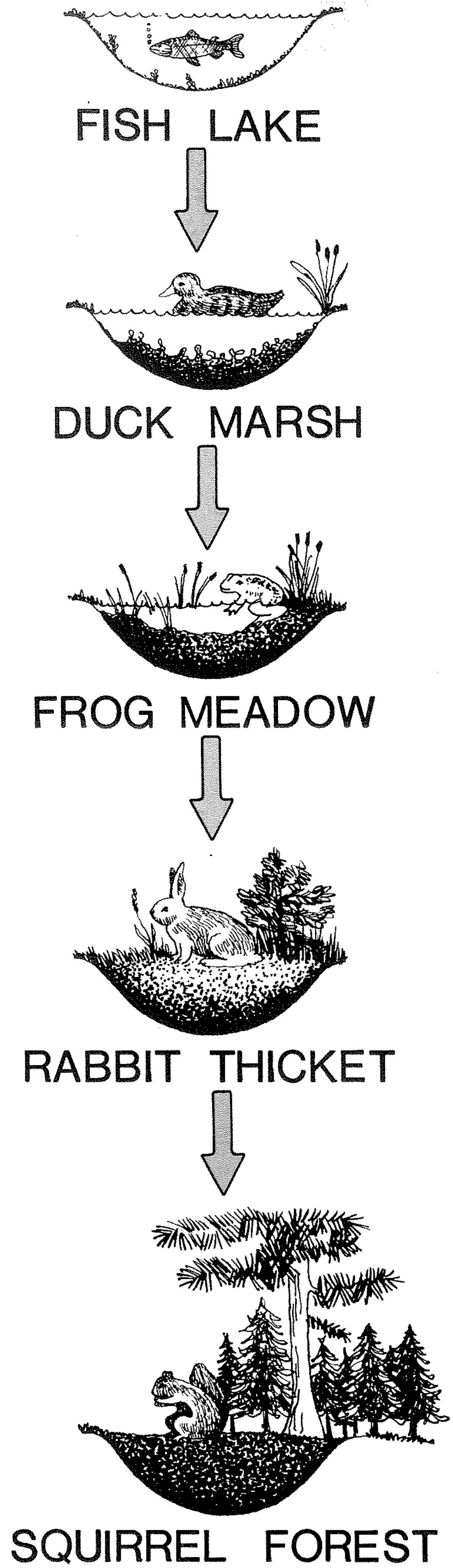

Figure 11. As landscape changes through ecological succession, new habitats develop. Consequently, its composition of animal species also changes as food, shelter and water become available in different quantities and qualities, and in new arrangements.

The goal of wildlife managers is to maintain, modify or develop habitats that will produce a desired variety and number of animals. To do this, managers need to understand not only the habitat but also the factors that influence the abundance and distribution of specific animal species and their populations.

A ***population*** is the number of animals of a specific species in a certain habitat. The fate of individual animals usually is not important to the fate of that species' population. Nature insures the survival of populations by producing more individuals than can survive. Surplus individuals serve as food for predators or die from other causes. Survivors become the new generation and, when mature, reproduce to maintain the population. Wildlife populations are continually changed and renewed, thus the term ***population dynamics.***

Why Populations Change

Animal populations may change in any habitat as a result of reproduction, social conflict, movements of animals, ecological succession or disturbance, and death.

Most animals have the ability to produce excess young, which is a major survival mechanism. Production of new individuals (***natality***) is influenced by at least seven factors: conditions of the environment and habitat; minimum breeding age; maximum breeding age; number of young produced per year; length of life after maximum breeding age; sex and age composition of the population; and mating habits related to age and sex compositions of the population.

Animals add to or subtract from populations by moving into or away from a habitat. Young animals often are forced to leave the area where they were born because the immediate habitat's carrying capacity allows for only a certain number of home ranges and territories. Sometimes the habitat changes, which affects the number of animals it can accommodate. Movements also govern some species' seasonal habitats. Songbirds and waterfowl, for example, migrate between summer and winter habitats. Mule deer migrate within their home range, from high mountain summer ranges to winter ranges at lower elevations.

Various death (***mortality***) factors, individually or in combination, take animals from a population. Some of those factors are starvation, weather, predation, disease, pollution, accident, hunting and old age.

The Population "Bathtub"

Now let us examine the interrelationships among factors of reproduction, movement, ecological succession, carrying capacity and death. We can think of wildlife populations as water in a bathtub (Figure 12). The tub represents a habitat and social system. Water going into the tub through the faucet signifies births and ***immigration*** (inward movements). Water going out of the tub represents deaths and ***emigration*** (outward movements). Too much water going in (births and inward movements), without that same amount going out (deaths and outward movements) will fill the tub, and water (animals) will overflow (lost from the population). The size of the tub represents the carrying capacity of a habitat at a given time.

There are a number of ways that a population of animals (water) in a habitat (bathtub) can increase. The ways include: increased reproduction; increased immigration; decreased death; decreased emigration; and improved carrying capacity of the habitat.

The rate and success of reproduction increase when habitat conditions are favorable. Reproductive rate and success decrease when conditions are bad. For example, lynx raise more young and move into new areas when habitat conditions support a high population of snowshoe hare, its major source of food. When hare populations are low, fewer lynx are born and fewer young survive.

Carrying capacity of habitat can be improved by gradual ecological change over time or through accelerated change following disturbance such as by fire, insects or diseases, or purposeful manipulation by people of the habitat base (increasing the size of the bathtub). Improved carrying capacity means, in essence, more food, water and shelter available to animal populations in a given habitat. For example, a marsh can be improved for geese and some other wildlife of the marsh if food and shelter resources of that marsh are increased and arranged in a manner that reduces social conflict.

Proper quality and adequate quantity of food, shelter and water are the best defenses against high rates of death. All living things eventually die regardless of habitat conditions, and more young are born than will survive to reproduce. The young that do not die will seek territories left by older animals. If none are available or if the habitat is not increased substantially, social conflict may lead to emigration or death. Think what it would be like if one pair of robins raised six young in your backyard, and all of their young survived and raised six surviving young each year thereafter. In five years, there would be 2,048 robins (Figure 13). It would be impossible for all of them to find territories, much less food, shelter and water in your backyard.

Death is an essential factor in maintaining healthy wildlife populations. If we count animals in a population when they begin to breed in April, then later as the young were

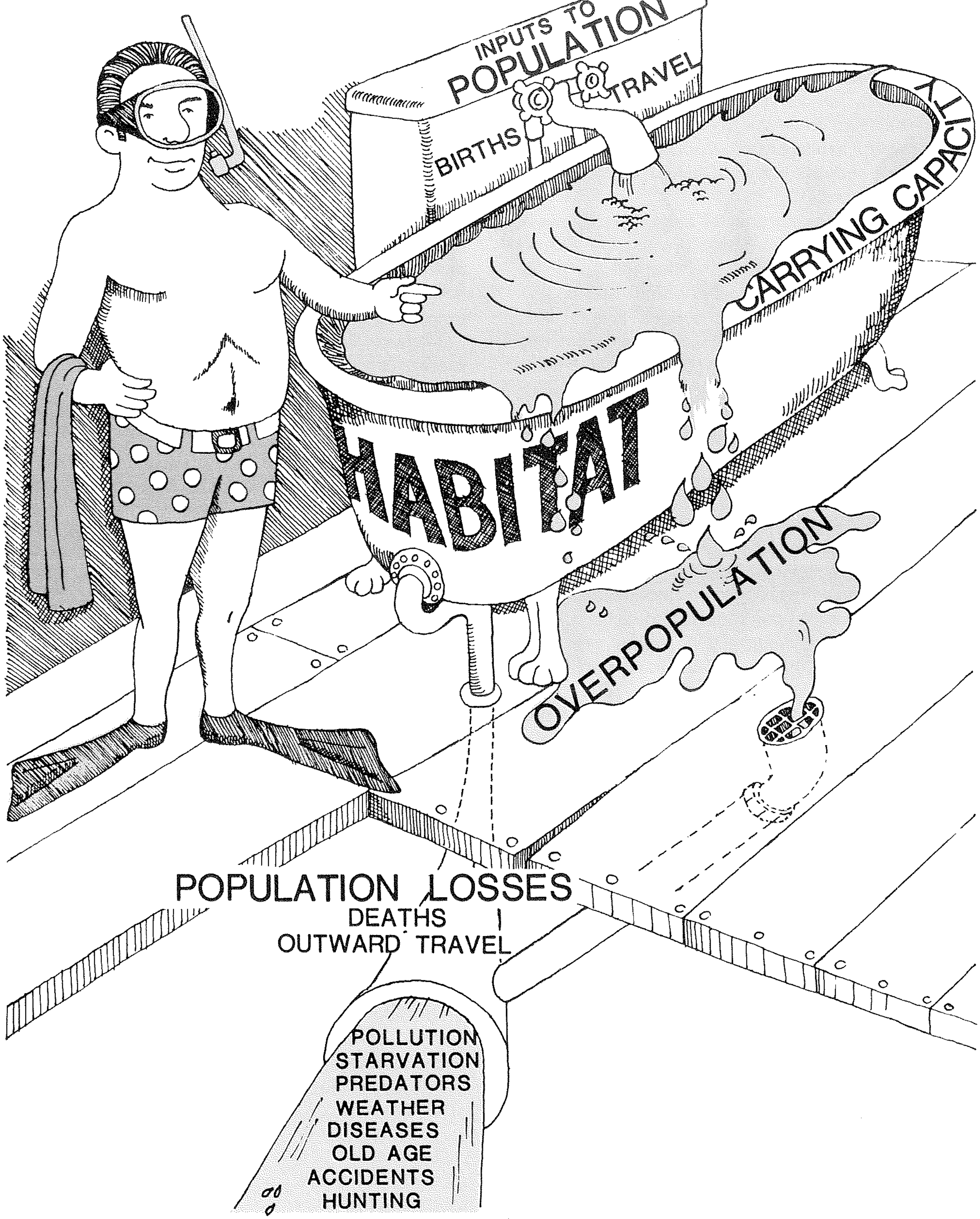

Figure 12. The "bathtub" concept of wildlife populations. Carrying capacity of a habitat is similar in principle to the water-holding capacity of a bathtub. Births and immigrations add animals to habitat. Deaths and emigrations remove animals. A population balance is achieved when the number of animals entering a habitat equals the number leaving.

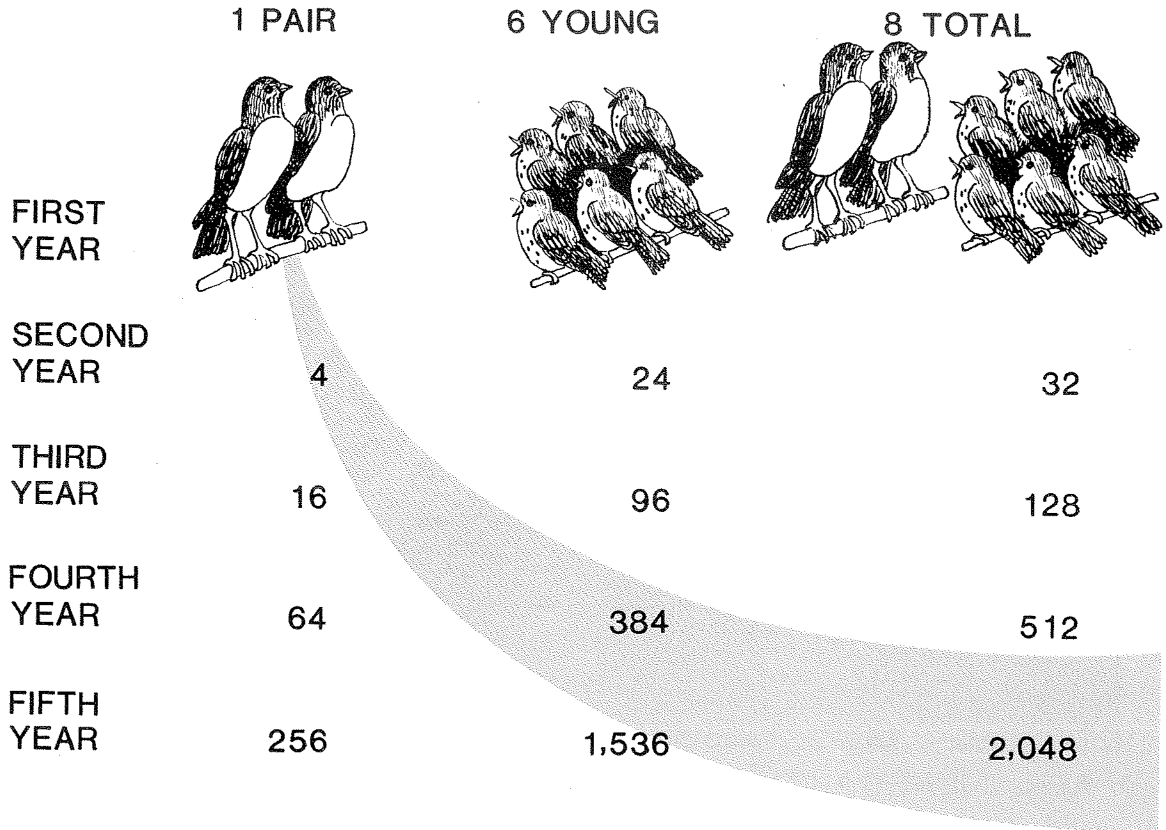

Figure 13. Potential population growth without limiting factors. A population of robins in a backyard would be astronomical in five years without normal losses to death and outward movement.

being produced, and finally as deaths remove the surplus, the population would be similar to those illustrated in Figure 14. The broken line in the illustration characterizes a ***population curve.*** The hatched portion below the curve is the ***biological surplus***, or the number of animals not needed to sustain the population. Biological surplus is in excess of a habitat's carrying capacity. Therefore, surplus animals must either emigrate or die from one of the many death factors. In the bathtub concept, biological surplus is represented by water spilling over the rim.

Population Characteristics

Population curves differ depending on the species of animal being considered. The differences are most pronounced in the rates of reproduction and death. This can be illustrated by separating animals into three general groups: high producers with short lives; medium-to-high producers with medium-length lives; and low producers with long lives.

The group of ***high producers with short lives*** includes such animals as grouse, quail, pheasants, rabbits, hares, field mice and songbirds. As much as 90 percent of their populations may die each year. Many of the animals in this category do not need to travel far from their places of birth to obtain all of their living requirements. Exceptions are many songbirds, that make long migrations to seasonal habitats.

The small animals of this group have high reproductive rates. They produce more young than are needed to maintain the population level. Bobwhite quail, for instance, will begin to breed when one year old. A pair can potentially produce 14 young each year. Without normal rates of deaths, the pair could yield 128 young within two years and 1,024 offspring by the third year. Rabbits can breed before they reach one year of age and are capable of more than one litter per year. So, even as a high percentage of these animals die, enough animals are left to produce young and keep the population strong—provided habitat ingredients are adequate and unusual mortality factors do not exist.

The group of species that are ***medium-to-high producers with medium-length lives*** is represented by ducks and geese. These waterfowl have about the same young-producing potential as animals in the previous category, but they may live six or more years. Since they live longer, they breed for more years. Most ducks breed at one year of age and most geese at two years or older.

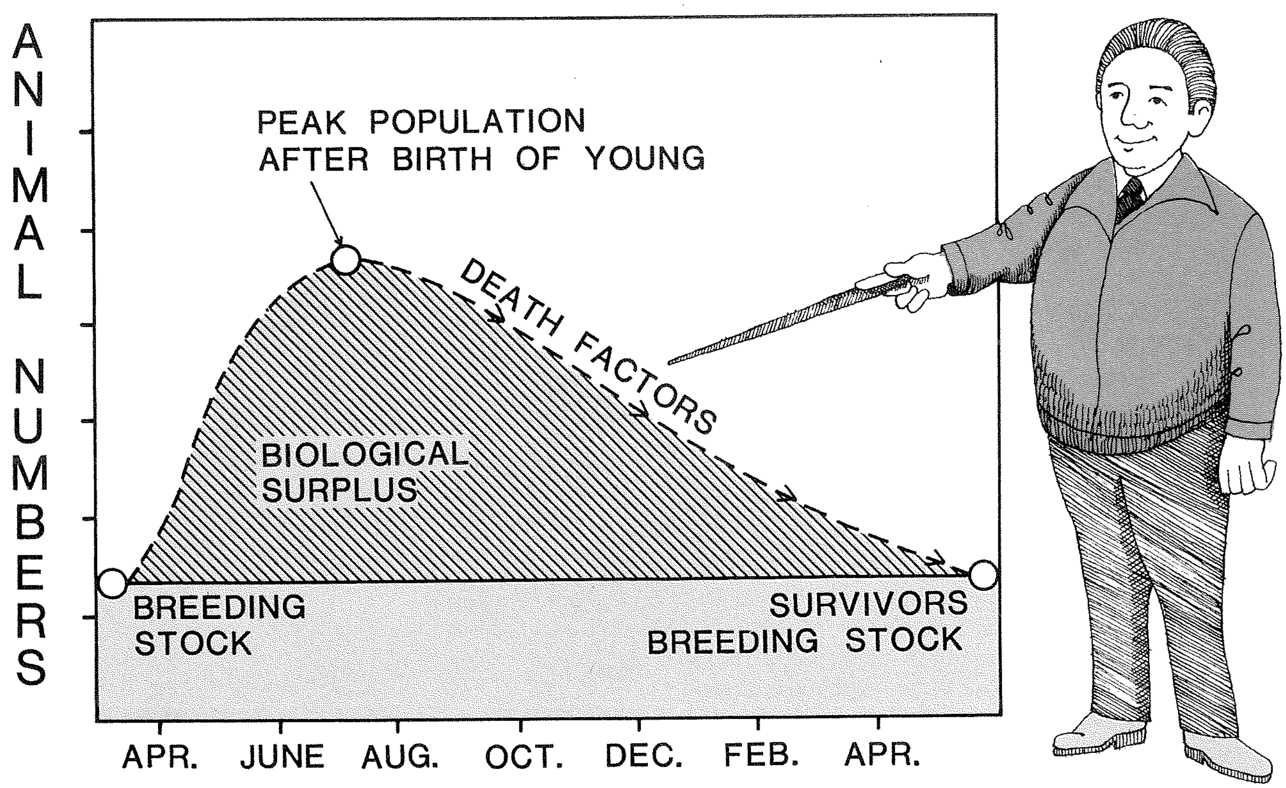

Figure 14. Population curve. Each population of animals annually produces more young than can survive to reproduce. This biological surplus is not needed to maintain the population.

The rate of death within this group is less than for the previous group. About one-half of many duck populations die each year, compared to 90 percent annual mortality for some high-producer populations.

Space requirements are greater for the medium producers. In many areas, migratory waterfowl cannot satisfy their living requirements within a single, seasonal habitat. Nesting for some waterfowl takes place in northern Canada while their winters are spent in southern United States, Mexico or Latin America. During migration to breeding or wintering habitats, waterfowl must have their food, water and shelter requirements met along the way.

The group of ***low producers with long lives*** is represented by moose, deer, elk, caribou, bighorn sheep, pronghorns, bears, coyotes and other large mammals. These species tend to live longer and need more space to survive than small animals or waterfowl. They require large home ranges to fulfill their roles and to secure their habitat needs. Some species of this group also migrate between summer and winter ranges. Only one-third or less of their populations dies each year and their reproductive rates are relatively low. Species in the deer family, for example, have one or two young per year; bears may have two cubs every two years; and coyotes have 6-11 pups per year, but they need more space to survive than do smaller animals or waterfowl.

SEVERAL ASPECTS OF WILDLIFE POPULATION MANAGEMENT

With the preceding background on habitats and animal populations, we can explore how scientific knowledge is used in applying wildlife management practices. Wildlife managers use their understanding of Nature to improve carrying capacity of habitat, and thereby promote the well-being of animal species. To maintain healthy population levels of any species, managers must examine closely the complex relationships among population dynamics of all species in a particular environment and the amount of available habitat and its quality. With scientific information in hand, managers work to maintain, create or improve habitat and, where harvesting can be permitted, set guidelines for removing individuals without jeopardizing populations.

In addition to scientific information, the management of wildlife depends on public understanding and support. Several aspects of wildlife populations and their management need improved public understanding. These include management of predators, pests and harvestable populations.

Predators

Animals that live by killing other animals for food are called ***predators.*** Foxes, wolves, coyotes, bears, hawks, skunks and owls are just a few of these species in North America. Animals killed and eaten by predators are called ***prey.*** Rabbits, grouse, mice, pheasants, prairie dogs, songbirds, deer and ducks are among the many prey species. ***Predation*** is one way in which the energy flow of life is carried out; it is an integral function in food webs.

Some persons accuse predators of killing too many prey, especially animals prized by people—such as livestock, ***furbearers*** and ***game*** (animals that legally can be hunted for recreation in a particular area)—thus lowering the prey populations. In terms of our prior analogy, predators are suspected of letting too much water out of the tub. But the facts show differently. The number of prey usually regulates the number of predators in a given habitat. When prey populations increase, predator populations also increase; and when prey decline in number, so do predators.

Under favorable habitat conditions, most mortality factors do not add new or faster drains in the bathtub, they merely contribute to a normal rate of outflow. As one mortality factor decreases in its effect on wildlife populations in a given habitat, another factor increases. This concept is known as ***compensatory mortality.*** Animal populations tend to increase reproduction when confronted with a specific mortality factor such as predation. Predation and other mortality factors help to relieve pressures of habitat loss and social stress. Compensatory mortality is actually Nature's way of safe-guarding a population. The death of one individual improves the chances of life for another and, hence, survival of the population. The strong and more adaptable animals in any wildlife population generally survive. The weak and less adaptable commonly perish. Thus, factors of compensatory mortality, such as predation, help keep animal populations healthy.

Pests

The diets of certain animals—including some rodents, birds and carnivores—include important agricultural, forestry, horticultural and other valued resources. In some areas of the country, these animals have caused extensive damage to potential consumer products, and economic difficulties for landowners and operators. Where the apparent benefits of such animals are overridden by the damages they cause, the animals are referred to as ***pests.*** It is essential to understand that pest damage is caused by individual animals. However, there has been a tendency on the part of persons encountering damage to label an entire population or species as "pest," not just the individuals that cause damage. Indiscriminate elimination of pests can disrupt the food web in any habitat, and the ultimate consequence may be worse than the initial problem caused by individual pests. Most animals cause no problems for people.

However, pest animals pose serious problems for some wildlife and land managers. Managers must determine how to reduce damages caused by pests without eliminating populations or species of animals and without endangering the food web of all wildlife in an area with a pest problem. To obtain favorable results, methods used to eliminate individual pests must be applied through a well-designed management effort.

Controls include trapping, poisoning, shooting, and the use of "scare" devices and reproductive inhibitors. Each method has a specific use and, if properly applied, can be useful in reducing crop, livestock and other losses.

The use of certain chemicals can be effective for both pest and predator control. But unless used with extreme care, poisons can result in unwarranted, nonselective losses of wildlife. Poisons intended for the elimination of pest plants or animals, often referred to as ***pesticides***, frequently are accessible to nonpest organisms. So are some chemical substances, such as mercury and lead, which are released in the environment without intent to harm plants or animals. Such substances may be lethal not only to animals that consume or come in direct contact with them, but to animals that feed on plants or animals that have been contaminated. Also, some animals, contaminated either directly or indirectly by toxic chemicals, do not die. However, the chemicals may accumulate in their biological systems and adversely affect behavior, reproductive success or the health of offspring.

Osprey, for example, subsist primarily on a diet of fish. These fish may be contaminated with the toxic substance DDE, a residual poison of the pesticide DDT. When contaminated fish are eaten by a female osprey, ***toxins*** build up in her system. Although the build-up may not kill the osprey, it causes the shells of her eggs to be thin and, consequently, to break easily and prematurely. Similar reactions have led to serious declines in populations of bald eagle, peregrine falcon, brown pelican and other species in addition to the osprey. Also, because wide-ranging animals frequent habitats used by more sedentary animals, uncontrolled use of pesticides can have adverse impacts on animals far from a problem situation. Fortunately, some of the most dangerous poisons, including DDT, have been removed from general use. These actions will have long-term and far-reaching beneficial effects.

People have created habitats and conditions that encourage pests. Therefore, more of these animals may be present than is ecologically, economically or socially acceptable. Particularly in artificial environments, pests tend to withstand most control efforts. Like all wildlife, pests produce biological surpluses. These surpluses can absorb deaths from managed control efforts without causing harm to the species or populations elsewhere. Use of traps, scare devices, reproductive inhibitors, toxic chemicals and shooting may be the only logical means of curtailing damage caused by pests in certain situations.

Bounties, which are direct dollar payments for removing unwanted wildlife, have been used for hundreds of years as a pest- or predator-control technique and probably have been abused for that long too. Properly used, bounties may be helpful in selectively removing individual problem animals. In actual practice, their value as a means to control wildlife populations has not been proven. Bounties are subject to fraud. Too frequently, taxpayer funds are used to pay for animals removed from areas where there are no pest problems. Hides or bountied parts are transported into areas where bounties are paid. Considerable money may be spent without satisfying objectives, and animals may be killed unnecessarily.

Harvests

Hunting and trapping have been traditions during all of human history. In parts of the world, survival of some people still depends on hunting and trapping. In North America, hunting is a recreation and management tool commonly permitted in management units to maintain desirable, predetermined levels of wildlife populations. It helps to minimize agricultural, forestry and horticultural damages, and provides recreational opportunities, food and other associated economic benefits. In some North American communities, residents depend considerably on income from trapped animals. In addition, they rely on uses of hides and other parts in daily activities.

The effects of hunting and trapping on wildlife populations should be understood better. With well-designed regulations and proper management, hunting and trapping ***harvest*** only kinds and numbers of animals that can be replaced through natural reproduction. This harvesting is similar to reaping agricultural crops. Products can be taken from the environment for our benefit, while the sources are rejuvenated through reproduction.

Some animals withstand hunting and trapping better than others. Wildlife managers, therefore, have to apply their knowledge of population dynamics to regulate the annual harvest of each game species. For example, large animals such as deer and bear—which are in the group of low producers with long lives—have low population-turnover rates. Consequently, up-to-date knowledge of their populations must be applied carefully in establishing annual harvest limits and seasons. Hunting is allowed only if reproduction provides a surplus that can be harvested without impairing the basic breeding stock (Figure 15).

Populations of animals that live in isolated environments or that have very specific habitat requirements can be overhunted or overtrapped if harvests are not regulated closely. For example, unregulated hunting would be harmful to the wild sheep of North America because of their restricted ranges. But managed hunting can prevent excessive numbers of sheep and, thereby, minimize disease transmission. Also, habitat quality can be maintained and the well-being of a sheep population insured.

Wildlife researchers and managers have closely studied the effects of hunting and trapping on wildlife in North America for approximately the past 50 years. Responses of game animal populations in areas where regulated harvesting has been permitted have been compared with populations of the same species not subjected to hunting or trapping. Time and again, findings have revealed that harvested populations continue to thrive at levels equal to those of the unharvested populations. In harvested and unharvested populations, the biological surpluses are lost. In harvested populations, harvesting removes much of the surplus, and natural mortality and emigration removes the rest. In unharvested wildlife populations, the biological surplus is removed totally by emigration and by death factors other than harvesting. Therefore, hunting and trapping have been shown repeatedly to remove portions of

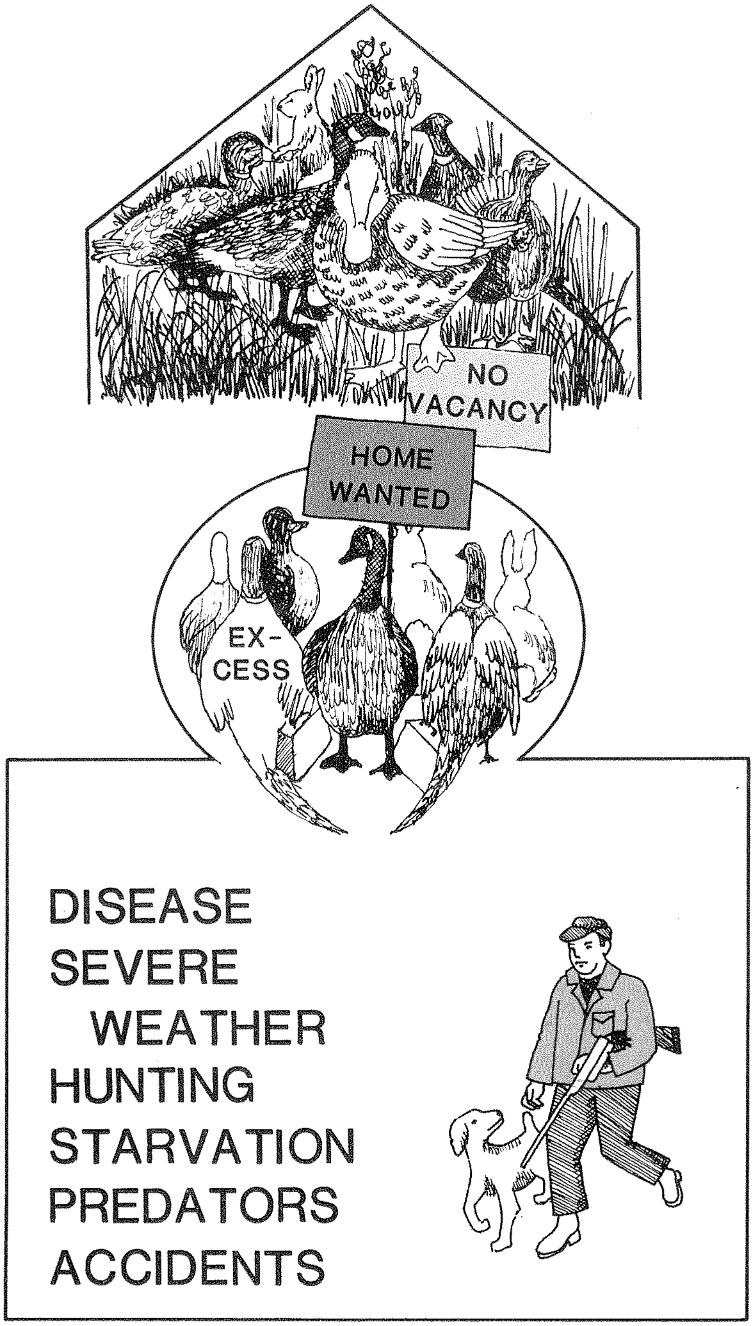

Figure 15. When carrying capacity of habitat is approached, reached or exceeded, harvesting is an important management tool. Hunting and trapping can remove some of the biological surplus that otherwise would be lost to various death factors and social pressures. It also protects habitat from overuse by too many animals; and it provides recreation, food and other benefits to the harvester. Furthermore, money from the sales of hunting and trapping licenses is the primary source of support for wildlife and habitat management throughout North America.

game populations that, if not harvested, would perish or leave anyway. Removals by harvesting can be made without imposing limitations on a population's ability to rejuvenate itself.

When severe conditions drastically reduce a wildlife population, the surviving breeders can accelerate recovery or compensate for losses by producing at higher than normal rates. This has been documented in some populations of bobwhite quail, ruffed grouse and other species. Coyotes, for example, have expanded their ranges despite hunting, trapping and poisoning.

Overharvesting of a wildlife population is not likely to occur under carefully regulated hunting. However, it can happen in conjunction with low productivity or high mortality caused by extreme natural conditions, such as severe spring weather and habitat degradation. A characteristic or principle of human behavior can help prevent such possibility. Known as the ***principle of diminishing returns***, it recognizes that most hunters quit pursuing a harvestable wildlife population of low density. Interest wanes when hunting requires excessive physical exertion, personal time or financial outlay. Equally important—as a wildlife population's density decreases, the remaining animals tend to be extremely wary and elusive. This, too, can discourage hunters from exerting normal harvesting pressure on a particular population. The principle of diminishing returns helps to assure, for example, that cock pheasants are not overhunted in a male-only season.

This principle does not apply to all depressed wildlife populations in all areas. Consequently, it has been necessary to establish management units where hunting or trapping can be controlled by seasons, bag limits or additional harvesting regulations. These actions curtail harvests and help assure recovery of a wildlife population under prevailing habitat and weather conditions.

Despite these biological facts and relationships, some people believe hunting should be prohibited. There are three main reasons for this antihunting sentiment. First, some people think that hunting decimates wildlife populations. Knowledge of wildlife population dynamics and management principles—particularly compensatory mortality and biological surpluses—disproves such arguments. Second, some people believe wild animals should not be hunted in the name of recreation. Others disagree. It is a view that individuals must decide for themselves. But the fact remains that hunting is important for maintaining and managing wildlife populations at certain times and in designated areas. Hunting critics should recognize that initial and continued support for wildlife management has come from hunters.

Third, a growing number of persons are reacting unfavorably to unethical behavior of outdoor recreationists. Some people do, in fact, shoot signs, leave gates open, kill protected animals, trespass and commit other illegal or unethical acts. These persons—some hunters, some not—represent a small fraction of the total outdoor recreation public. However, their behavior not only is harmful to wildlife and the environment, but it diminishes public acceptability of harvesting as a practical wildlife management tool and as an outdoors pursuit enjoyed by millions of people. To counteract such behavior and to stem unfounded attitudes against hunting and trapping, outdoor recreationists should initiate programs to assure their activities are carried out in a socially acceptable manner and in compliance with applicable rules and regulations.

Hunting-antihunting debates cannot be permitted to derail or defuse the much-needed wildlife ***conservation*** effort. Attention must focus instead on the critical issues—maintenance and restoration of wildlife habitats and populations.

Wildlife managers enhance and improve habitats, minimize conflicts of wildlife with consumer products, and provide opportunities for recreational and commercial uses of wildlife. But what do managers actually do to maintain habitat and healthy animal populations, promote wise use of wildlife resources, and provide for wildlife-based recreation?

Evaluate Populations and Habitats

The first step in wildlife management is to determine the abundance and distribution of animals, and the extent of their habitats. Animals can be identified and counted by their songs, calls, tracks, droppings and by actual sightings. Because some animals have large home ranges, managers and researchers learn where, when and why the animals move by marking individuals with colored tags, bands or electronic devices. Habitat types are measured by classifying vegetation from aerial photographs and by examining plants during field surveys. To determine the amount of habitat needed by a given species of animal takes detailed studies of its habits and environment. Hunter surveys, combined with other scientific data, also yield valuable information on the size, density and distribution of game populations.

The second step is to evaluate the quality of animals and habitat. It is important to know the health of animal populations. If supplies of nutritious food are not available, animals may not be able to resist diseases, parasites, weather and predators. Managers and researchers learn the food requirements of animals in many ways. They examine food remains in stomachs and droppings; and with spotting scopes, they observe animals to determine what they eat. Wild animals raised in captivity are taken into natural habitats where they can be observed at close range to learn the kinds and amounts of food eaten. These evaluations must be conducted at all times of the year because preferred and needed foods may differ by season or by weather conditions. Samples of plants known to be animal foods are taken into the laboratories and analyzed for nutritional quality. These factors, as well as reproduction, death, and age and sex ratios, help determine the status of animal populations.

In many cases, researchers provide wildlife managers with detailed facts concerning population dynamics and habitat relationships, required for wise decision making. Recreational hunters also perform valuable services for the wildlife manager. First, through harvesting, they provide actual animal population controls and ecological balances. Second, they submit animals for examination, and accounts of recreational experiences. This information helps to provide basic facts used to manage wildlife populations and habitats more effectively.

Manage Populations and Habitats

Reduction and destruction of habitats are the most severe problems facing wildlife and wildlife managers. When wildlife managers have information about quantity and quality of habitat, status of wildlife populations and potential limiting factors, they strive to maintain suitable environments for the animal populations. If the amount, quality and diversity of habitat ingredients for a given population are not adequate, managers may attempt to improve the habitat, reduce the number of animals, or do both to meet population goals. If hunting, trapping or other uses of wildlife are desired and ecologically feasible, managers advise on regulations for harvesting surplus animals.

In other words, wildlife managers strive to develop and maintain habitat conditions suitable to species that can benefit from and cause benefit to a particular area. They know, for example, that early stages of forest succession provide food and shelter for deer, moose, grouse, catbirds and other wildlife. In cooperation with foresters, wildlife managers plan selective timber harvests or prescribed burns to encourage growth of shrubs, grasses and other flowering plants. However, they leave certain large trees that provide shelter, food or nesting sites for other species, thus providing ecological diversity.

Wildlife managers also work with landowners to maintain shelterbelts, woodlots, fencerows, wetlands and uncultivated plots because these areas provide essential habitat ingredients for a variety of wildlife.

They work to reduce pollution and environmental degradation. Houses, factories and roads are built in wildlife habitat, so wildlife managers try to minimize impacts of these developments by suggesting alternative locations, construction modifications and standards to avoid or reduce pollution.

A big and important job of wildlife managers is to promote and enforce laws that protect habitats and animals from careless destruction. But they cannot do it alone. While managing habitat is the primary job of professional wildlife managers, the task of protecting and preserving environments that benefit both wildlife and people is everyone's responsibility. Managers can improve habitat for wildlife only with public understanding and cooperation.

Assist Threatened and Endangered Species

Wildlife managers must take special measures to maintain critical habitats for threatened and endangered wildlife species. Federal and some state laws define an ***endangered species*** as one in danger of extinction throughout all or a significant portion of its range. ***Threatened species*** are those likely to become endangered within the foreseeable future. In 1976, the U.S. Department of Interior listed 114 species as endangered or threatened in the United States, including: 54 birds, 34 fishes, 18 mammals, and 8 reptiles and amphibians. Mexico had 25 threatened or endangered species, and Canada had 10.

Landscape alteration accounted for 63 species being on the U.S. list (Figure 16). Twenty species became threatened or endangered after exotic wildlife was introduced into habitats where they transmitted disease and competed with native animals. Nine species were persecuted as pests, and eight others were considered rare to begin with. Commercial exploitation curtailed populations of five species, and adverse effects of pesticides limited four others. Primary causes for the decline of four species are unknown, and one species is endangered because of illegal killing. Many of the listed species were influenced by a combination of causes. Approximately 55 percent of all endangered wildlife species in the United States are in jeopardy as a direct result of human impact on the landscape. Regulated recreational hunting has not caused any species to become threatened or endangered.

Forty bird and mammal species known to have been native to the United States and its territories became extinct since the time of Christopher Columbus. Most extinct species once lived on islands or in isolated mainland habitats. Of 32 species of North American birds that have become extinct in recent history, 26 were indigenous to Hawaii. Two of the eight extinct North American mammals were meadow voles, one of which lived on a small island in Long Island Sound in the eastern United States. The other lived exclusively in an isolated California marsh. The heath hen was lost after its habitat was confined to a single island off the coast of Massachusetts.

In each of these examples, the animals' habitats were so restricted that when disrupted, the animals either had no opportunity to find new habitat or perished before they could. Other extinct species of wildlife once native to the United States were doomed as a direct result of human carelessness and indifference or ignorance.

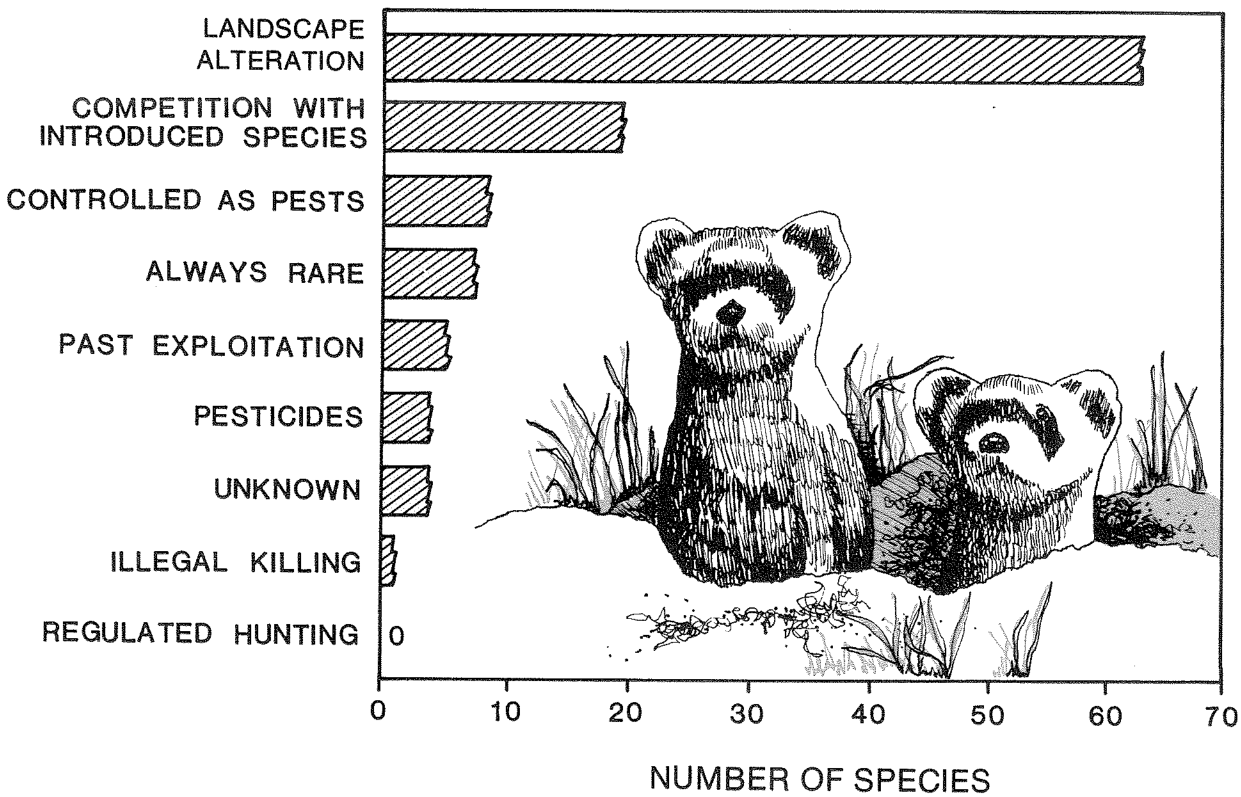

Figure 16. Primary causes for 114 wildlife species being designated as threatened or endangered in the United States, 1976. Species are added or removed from these categories in response to changing statuses of their populations. Black-footed ferrets, as shown here, are endangered.

Perhaps the first animal of North America whose fate was sealed by human exploitation was the Great Auk. This large, flightless bird was lost forever in 1844 after repeated invasions by whalers of its nesting colonies on islands in the north Atlantic Ocean. Mindless of the fact that the Great Auk could not recover, whalers slaughtered the birds to obtain eggs, feathers and oil.

The most dramatic loss of a single species was the demise of the passenger pigeon. Less than one century ago, countless millions of these birds darkened the sky for miles when they flew to feeding and nesting cover. The birds were shot and trapped by the ton, largely for commercial purposes. Combined with logging practices that destroyed great expanses of the passenger pigeons' hardwood habitat, the wanton and frequently wasteful killing of the birds eliminated the species early in this century.

The colonization of North America rapidly altered the habitat of wildlife, but of even greater harm was the settlers' attitude that wildlife was an inexhaustible resource. Before people began to understand the damage they were doing to wildlife populations, such species as elk, wild turkey, pronghorn, Badlands bighorn sheep, eagles, white-tailed deer, bison, egrets and spruce grouse, to name a few, were on the verge of extinction. Through enlightened public attitudes and wildlife management efforts, most of these species have been restored.

Some populations of grizzly bear, wolf and cougar were exterminated because they threatened livestock and people. Prairie dogs competed with livestock for scarce grass in the semiarid West, so massive eradication campaigns took place. Not only were some populations of prairie dogs destroyed, but black-footed ferrets that fed on prairie dogs and lived in prairie dog "towns" became endangered as well, and remain so today.

Most problems developed when both wild and domesticated animals were introduced to North America. In some cases, these exotics were carriers of diseases, and in many instances, they upset delicate native food chains. Introduced predators such as house cats, rats and mongooses preyed on resident species. Domestic livestock ate food that native wild animals needed. Even now, crop-producing practices and intensive livestock grazing on natural grassland habitats along the Gulf coast of Texas are threatening the Attwater's prairie chicken.

Questions arise about which species are endangered. In some cases, all populations of a species are endangered, while in other cases, only designated populations are in need of close attention. Entire remnant populations of both the whooping crane and California condor are endangered. Timber wolf populations in Alaska and Canada are thriving, while in the lower 48 United States they are considered threatened or endangered and need intensive management.

Threatened and endangered wildlife present a great challenge to resource managers and all citizens. When a species becomes extinct, its unique genetic characteristics—accumulated over eons of time—are lost forever. And its vital role in food chains, through energy and mineral transfers, also is eliminated. In our history, such losses have been unfortunate and unplanned.

In recent years, our society, through the Endangered Species Act of 1973, directed that actions be taken to prevent additional extinctions of wildlife. Now, our obligations—legal and moral—are to develop alternatives to guide human actions in a manner that maintains and enhances genetic, functional, recreational, aesthetic and other values of wild animals and plants.

Establish Wildlife Management Areas

Unlike some threatened and endangered wildlife, many species have been able to benefit from sound management practices, public concern and the establishment of wildlife management areas. Wildlife management areas, including state and national wildlife refuges, are necessary to maintain high quality, irreplaceable habitat. Such areas also provide opportunities to study and learn more about the dynamics and specific requirements of wildlife populations. In addition, the wildlife management areas are attractive seasonal habitats for migratory animals.

Together with legislation and more extensive and intensive management, wildlife management areas have helped restore and build populations of some waterfowl, shorebirds and endangered species. For example, when settlement of the United States expanded during the Eighteenth and Nineteenth centuries, there may have been as many as 100 million American bison on the North American continent. Unrestricted shooting of these majestic animals, along with destruction of their habitat by settlement and agriculture, rapidly depleted the bison herds. By 1895, only 800 remained and were confined to areas of poor habitat. Today, more than 6,000 bison live on management areas in the western United States and Canada. That population would increase substantially if additional habitats were available and accessible. However, most of the species' former habitats are used at this time for other purposes, especially food and fiber production.

Another example is the restoration of the nearly extinct trumpeter swan population in the United States. In 1935, only 83 trumpeters were known to exist south of Canada. Subsequent actions set up management areas, restocked ancestral ranges and reduced poaching. The population increased to approximately 1,000 by 1970. At that time, the trumpeter was removed from the country's official endangered species list.

Although habitat protection can be effective management in some areas and situations, it can create problems in others. For example, overzealous guarding against fire and timber harvesting can result in reduced growth of young plants that many species of wildlife need. By attempting to keep habitats undisturbed, an artificial environment may be created. Periodic disturbance of vegetation may be needed to provide attractive conditions for many plants and animals.

Habitat requirements of the Kirtland's warbler illustrate the need for sensitive management. This bird nests only in Michigan and has very specific breeding habitat requirements. It occupies only jack pines 6-8 feet (1.8-2.4 meters) high. As a result of no-fire and limited timber-harvest policies, and parasitic egg laying by cowbirds, the Kirtland's warbler population became endangered. Wildlife and forest managers have responded to the situation by establishing management areas, instituting prescribed burning, planting jack pine and controlling cowbirds. Although Kirtland's warblers are still on the endangered species list, they are increasing in number. Controlled disturbances of vegetation, primarily to aid the warblers, also have benefited other animals. Through similar application of scientific knowledge, plus refined management practices and increased public support, there are many opportunities for restoring and maintaining wildlife populations.

OPPORTUNITIES FOR NEEDED ACTIONS

Having read this booklet, go on learning and caring about wildlife. Read other factual information. Get on the mailing lists of state or provincial wildlife management agencies to receive newsletters, reports and educational materials. Subscribe to natural resources-related periodicals. Visit your local library and discover books and other sources of current information on wildlife and Nature in general. Learn more about particular phases of wildlife management that are of interest to you.

There are numerous opportunities to learn and participate actively in conservation affairs. Join a local bird club, sportsmen's organization, nature study group or other associations. Visit nature reserves and wildlife management areas open to the public. Ask questions of wildlife managers. Speak out when landscape alterations unnecessarily threaten wildlife and wildlife habitat. Make your knowledge and opinions about conservation issues known to decision makers. Encourage others to become involved in working with Nature. Remember—wildlife requires your help. Informed and actively concerned citizens are needed friends of wildlife.

There is no summary or conclusion to this brief discussion of Nature, wildlife and wildlife management. Like the landscape, the ecology of wild things is ever-changing. Always there will be more that we can learn and do to maintain our natural heritage. We need to help wildlife by working with Nature because wildlife is essential to and a barometer of the quality of our own lives.

ADDITIONAL SOURCES OF INFORMATION

Newsletters: These items cover current issues, policies and programs in natural resource fields, and give interesting information on wildlife and other resource management. Request to have your name added to their mailing lists. Also identify and request newsletters from your local area.

Audubon Leader. National Audubon Society, 950 Third Avenue, New York, N.Y. 10022.

Conservation News. National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036.

Conservation Report. National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036.

Endangered Species Technical Bulletin. Department of the Interior, U.S. Fish and Wildlife Service, Endangered Species Program, Washington, D.C. 20240. Provides a monthly update on endangered and threatened wildlife.

Outdoor News Bulletin. Wildlife Management Institute, 1000 Vermont Avenue, N.W., 709 Wire Building, Washington, D.C. 20005.

Wildlife Report. Canadian Wildlife Federation, 1673 Carling Avenue, Ottawa, K2A 1C4.

Magazines: These periodicals cover timely wildlife and conservation topics. They are attractive, well-written, entertaining and informative. Subscription may be obtained as part of organization membership.

Audubon. National Audubon Society, 950 Third Avenue, New York, N.Y. 10022.

International Wildlife. National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036.

National Wildlife. National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036.

Ranger Rick. National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036.

Publications from your state or provincial wildlife management agency.

Professional Journals: Results of scientific study on wildlife and natural resources management subjects are reported or summarized in these journals. Reports tend to be specialized, but their abstracts provide up-to-date and useful information that will keep you informed of wildlife research and management efforts. Copies or reprints can be obtained from the publisher or sponsoring organization.

The Journal of Wildlife Management. Published by The Wildlife Society, 7101 Wisconsin Avenue, N.W., Washington, D.C. 20014.

Transactions of the International Association of Fish and Wildlife Agencies. Published by the International Association of Fish and Wildlife Agencies, 1412 16th Street, N.W., Washington, D.C. 20036.

Transactions of the North American Wildlife and Natural Resources Conference. Published by the Wildlife Management Institute, 1000 Vermont Avenue, N.W., 709 Wire Building, Washington, D.C. 20005.

Wildlife Society Bulletin. Published by The Wildlife Society, 7101 Wisconsin Avenue, N.W., Washington, D.C. 20014.

Booklets and Books: These represent some of the best-written, most informative discussions of ecology, conservation and wildlife management. Natural resources philosophy, history, practices and procedures are presented in ways that can be understood and appreciated by general and scientific audiences alike. These books usually can be found at libraries or secured from the publishers.

Allen, D. L. 1962. *Our Wildlife Legacy.* Funk & Wagnalls, New York. 422 pp. History and basic reading; a classic in the field of wildlife sciences.

Bailey, J. A., W. Elder and T. D. McKinney, eds. 1974. *Readings in Wildlife Conservation.* The Wildlife Society, 7101 Wisconsin Avenue, N.W., Washington, D.C. 20014. 722 pp. The fields of economics, philosophy, sociology, ecology and biology are explored as they relate to wildlife sciences.

Cox, G. W., ed. 1974. *Readings in Conservation Ecology.* Appleton-Century-Crofts, New York. 666 pp. A collection of useful articles that relate the parts of biological study to the whole of ecological study.

Dasmann, R. F. 1964. *Wildlife Biology.* John Wiley & Sons, Inc., New York. 231 pp. A classic textbook for the study of wildlife sciences.

Errington, P. L. 1967. *Of Predation and Life.* Iowa State University, Ames, Iowa. 277 pp. Many of the secrets of life can be learned by studying the relationships of death. Dr. Errington presents scientific detail in an enjoyable and readable book.

Horwitz, Eleanor, ed. 1977. *Ways of Wildlife.* The Wildlife Society. Citation Press/Scholastic. New York. 160 pp. A useful and informative book about wildlife with examples and exercises for classroom use.

Knight, C. B. 1965. *Basic Concepts of Ecology.* The MacMillan Company, New York. 468 pp. Abiotic and biotic facets of natural ecology are presented in clear, well-organized style.

Leopold, A. 1933. *Game Management.* Charles Scribner's Sons, New York. 481 pp. Known as the father of wildlife management, Leopold was ahead of his time. Many of his contributions to the profession still are used or are being rediscovered today. This book is a compilation of his teachings and the basis for scientific wildlife management.

Leopold, A. 1966. *A Sand County Almanac and Sketches Here and There.* Oxford University Press, New York. 269 pp. Leopold was an outdoorsman, naturalist, hunter, writer, philosopher and teacher. The essence of his life, knowledge and ethics is reflected in this easy reading book.

Matthiessen, P. 1959. *Wildlife in America.* The Viking Press, New York. 304 pp. The first comprehensive story of wildlife in America.

McGraw-Hill Book Company. 1967. *Our Living World of Nature.* Webster Set, New York. 5 titles, 8 volumes. A highly recommended series about wildlife and ecology in North America.

McNall, P. E. and H. B. Kircher. 1970. *Our Natural Resources.* The Interstate Printers and Publishers, Inc. Danville, Illinois. 296 pp. Biological and earth sciences are presented in text form, but very readable for students of all ages.

National Shooting Sports Foundation, Inc. *The Hunter and Conservation.* 1075 Post Road, Riverside, Connecticut 06878. 23 pp.

Reiger, J. F. 1975. *American Sportsmen and the Origins of Conservation.* Winchester Press, 205 E. 42nd Street, New York 10017. 316 pp. Well-documented insight into the history of sportsmen's contributions to conservation.

Strohm, J., ed. *Endangered Species.* National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036. 62 pp.

Teague, R. D., ed. 1971. *A Manual of Wildlife Conservation.* The Wildlife Society. Washington, D.C. 206 pp. An insightful glimpse at the multi-disciplinary aspects of wildlife conservation.

Time/Life Books. 1961-1973. *Life Nature Library.* New York. 25 volumes. An excellent reference series about Nature and its components.

Trefethen, J. B. 1976. *The American Landscape: 1776-1976, Two Centuries of Change.* Wildlife Management Institute, Washington, D.C. 91 pp.

Trefethen, J. B. 1975. *An American Crusade for Wildlife.* Winchester Press. New York. 409 pp. An enlightening history of wildlife conservation by a lifelong scholar of the subject.

Trefethen, J. B. 1964. *Wildlife Management and Conservation.* D.C. Heath and Company. Boston. 120 pp. Wildlife resources and man are discussed in a sensitive and sensible manner.

Wildlife Management Institute. *Placing American Wildlife Management In Perspective.* 1000 Vermont Avenue, N.W., 709 Wire Building, Washington, D.C. 20005. 27 pp. Overview of management results and considerations in the U.S.