Key Points for the Area of Study

Wildlife

a. Identify common wildlife species by sight or sound and wildlife signs (keys will be used for more extensive identification)
b. Identify basic wildlife survival needs
c. Describe specific adaptations of wildlife to their environment and role in the ecosystem
d. Describe predator/prey relationships and examples
e. Describe the potential impact of the introduction of non-native species
f. Describe the major factors affecting threatened and endangered species and methods used to improve the populations of these species
g. Describe ways habitat can be improved for specific species by knowing their requirements
h. Discuss the concepts of carrying capacity and limiting factors
i. Discuss various ways the public and wildlife managers can help in the protection, conservation, management, and enhancement of wildlife populations
j. Describe food chains/web and cite examples
k. Describe factors that limit or enhance population growth
l. Evaluate a given habitat for its suitability for designated species, given a description of their habitat needs
References


<table>
<thead>
<tr>
<th>Wildlife</th>
<th>TEKS Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong> Identify common wildlife species and wildlife signs (keys will be used for more extensive identification)</td>
<td>Biology A-C; Wildlife, Fisheries, and Ecology Management 3 B, 7 A-C;</td>
</tr>
<tr>
<td><strong>B.</strong> Identify basic wildlife survival needs</td>
<td>Biology 12 D; Environmental Systems 4 F; Wildlife, Fisheries, and Ecology Management 7 A,D;</td>
</tr>
<tr>
<td><strong>C.</strong> Describe specific adaptations of wildlife to their environment and role in the ecosystem</td>
<td>Biology 7 A-E, 9 B, 12 A-C; Environmental Systems 4 A-B, 6 C-E; Range Ecology and Management 3 A,B,C;</td>
</tr>
<tr>
<td><strong>D.</strong> Describe predator/prey relationships and examples</td>
<td>Biology 12 A; Wildlife, Fisheries, and Ecology Management 5 E;</td>
</tr>
<tr>
<td><strong>E.</strong> Describe the potential impact of the introduction of non-native species</td>
<td>Biology 12 F; Environmental Systems 4 F, 9 I; Range Ecology and Management 3 A,B,C, 7 A-D, 8 A-D;</td>
</tr>
<tr>
<td><strong>F.</strong> Describe the major factors affecting threatened and endangered species and methods used to improve the populations of these species</td>
<td>Environmental Systems 4 F,G,H, 5 F, 9 E,F; Advanced Environmental Technology 5 F-I, 6 C,E,F, 7 B,D,E,F, 8 A-D;</td>
</tr>
<tr>
<td><strong>G.</strong> Describe the ways habitat can be improved for specific species by knowing their requirements</td>
<td>Environmental Systems 7 A</td>
</tr>
<tr>
<td><strong>H.</strong> Discuss the concepts of carrying capacity and limiting factors</td>
<td>Biology 12 D; Environmental Systems 4 F, 7 A-D; Range Ecology and Management 4 B,C</td>
</tr>
<tr>
<td><strong>I.</strong> Discuss various ways the public and wildlife managers can help in the protection, conservation, management, and enhancement of wildlife populations</td>
<td>Environmental Systems 4 F,G,H, 8 A; Range Ecology and Management 3 B, 7 A-D, 8 A-D; Wildlife, Fisheries, and Ecology Management 2 C, 3 A, 4 A-L, 8 A-C</td>
</tr>
<tr>
<td><strong>J.</strong> Describe food chains/webs and cite specific examples</td>
<td>Biology 9 D, 12 A,C,F; Environmental Systems 4 F, 6 C,D,E; Range Ecology and Management 3 A;</td>
</tr>
<tr>
<td><strong>K.</strong> Describe factors that limit or enhance population growth</td>
<td>Environmental Systems 4 F, 7 A-D; Range Ecology and Management 8 A-D; Wildlife, Fisheries, and Ecology Management 5 C,E</td>
</tr>
<tr>
<td><strong>L.</strong> Evaluate a given habitat for its suitability for designated species, given a description of their habitat needs</td>
<td>Biology 12 D, Environmental Systems 4 D, 5 A;</td>
</tr>
</tbody>
</table>
"When we try to pick out anything by itself we find it hitched to everything else in the universe."
John Muir

Defining Ecology

The term "ecology" is derived from the Greek words, oikos, for house or household, and logos, which refers to "the study of" some particular topic. Literally translated then, ecology means the study of households, in this case, the households of nature. German zoologist Ernst Haeckel, who is credited with coining the word in 1870, defined it as follows: "By ecology we mean the body of knowledge concerning the economy of nature – the investigation of the total relations of the animal both to its inorganic and its organic environment." If you peruse modern texts for a more current definition, you will find that they still focus on the key importance of relationships and interactions. "Ecology is the study of the relationships of organisms to their environment and to one another" (Brewer, 1994). "Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms" (Krebs, 1972). A somewhat different definition, offered by Odum in 1963, stressed the then emerging systems approach; "Ecology is the study of the structure and function of ecosystems."

Trophic Relationships

To early ecologists, it became apparent that the most obvious functional relationship linking plants and animals together in any ecosystem was food based. Feeding or trophic relationships delineated who ate whom in order to obtain the energy and nutrients necessary for survival. Hence, any community of organisms could be organized on the basis of the following trophic levels:

- **Producers** – Those organisms capable of producing their own food, primarily by fixing energy from the sun via photosynthesis. These *autotrophs* (self-feeders), most of which are plants, then serve as the primary energy source for the rest of the biosphere!

- **Herbivores** – Those organisms obtaining their energy directly from plants. Also referred to as primary consumers.

- **Primary Carnivores** (secondary consumers) – Those organisms obtaining their energy from herbivores.

- **Secondary Carnivores** (tertiary consumers) – Those organisms obtaining their energy from other carnivores. While one could conceivably continue “stacking up” carnivores in this fashion indefinitely, most ecosystems rarely exceed 4 or 5 trophic levels.

- **Detritivores** – Also known as decomposers, these organisms obtain their food from dead plants and animals. Through their actions, the
building blocks of life are returned to the environment in elemental form to be used yet again. While often not considered a distinct trophic level, they are indispensable members of the biotic community.

**Food Webs**

A sequence of organisms, each of which feeds on the one preceding it, forms a *food chain*. A local example might be:

Hackberry leaf – Hackberry caterpillar – Pewee – Sharp-shinned hawk.

In most communities, several to hundreds of such food chains exist, and are interconnected in such a way as to form a *food web*. Were all organisms to be included, such food webs would be too complex to actually draw, so most depict only a select group of organisms, as illustrated by Varley's simplified food web of an oak woodlot (Fig 2).

This food web also illustrates several other "complexities" about trophic organization. First, not all organisms fit neatly into a single trophic level. Voles and mice, for example eat both herbs and insects, and like many other animals, including us, are considered *omnivores*. Second, while detritivore food webs are often considered separately, in reality the so-called herbivore food web and detrivore food webs usually interdigitate in a complex fashion. Finally, such food webs do not tell us much about which species are the most "important" to the stability of that particular community.

**Pyramids of Numbers and Biomass**

A general pattern emerges from observing community structure based on trophic relationships. There are usually many more plants than herbivores, greater numbers of herbivores than carnivores, and seldom more than a few top carnivores. This is the so-called *pyramid of numbers*. Similarly, a *pyramid of biomass* almost always results if dry weight is substituted for numbers. Fig. 3 illustrates both pyramids for a thousand square meters of temperate grassland. This rapid decline in both numbers and biomass accounts for the previously noted fact that there are seldom more than four or five trophic levels in any community.

**Energy Flow**

In order to understand the above patterns, we need to examine energy and energy flow within an ecosystem. Without getting sidetracked by a physics lesson, we're going to define energy as the capacity to do work. When you are "out of energy", your capacity to do work certainly feels limited. Work, however, isn't confined to just physical labor. It also includes maintaining basic metabolic functions, such as biochemical transformations, biosynthesis, secretion, and cell
maintenance. Lying in bed in a coma still requires energy! Thus, as long as they’re alive, all organisms continually lose energy in the form of heat. Unless an organism can replenish that energy which is constantly being lost, it will die.

The original source of all energy utilized by organisms is the sun. Unfortunately, the sun’s energy or solar radiation cannot be used directly by most organisms to meet their constant energy needs (sun bathing would otherwise be looked at in a whole different light, so to speak). Only those organisms capable of photosynthesis can accomplish this. Interestingly, less than 1% of the solar radiation reaching the Earth’s atmosphere is fixed in the form of chemical bonds in photosynthesis, yet this is sufficient to produce all of the plant and animal biomass on the planet! Unless this chemical form of energy in plant and animal tissue enters long-term storage (as was the case in the formation of oil, gas and coal), all of it is eventually degraded to heat, a form of energy no longer capable of performing biological work. That is why we say that energy flows through an ecosystem. The daily influx of energy from the sun that is fixed by the producers is roughly balanced by the daily outflow of heat produced by the myriad of living, metabolizing organisms, ultimately radiating back into outer space.

Ecological Efficiencies
Let’s now go back and more closely examine the basic pattern we find in nature with regard to the pyramid of numbers and biomass. Why is it that most ecosystems support only three to five trophic levels? Why not 10 or 20 or 100? Is that picture we’ve all seen of a tiny minnow being swallowed by a larger fish and that by a still larger fish, and it in turn by a yet larger fish, and on and on until the last is swallowed by the giant whale false? In a word, yes! In order to see why, we need to understand what happens to a “packet” of energy as it makes its way from one trophic level to the next. Let’s return to our 1000 square meters of grassland (Fig. 3) and assume, for purposes of illustration, that our initial packet of solar energy fixed by all of the plants in that ecosystem has a value of 10,000 units. As we shall see, only a small percentage of this energy is going to end up in the next trophic level, the herbivores. First, some of that energy will be needed by the plants to meet their own metabolic needs. For plants, that figure lies between 20 and 75%, thus leaving between 25-80% of the energy plants fix in photosynthesis for growth or net production. Put another way, we can say that the net production efficiency of plants is between 25-80%. This is the new plant biomass (energy) available for consumption by the herbivores.

If we take an average net production efficiency of 50% (actually typical for grassland plants) we now have 5,000 units of energy available to the herbivores. But herbivores are not going to consume every last shred of plant material available. The harvesting efficiency of grassland herbivores varies between 5-30%. Let’s assign a value of 20% to our herbivores. That means they will eat (ingest) only 1,000 units of energy (5,000 x 20% = 1,000). As you can see, we have already “lost” 90% of the energy we started with!

Let’s continue to follow our packet of energy, now 1,000 units, as it proceeds through the herbivores. First, we have to be aware that most consumers don’t digest, or assimilate everything they eat. Because plant material contains a lot of indigestible parts, assimilation efficiencies for herbivores are typically low, ranging between 30-60%. Thus, we are now left with between 300-600 units of energy that are actually digested (assimilated) by the herbivores; the remainder leaves the animal as fecal material, or egestion. Can all of the energy assimilated by an herbivore be applied towards growth? No. A significant amount of this energy must also be used to take care of an animal’s basic metabolic needs.
Here is where we see a large difference between ectotherms and endotherms. You may know the former as "cold-blooded" and the latter as "warm-blooded" animals. Whereas ectotherms can put 20-50% of their assimilated energy towards growth, endotherms (birds and mammals) can only muster 1-3%. Why is this tissue growth efficiency so low for birds and mammals? Because most of their assimilated energy must be used to maintain an elevated body temperature (high metabolic rate). Since ectotherms simply assume the temperature of their surroundings, their metabolic needs are substantially less and they can put more of their available energy directly into growth.

Let's apply the above tissue growth efficiencies to an average value of 500 units of energy assimilated by the grassland herbivores. Ectotherms, such as grasshoppers, will produce between 100-250 units of new tissue (500 x 20-50%), while endotherms, such as mice or rabbits, will produce only 5-15 units (500 x 1-3%). Out of our original 10,000 units of energy, we have managed to produce only 100-250 units of herbivore tissue if we're talking grasshoppers and the like, and a very scant 5-15 units of herbivore "meat" if we're considering birds and mammals. This is all that will be available to the next trophic level, the primary carnivores. We have lost somewhere between 97.5 –99.95% of the energy originally fixed by plants in photosynthesis!

Having "crunched the numbers" above, you can begin to appreciate the rather drastic reduction in numbers and biomass usually portrayed in the third and fourth levels (carnivores) of the respective pyramids (refer again to Fig. 3). This is why the fourth trophic level is usually drawn as a thin line, representing only one or two top carnivores for an area of the size used in our illustration.

As a simplification, ecologists often employ the "10% rule" to illustrate the decline in available energy from one trophic level to the next. Thus, if each succeeding trophic level has only 10% of the energy available in the previous level, then only .01% of the original amount of energy fixed by the plants in photosynthesis would be found in the fourth trophic level (secondary carnivores) in any given area! It is this low trophic-level efficiency that accounts for the small number of trophic levels observed in any ecosystem.

**Management Implications**

The exceedingly small amount of energy available to the highest trophic level accounts for the fact that "big, fierce animals", those top carnivores, are exceedingly rare. In fact, most top carnivores need to be highly mobile to cover the vast amount of ground needed to supply their energy needs. Home ranges of wolves and mountain lions, for example, are on the order of hundreds of square miles! Their predatory activities often form crucial energy links between neighboring ecosystems or landscapes. It also explains why many of these top carnivores are often on endangered species lists. Never existing in large numbers, encroaching development and increasing levels of habitat fragmentation are compromising their need for large expanses of suitable habitat. It is also putting them in more frequent contact with human activities, often with negative consequences.

The territorial need of these top carnivores also highlights a critical question facing today's conservation biologists. As wildlife habitat continues to shrink, biologists are recognizing that the long-term survival of many species may ultimately depend on our willingness and ability to set aside sufficiently large tracts of land as biological reserves. The important question is – How large of an area is needed to maintain viable populations of that region's largest carnivores? Is
there the financial and political wherewithal to create at least one park or preserve on the magnitude of thousands of square miles? If not, we might not only lose those magnificent large predators but also the long-term stability of entire biological community of which they are important, perhaps critical, members.

The above text is selected sections re-printed from the Texas State Master Naturalist Manual. By Louis Verner, Ph.D., Texas Parks and Wildlife Department, With Contributions from John Davis, Debbie Reid, Antonette Villarreal and Mark White

Nutrient Cycles

"For every atom lost to the sea, the prairie pulls another out of the decaying rocks. The only certain truth is that its creatures must suck hard, live fast, and die often, lest its losses exceed its gains." Aldo Leopold

The never-ceasing quest for energy among all living organisms is an important determinant of many of the unique and peculiar traits of organisms. Entire books have been written about the adaptations related to either acquiring food or avoiding becoming food. But energy needs aren't their only consideration. In addition to the basic building blocks of organic matter (carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur), at least 20 other elements are considered essential to life. These elements move freely between the abiotic and biotic portions of an ecosystem as plants take in carbon dioxide from the air, and water and minerals from the soil to produce carbohydrates, fats and proteins. They are then passed along the food chain to both herbivores and carnivores. Nutrients are eventually returned to their elemental form and again take up residency in the abiotic environment upon decomposition of both excretory waste and dead plant and animal tissue.

This circulation of elemental materials is thus another important aspect of ecosystem function. Note that unlike energy, which flows through an ecosystem, matter is continually recycled. Some elements that currently (and temporarily) make up your body may well have resided in a dinosaur a hundred million years ago, or in the primordial bacteria that first colonized the planet almost 4 billion years ago!

Nutrient cycles are more formally referred to as biogeochemical cycles. It emphasizes the fact that the biological (bio) realm and the rest of the earth (geo) are inextricably interconnected through the movement of essential chemical elements. Biogeochemical cycles have no starting point. They are not for the ultimate benefit of plants or consumers any more than they are for detritivores or bacteria.

Of the many existing biochemical cycles, those most frequently detailed include the cycling of carbon, nitrogen, phosphorus and sulfur. Common to all are the presence of either a gaseous or sedimentary reservoir, and a change in the chemical nature of the element as it passes from one step to the next. We will examine the nitrogen cycle, hydrologic cycle and the phosphorous cycle in more detail. Those wishing to learn more about the cycling of other nutrients are encouraged to do so by consulting any ecology text.

The Nitrogen Cycle

"The more flesh, the more worms." Hilliel

Nitrogen, in the form of NH, is the building block of all plant and animal proteins. However, it does not exist in this form in nature, and outside of biological processes, it
exists almost entirely in its non-reactive molecular form, N\textsubscript{2} gas. The earth's atmosphere, which is 79\% nitrogen, is the vast reservoir for this important nutrient. Plants can only take up nitrogen as either ammonia (NH\textsubscript{3}) or nitrate (NO\textsubscript{3}), so even though life is bathed in nitrogen, it can't use any of it unless it is first "fixed" (Fig. 4).

![Simplified diagram of the gaseous nitrogen cycle](image)

**Figure 4: Simplified diagram of the gaseous nitrogen cycle**

**Nitrogen Fixation**

*Nitrogen fixation*, the process of converting N\textsubscript{2}, to ammonia (NH\textsubscript{3}), although energetically expensive, is accomplished by a wide variety of terrestrial and aquatic microorganisms, especially by both free-living and symbiotic bacteria: In many terrestrial environments, leguminous plants (members of the pea and bean family) often harbor the bacterium, *Rhizobium*, in root nodules. This is a symbiotic arrangement; that is both organisms benefit from the relationship. The bacteria tap into the plant's stored food, acquiring the energy necessary to carry out fixation, while the legume benefits by having access to the excess of ammonia produced beyond the needs of the bacteria. This is why legumes are often high in protein. It is also why legumes like vetch, clover and alfalfa are often planted as cover crops. *Rhizobium* not only provides for the needs of itself and its symbiont, it may actually result in as much as 250 pounds of nitrogen compounds being added annually to each acre planted.

**Ammonification**

Animals and decomposers produce their proteins from the plant or animal proteins in their diet. When these proteins are broken down in respiration, a waste product, ammonia, is produced. This may be voided directly (fish) or it may first be converted to a less toxic form. Most mammals, us included, convert it to urea, while most birds, reptiles and invertebrates convert it to a more solid form, uric acid. These compounds are the source of energy for another group of bacteria, which convert the nitrogen compounds to ammonia in a process known as ammonification. Upon death, this same process will break down an organism’s body proteins.
Nitrification

While ammonification returns nitrogen once again into a form immediately utilizable by plants, ammonia is often further acted upon by two separate groups of bacteria (again as a means of obtaining energy) in a two-step (especially here in Texas) process known as nitrification. The first group of bacteria converts ammonia to nitrite (NO₂) and the second group converts nitrite to nitrate (NO₃).

Both of these compounds are negatively charged (anions) and often precipitate out as various salts when bonded to positively charged cations, such as potassium or magnesium. As such they can be retained in soils for an much longer time than ammonia, and are therefore important components of a soil's fertility. Like table salt, these nitrogenous salts readily dissociate in water, thus making nitrate available for uptake by plants after a rain.

Denitrification

The above reactions will only take place under aerobic conditions that is where oxygen is present. Soils that have been compacted, waterlogged, or are otherwise anaerobic, will often set the stage for a loss of utilizable nitrogen in soils. Yet another group of bacteria, all anaerobes, will obtain significant energy by converting nitrate or nitrite back to elemental nitrogen, N₂. Although this may be looked at by some as a "negative" or harmful process (well-aerated soils are more productive), denitrification does bring the nitrogen cycle full circle, insuring that atmospheric concentrations of nitrogen are maintained and that the system as a whole remains in balance.

The Hydrological Cycle

While not considered a nutrient, per se, we are going to briefly review the main features of the hydrological or water cycle. Not only is water a key constituent of life in its own right, but it also serves as the medium through which many other nutrients are carried.

The hydrological cycle details the circulation of water between ocean, earth, and atmosphere (Fig. 5). Atmospheric water falls on the earth as precipitation in the form of rain, snow or fog. About five sixths of the water evaporated in the cycle comes from the oceans, but only three fourths of global precipitation falls on them. The difference is that which is exported to the land. In heavily vegetated areas, much of the precipitation is intercepted by plants and released back to the atmosphere as evapotranspiration. That which does not, soaks into the ground or becomes surface runoff, creating our streams and rivers. Water that percolates through the soil may eventually reach an impermeable layer and reside there as groundwater. Its upper surface is referred to as the water table. Geological formations that yield water in usable (in human terms) quantities are referred to as aquifers. If not used somewhere along the way, all ground and surface water eventually returns to the sea,
Carried in solution will be many nutrients either leached from the soil or derived from the weathering of parental rock. These nutrients will eventually be deposited as ocean sediments and their biogeochemical cycle will not be completed unless, and until, these deposits are again raised above sea level in a geological uplift.

The Phosphorus Cycle

Phosphorus is one of the 36 or so elements recycled through sedimentary cycles. These differ from gaseous cycles in that the nutrients move through the cycles much slower. The elements can be tied up in sedimentary rocks or other reservoirs for long periods of time, even thousands of years. Phosphorus, primarily in the form of phosphate ions (\(\text{PO}_4^{3-}\) and \(\text{HPO}_4^{2-}\)), is important to both plants and animals. Phosphorous is an essential part of the DNA molecules that carries the genetic blueprint for organisms. Phosphorus is an important component of ATP and ADP molecules that store the chemical energy for use by organisms in cellular respiration. Phosphorus is also vital for the development of bones and teeth in animals.

Phosphorus is released from phosphate deposits through weathering processes which breaks down the phosphorus into usable forms that are dissolved in water and taken up by the roots of plants. Animals obtain phosphorus by consuming plants or animals that have eaten plants (herbivores and omnivores). Some rodents obtain phosphorus and other minerals by gnawing on the bones and other hard tissues of dead animals. Animal waste products and the decay processes of dead animals and plants return much of the phosphorus to the soil, which finds its way to rivers and ultimately to the ocean bottom as insoluble deposits of phosphate rock. Because phosphate compounds are fairly insoluble in water and only found in specific rock formations, most soils contain only minute amounts of phosphorus. Therefore, phosphorus can be the limiting factor for the growth of plants in many areas.

Additional information on food chains, webs, energy flow and nutrient cycles can be obtained from the following references.

Books


Web Sites
http://www.ultranet.com/~jklimball/BiologyPages/F/FoodChains.html#Food_Webs
http://www.rnarietta.edu/~biol/102/ecosystem.html

Predator — Prey Relationships
Species interact with one another in a variety of ways. One of the most notable is predation. A predator is defined as an individual member of one species that captures and feeds on parts or all of a member of another species. The prey organism is the one that is captured and serves as a source of food for the predator. The interaction between these two organisms is often referred to as a predator- prey relationship. Some scientists describe this relationship as an arms race.
Predators have developed various techniques to capture their prey including pursuing, stalking and ambush. Predators have developed tactics to hunt alone such as a Cooper's Hawk or to hunt together in packs such as wolves. Prey species have countered with methods to avoid capture from their predators. These methods include speed and agility, camouflage, mimicry, and chemical defense. Even plants can be said to have developed methods to avoid predation. Some species of plants have sharp thorns to discourage browsing, other have toxins which make them unpalatable to all but the most specialized predators. Predator – prey relationships are complex and interesting interactions among different species. For more information refer to other ecology and mammalogy text books or web sites. A couple of references are listed below.

Books


Web Sites

Basic Wildlife Survival Needs
At the simplest level all animals require 4 basic factors in order to survive: (1) food, (2) water, (3) cover (shelter), and (4) the spatial arrangement of these three factors so that they are accessible to the animal. In other words, an animal's food, water and cover must be within a reasonable distance of that animal's ability to obtain them as needed. For example, both the eastern wood rat and the gray fox live in similar habitats, forested areas intermixed with small openings. Since the fox is a larger animal and mainly carnivorous, it ranges over a greater area on a daily basis to meet it nutritional requirements than does the smaller herbivorous wood rat. Every animal has its own unique set of habitat requirements that must be met for that animal to survive and reproduce.

Animals live in a variety of habitats: forests, grasslands, wetlands, xeric, mountainous, and marine to name a few. For each habitat, animals have developed special adaptations that allow them to best utilize the available food, water and cover resources. Moles possess large spade-like front limbs to aid in digging into the soil. Squirrels are equally adept at moving about in the upper canopy of the forest and along the forest floor, enabling them to exploit resources throughout the vertical strata of their habitats. To obtain a thorough understanding of the habitat requirements of a given species, it is imperative to study the life history of that animal.

Refer to the following web site for more information.

http://www.indiana.edu/~bradwood/eagles/habitat.htm
Population Dynamics

Terms used by wildlife biologists and ecologists frequently have very specific meanings that differ from the common usage of those words. In the case of the term, population, the common usage and scientific meaning are actually quite close. Most people use the word population to refer to the number of people inhabiting a certain area, such as the population of Austin, Texas or the population of the United States. Biologists define population as a group of individuals of the same species that occupies a particular area at the same time. For example, wildlife biologists may be interested in a population of endangered red-cockaded woodpeckers living in a stand of loblolly pine or a population of beaver living in a particular watershed. Population studies usually begin with a determination of the size of the population. Biologists refer to the number of individuals per unit area as the population density. For example, the population density of cotton rats living in grassland may be 30/acre while the population density of white-tailed deer in a forest may be 10/square mile. Many environmental factors, both biotic (living) and abiotic (non-living), affect population density. Ultimately, though, changes in any population's density can be attributed to a change in one or more of the following four population parameters:

- **Natality** – the production of new individuals through either sexual or asexual reproduction
- **Mortality** – loss of individuals through death
- **Immigration** – new individuals moving into a population
- **Emigration** – residents moving out of a population.

In part, the job of population biologists and wildlife managers involves assigning values to each of these four variables to better predict future population trends. Scientists often use mathematical models or equations to help them make predictions. All the fancier models of population growth (which we happily won't go into) are based on this simple equation:

\[ N_{t+1} = N_t + B + 1 - D - E \]

Verbally this reads: The number (N) of individuals in a population at some unit of time in the future (\(N_{t+1}\)) is equal to the current number of individuals (\(N_t\)) plus the number of new individuals recruited via reproduction (B) and immigration (I), minus the number lost to death (D) and emigration (E) over that unit of time. If recruitment exceeds losses, the population grows; if not, the population declines.

Population biologists also make a distinction between those factors affecting population growth that are internal to the population (intrinsic factors) and those that are outside or external to the population (extrinsic factors). Examples of intrinsic factors include a population’s sex and age distribution, age-specific fecundity (rate at which females produces offspring) and social structure. A population comprised mostly of young, reproductive individuals is going to have a faster rate of growth than one that has a high percentage of older, post-reproductive individuals. A population of 70 females and 30 males will grow faster than a population of 30 females and 70 males. A population of field mice has the potential to grow faster than a population of bobcats because female mice start having litters at an earlier age (some as young as 6 weeks!), have more offspring per litter (up to ten or more) and more litters per year (some give birth to new litters every 3-4 weeks). Compare that to a female bobcat, who will not produce her first litter until she is about a year old, and will only produce one litter per year, averaging 2-3 kittens each.
Here are two examples of how social structure may influence population size. Certain species of salamanders need a critical minimum number of individuals in the population for successful breeding to occur. If the population drops below that number, no new young will be produced and the population may go extinct, even though some reproductive males and females remain. Territorial species, such as many of our songbirds, will behaviorally limit the number of breeding pairs allowed in a given habitat. Thus, population densities of many bird species may remain relatively constant from year to year in a given area, as long as the habitat quality doesn't change.

There are also many extrinsic (external) factors affecting population growth, including competition, predation, disease, pollution, hunting, and carrying capacity of the environment.

**Carrying Capacity**

Carrying capacity is a very important ecological concept. It is defined as the maximum number of individuals of a given species that a habitat can sustain indefinitely. When habitat quality improves, its carrying capacity increases. If it declines so does the carrying capacity. This is why both the *quantity* and *quality* of wildlife habitat is so critical to maintaining wildlife populations and why wildlife managers "manage" habitat, not wildlife.

What influences habitat quality? Habitat consists of the food, water, shelter, and the spatial arrangement of resources needed by a given species for survival and reproduction. Changes in any of these can dramatically affect a population's size. Note, however, that the same habitat may have very different carrying capacities for different species. The carrying capacity of one acre of grassland may be in the thousands for a small herbivorous insect, in the tens for a herbivorous rodent and perhaps only one for cottontail rabbits. Also, be aware of the fact that increasing the habitat quality (carrying capacity) for one species may have a negative effect on the carrying capacity for other species.

---

**Figure 6:** TWO ELEMENTARY FORMS of population increase: Exponential growth (curve on left) and logistic growth (curve on right).
Population Growth Models

For many species (most invertebrates), populations may exhibit exponential growth or "J" shaped growth curves (First graph, Fig. 6). After starting slowly, numbers begin to accelerate rapidly, increasing at an ever-increasing rate, mimicking the way money grows in an account earning compound interest. These populations often continue to grow exponentially until a sudden change in environmental conditions causes them to "crash". An insect population growing exponentially throughout the spring and summer may be brought to a sudden halt by the first cold snap. This is density-independent growth; the growth rate of the population is independent of the population density.

Other species, especially long-lived vertebrates, may exhibit a logistic growth pattern, as idealized in the second graph of Figure 6. Their populations show the effects of increasing environmental resistance. The greater the population size, the more the environment "pushes" against further growth. As numbers of individuals approach the habitat's carrying capacity (K), the population growth rate gradually slows until at K it becomes zero, thus stabilizing the population at carrying capacity. This density-dependent growth is the result of both intrinsic factors (greater social stress leads to lower natality rates, lower survivorship rates, higher emigration rates, etc.) and extrinsic factors (increased predation, disease).

No species in nature follows either pattern exactly or indefinitely. The logistic growth model, for example, assumes that populations are capable of immediately changing their growth rates in response to environmental resistance. The reality is that there is usually a lag effect, or time delay. A population at carrying capacity may continue to grow for some time before environmental factors leading to zero population growth take effect. Thus, rather than leveling out at K, a population may overshoot it, leading to over-exploitation of resources, degradation of habitat quality, and an eventual decline below the original carrying capacity. The long-term result may either be a population that oscillates around K in an increasingly tighter pattern (damped oscillation) or one that exhibits more or less regular periodic cycles of abundance. Periodic fluctuations in numbers have often been documented in northern habitats such as the classic 10-year cycle exhibited by snowshoe hare, lynx, ptarmigan and ruffed grouse and the 4-year cycles exhibited by various species of voles and lemmings.

Management Implications

Despite their apparent limitations, these basic models have served as the foundation for more sophisticated attempts to understand population dynamics. Population models are the primary tools of today's resource managers. The objective of all natural resource management is to produce the greatest yield without endangering the long-term health of the resource being harvested. Whether we are discussing forestry, fisheries or wildlife, the resource manager must know enough about the population dynamics of the species in question to accurately set appropriate harvest rates on a year to year basis. Sadly, much of human history is strewn with examples of how poor management has led to the destruction of a once abundant resource.

One application of the logistic population growth model (Fig. 6, second graph) has been the basis of scientific resource management since the 1930's. The model predicts that the maximum sustained yield for any population is obtained not when populations are at their highest level or at carrying capacity, but rather at a point much below K. In its simplest form, the logistic model reveals that the highest rate of population increase occurs at the mid-point of the growth curve, or when N = 1/2K. Thus the maximum sustained yield for a game species would be obtained by cropping that population back to one half the carrying capacity prior to
the next breeding season. To determine actual hunting or "bag" limits, wildlife managers must collect and analyze both population and habitat data to determine the relationship between a population's current size and its potential for future growth set by the carrying capacity of the habitat.

General Habitat Management Considerations/Recommendations

Fundamental requirements that must be considered when managing wildlife habitat include food, cover, water and the proper distribution of these elements.

Wildlife and habitat management should be directed at maintaining a productive and healthy ecosystem. The ecosystem consists of the plant and animal communities found in an area along with soil, air, water and sunlight. All management activities should be aimed at conserving and improving the quantity and quality of soils, water and vegetation.

Managing for plant diversity is essential. A diverse habitat has a good mixture of various species of grasses, forbs (weeds), and browse (woody) plants. Many of these plants will be at various stages of growth, which adds another element of diversity. The diversity of vegetation increases the availability of food and cover for wildlife species. A greater diversity of range plants results in more food being made available during different periods of the year. The volume and diversity of plants protects the soil from erosion. Also, the decomposition of vegetation helps restore needed minerals to the soil to sustain plant life. Vegetation improves the water cycle by increasing water infiltration into the soil and reducing surface runoff.

An ecologically based habitat management program serves to improve water cycling, mineral cycling, and energy flow and manipulate plant succession. These processes enhance vegetative quantity, quality and diversity. A greater diversity of all life forms, including microorganisms, insects, reptiles, amphibians, birds and mammals may be achieved under sound management. The land's long term health is improved and conserved for future generations to utilize as a source of income, recreation and for aesthetic enjoyment.

Plant communities with a diversity of grasses and native broad-leaved weeds (called forbs) are more productive than those comprised primarily of grasses. The climax plant community of most rangelands is comprised primarily of perennial grasses with a relatively low forb component. While this may be suitable for livestock and some grassland wildlife, most species are dependent on the seeds and foliage of forbs. Periodic disturbances such as fire, soil disturbance, livestock grazing, and mowing can set back plant succession and maintain a diverse plant community, simulating conditions under which plants and animals evolved within ecosystems in Texas.

Livestock Management Recommendations

Livestock management is the single most important factor that affects deer and most other wildlife populations in the post oak savannah and most of the blackland prairie. Stock cattle at the NRCS (formerly SCS) recommended rate. Moderate to light stocking rates for well-managed pastures in this area are generally: one animal unit (cow with calf) per 8 15 acres on native grass; 3 - 6 acres on tame pasture; 50 - 75 acres on wooded areas. Where possible, rotate cattle in one herd through 3 - 10 pastures, letting pastures rest for at least as long as they are grazed. Rotate cattle out of wooded tracts wherever possible beginning in late August (when berries on American beautyberry begin to ripen) on through February - and/or - begin fencing off woods, especially bottomland areas to exclude cattle during this same
fall/winter period. This practice will prevent cattle from competing with deer for browse and forbs - American beautyberry, greenbriar, elm, hackberry, yaupon, rattanvine, grape, tickseed clover, etc. - that deer normally require for healthy maintenance and growth. Also, fence off or exclude one or more acres of native pasture in scattered locations to provide tall grasses and weeds for fawn nursery areas and quail/turkey nesting areas.

Several livestock grazing methods and systems have been developed which provide adequate periods of rest and allow vegetative recovery. There are many variations of these systems and the land manager needs to select the one that fits his particular situation. Some commonly used deferred-rotation grazing systems are: three pasture/one herd rotation, four pasture/one herd rotation, high intensity/low frequency (HILF), short duration, and four pasture/three herd rotation, or rest rotation. Regardless of the type of deferred-rotation grazing system used, the length of time that an individual pasture should be grazed, and the length of time that it would need to be rested before being grazed again, would be dependent on the size of the pasture, its grazing capacity, the time of year (growing season versus non-growing season), the amount of rainfall received since being grazed, and the class of livestock. Grazing schedules and livestock stocking rates for pastures within a grazing system need to be flexible and continually reevaluated based on rainfall patterns, seasons of the year, and local range conditions. Knowing how long to graze and how long to rest is more an art than a science, dependent more on environmental factors and the on-site conditions than on the calendar.

A well-planned cattle grazing system is compatible with wildlife habitat management. Since cattle primarily consume grass, they do not normally compete with most wildlife for the same food sources, unless forced to due to excessive stocking rates and/or continuous grazing pressure. However, goats and sheep more directly compete with wildlife. Goats prefer browse (the foliage of woody plants); sheep prefer forbs. The foliage and seeds of forbs and woody plants are important food sources for many species of wildlife. Excessive goat browsing also reduces the amount of low-growing woody brush needed for cover for many wildlife species and can limit the reproduction of woody plants. It is recommended that sheep or goats not be stocked on a ranch if maintaining and improving the habitat for wildlife is an objective, unless 4-6 months rest can be periodically provided in pastures to allow for the adequate recovery of woody plants.

Vegetation Management Recommendations

In the Post Oak Savannah and Blackland Prairie, managing native vegetation (browse, weeds, grasses) to prevent continuous overuse by deer or cattle so that the native vegetation provides the majority of nutrition year-around for deer and other wildlife should be of primary concern. Over 50 percent use on the current year’s growth of most plant species on a continuous basis will stress vegetation, causing less production or killing of the plant. Evidence of overuse on plant species includes the presence browse lines, hedging and the absence of native species that recently occurred on the site.

Wildlife has a certain requirement for cover. Cover provides a sense of security from disturbance and protection from inclement weather and predators. The amount and kind of cover vary with the species. A stand of herbaceous plants may provide adequate cover for some bird species and small mammals, while other species require woody cover (trees and shrubs) in lieu of or in addition to herbaceous cover. The best cover for a large species such as white-tailed deer in the Post Oak Savannah and Blackland Prairie is a mosaic pattern of woody brush and trees interspersed within open areas at an approximate 1/1 ratio of open
area to woody cover. Clumps or strips of brush should be wide enough so that an observer cannot see through them from one side to the other during the winter months when deciduous species are bare of leaves. Cover strips should be as continuous as possible to provide travel lanes. Deer and other wildlife can be displaced by disturbance from an area without adequate escape cover. A habitat that provides several different types and arrays of cover benefits more species of wildlife than a habitat that has limited types, amounts, and distribution of cover.

During the past 30 - 40 years, an estimated 25 percent or more of the Post Oak Savannah has been planted to monoculture tame grasses such as Coastal or common Bermuda, Bahia, Klein grass, etc. (often requiring the clearing of hardwood timber). Over-seeding these existing pastures with clovers, or gradually returning this acreage to native grasses and forbs can make these areas more productive for wildlife.

Upland hardwoods and the associated understory vegetation of the Post Oak Savannah of East Texas presently vary from heavily over-browsed by cattle and sometimes deer, to a dense yaupon understory shading out virtually all other browse and mast-bearing species. Good cattle management, utilizing rotation and/or excluding cattle from wooded areas via fences, coupled with periodic winter prescribed burning could revitalize these sites, making them much more productive. Biologically sound harvest strategies for deer; feral hog (and other large exotics, such as axis or sika deer) are also needed to prevent overuse of food and cover. Native white-tailed deer and feral hogs (and large exotics if present) are the only wildlife species present in the Post Oak Savannah and Blackland Prairie that can degrade or virtually destroy the habitat for not only themselves, but for the many smaller mammal and bird species that rely on the same vegetation for food and/or cover.

Many bottomland hardwood sites have also been heavily grazed/browsed by cattle, and in some instances deer. As with upland sites, rotation or exclusion of cattle, coupled with sound deer and feral hog harvest strategies can improve these situations. Large (1,000 acres +), unbroken tracts of climax stands of bottomland hardwoods are scarce. At least 65 percent of bottomland hardwoods of Texas have been lost to reservoir construction and agriculture activities. Loss and fragmentation of this nesting habitat for neotropical migratory songbirds appears to be a prime factor in the decline of many species that require relatively unbroken tracts of hardwoods. Harvest of high quality (high-grading) large oaks and pecans (high mast producers) in the past in some sites has resulted in mostly "weeder species, less valuable for wildlife" such as ash, elm, hackberry, sweetgum, etc. dominating these sites. Good timber management, utilizing a competent agency or private timber consultant, can prevent this scenario and help restore these abused sites to a more productive state.

Riparian area management has often been overlooked by land managers. These areas may have been impacted through poor timber harvest practices, and/or excessive, long-term livestock use. These low areas along stream courses, lying between uplands and streams/rivers, are capable of producing very important cover and food sources if managed properly. Riparian areas also function as important protected travel corridors, connecting feeding areas, fawning/nesting areas, and roost areas. These corridors (at least 100 yards wide) can provide connections to other wildlife populations and also prevent soil erosion. Reestablishment of native trees, shrubs, or herbaceous vegetation where needed can return this acreage to a functional, more productive part of the habitat. Providing alternate livestock feeding and watering sites by planned rotational grazing of livestock or fencing livestock out of these areas are also sound management techniques. It is usually best to defer or protect riparian areas from grazing during the growing season - April through October.
Management of vegetation, whether it be deciduous post oak woodlands, bottom land hardwoods, mesquite woods, or open grasslands, requires long-term planning. Any vegetation manipulation practice will have an impact on resident wildlife species, either good or bad, depending on the type of treatment used, the degree of use, and location. Before implementing vegetation control techniques, determine what the long-term effects will be for each wildlife species that occurs in the area and minimize the negative impacts. Consider the location and size of sensitive wildlife habitats that provide important nesting or roosting sites, feeding areas, desirable wildlife food producing plants, cover, water, and space needs. Wildlife can be displaced by disturbance from an area without adequate escape or security cover. The amount and distribution of cover on adjacent lands need to be taken into consideration when assessing the cover needs of wide-ranging wildlife species such as deer and turkey. A small ranch would need a larger amount of security cover on a percentage basis than would a larger ranch where the vastness of the area provides security.

The control of plant species such as ashe juniper, eastern red cedar, mesquite, prickly pear, Chinese tallow tree, locust, elm, and hackberry that invade a variety of rangeland sites is often warranted. When these species dominate an area, they diminish plant diversity and the quality of habitat for most wildlife species. Vegetation manipulation may be in the form of prescribed burning, range reseeding, native grass restoration, and mechanical, biological, or herbicide control of trees, brush, or weeds, and is important to create and maintain open rangelands for grassland dependent wildlife. Most of these practices will require the use of specialized equipment or machinery for plowing, discing, bulldozing, spraying, or other vegetation or soil manipulation procedures. The cost effectiveness of the different control measures must be considered prior to initiation of control measures.

Prescribed burning is an effective, low-cost habitat management tool that can be used to enhance plant diversity by stimulating the production of a variety of forb and grass species and to maintain woody plants at the low heights most beneficial to wildlife. Livestock as well as wildlife can benefit from a properly planned and conducted prescribed burn. However, there are legal constraints and liabilities in the use of fire. The land manager should be well-trained and knowledgeable on the proper use of fire before attempting a prescribed burn. Refer to Texas Agricultural Extension Service bulletin "Prescribed Range Burning in Texas" for details on the use of fire as a range management tool.

Prescribed Burning Recommendations: To maintain oak woodlands with dense, diverse, understory, prescribe burn about 15 percent of upland woodland sites during late November (after frost and leaf drop) through February (before green-up) on a rotating basis, burning each site every 5 - 7 years to remove old growth and stimulate new growth of browse and forbs (weeds and wildflowers). About 50 - 100 acres per burn site would be the maximum size to burn on these particular land tracts. In order to have enough low-level fuel to produce a hot fire, one or two years of cattle exclusion from wooded tracts may be necessary to allow growth of vegetation normally grazed by cattle. Prescribe burning of these woods shortly after leaf drop, before winter rains and time compact leaf litter, may be necessary for some tracts.

To restore and maintain oak savannah/native grasslands, prescribe burn about one-third of native grass openings each year, burning each site every three years, on a rotating basis, to remove old growth and young, invasive woody growth such as cedar, locust, and persimmon. This will stimulate new growth of plants that may have become dormant due to not having occasional fires to stimulate growth. Pasture burn sites should normally be less than 40 acres and be burned in late summer (late August through September) weather conditions permitting. See TAEX publication Prescribed Range Burning in Texas for good general guidelines,
especially for native pastures. About seven times more insects are usually found in burned native grass areas compared to unburned areas, thus providing much more spring and summer high protein food for quail, turkey, and other insect-eating birds, especially for the young.

It is often necessary for a pasture or woodland to receive a period of deferment from livestock grazing to allow for a build-up of enough fuel (herbaceous or non-woody plant litter) to carry a fire. Cattle should be excluded from burned areas for at least 3 months to allow re-growth of new, tender vegetation.

Prescribed burning can be the most inexpensive and effective habitat management technique for the Post Oak Savannah, Blackland Prairie, as well as other regions of the state.

The use of mechanical equipment to control woody plants will typically result in an initial growth of forbs and annual grasses and the re-sprouting of many woody species. Soil disturbance associated with mechanical controls releases the natural seed bank found in the soil, increasing the quantity, quality, and distribution of plants beneficial to wildlife. However, without periodic follow-up treatments of fire, herbicides, or additional mechanical manipulations, and/or without proper livestock grazing management, these sites will eventually again become dense stands of re-growth brush and trees. Mowing (shredding) areas of herbaceous plants and/or low-density woody plants is another form of mechanical treatment. Mowing should be postponed until after the peak of the nesting/young-rearing period of local ground-nesting birds and mammals. One-third of open areas can be mowed per year, preferably in strips or mosaic types of patterns, to create "edge" and structural diversity.

Biological control is the use of heavy grazing pressure by livestock such as goats to control or suppress woody plants and sheep to control herbaceous weeds. Under certain management goals, biological control of woody plants and forbs can be a legitimate practice if done correctly. However, it is not normally a recommended wildlife habitat management practice. Long-term heavy grazing pressure by goats, which prefer woody browse but will also consume forbs, will eliminate all leaves from woody plants up to a height of four feet. The creation of this "browse line" and the resulting park-like appearance of the woody plant community will have negative effects on the wildlife species that also depend on the low-growing foliage of woody plants for both forage and cover. Heavy grazing pressure by sheep, which prefer forbs, will reduce or eliminate forbs that are also beneficial to wildlife.

There are many specifically formulated herbicides on the market today that can selectively control unwanted vegetation to enhance wildlife habitat. Determining the proper product and application technique requires consultation with TAEX, NRCS, or TPWD personnel. Always advise that wildlife is a goal for your projects of this type, if herbicides are improperly used, they can have a significant negative impact on many plant communities and may suppress or eliminate plants other than the target species. Selective application methods, rather than broad-scale applications, are recommended to avoid the elimination of plants that are important to wildlife.

Range enhancement involves range reseeding and native grass restoration. Establishing native herbaceous plants (grasses and forbs) that provide food and cover benefit wildlife and provide erosion control benefits. Plant species selected and methods for establishment should be applicable to the county. Non-native species are generally not recommended, but if required for a specific purpose, non-native species should not exceed 25 percent of the
seeding mix. Seeding mixtures providing maximum native plant diversity are recommended. Key grass species adapted to the Post Oak Savannah and Blackland Prairie are: little bluestem, big bluestem, indiangrass, sideoats grama, and switchgrass. Many herbaceous broadleaf plants (known as forbs - weeds and wildflowers) are beneficial to wildlife for forage and/or seed production. Some important ones for these eco-regions are: native sunflower, tick clovers, three-seeded mercury, ragweeds, crotons, vetches, dayflower, cutleaf primrose, bur clover, sweet clovers, smartweeds, lespedezas, partridge pea, sensitive briar, snow-on-the-prairie, Illinois bundleflower, and Engelmann daisy.— Encourage "weed and wildflower" species by selective application of chemical, biological (e.g., grazing management) and/or mechanical means on native rangelands, Conservation Reserve Program lands, and tame grass pastures (e.g., coastal Bermuda). Natural Resource Conservation Service personnel in the area can provide detailed recommendations on range and native grass reseeding designed to meet individual goals.

Farming Practices: Delaying of shredding or mowing of hay or native grass pastures until after July 15 will usually avoid killing of young fawns or ground nesting birds by accident.

Use Integrated Pest Management to minimize pesticide applications (consult the Texas Department of Agriculture, Austin). If necessary, spot spraying is much preferred over broadcast spraying especially for broad-spectrum herbicides. Spray early in the spring while plants are still small, requiring less spray. It is important to remember that many "weeds" these herbicides may affect can be important to wildlife.

To provide weed seeds (ragweed, croton, sunflower, partridge pea, trailing wild bean, etc.) that are the basis of quail, dove, and other seed-eating bird's fall and winter diets, shallow disk 10 - 20 foot wide strips in sandy soil around the edge of brush and woods after the first freeze. This practice will promote growth of these important forbs the following spring and summer.

For specific management recommendations concerning deer, turkey, quail, endangered species and non-game refer to the appendices in the Comprehensive Wildlife Management Planning Guidelines for the Post Oak Savannah and the Blackland Prairie Ecological Regions; located at http://www.tpwd.state.tx.us/conserve/agland/agland.htm or the references listed below.

The above text excerpted from Management Planning Guidelines for the Post Oak Savannah and the Blackland Prairie Ecological Regions

Literature:

Refer to the following Texas Parks and Wildlife Department (TPWD) and Texas Agricultural Extension Service (TAEX) bulletins and pamphlets for additional habitat management and specific species management information:

Habitat:


Prescribed Range Burning in Texas by L.D. White and C. W. Hanselka, TAEX, Reprinted by TPWD, 4 PWD-BK-7100-196-7/91

Management Options in Post Oak Woodlands For Wildlife by D. W. Rideout, TPWD, #PWD LF N7100-237A (10/93)
Green-Tree Reservoir Management by B. Ortego, C. Frentress, H. Haucke, and J. Hogan Rose, #PWD-BK7100-157-1 1/88

Deer:
- Learn About Whitetails by R. L. Cook, #PWD-BK-N7100-7-2/93
- The Post Oak Savannah Deer Herd: Pak, Present, Future by D. W. Rideout, #PWD RP W7100-237B (9/94)
- Determining the Age Of a Deer by C. W. Ramsey, D. W. Steinbach, D. W. Rideout, TAEX #B-I453
- Coyote Creek Ranch - A Success Story by D. W. Rideout, TPWD, #PWD LF N84100-241 (10/93)
- Supplemental Forage Management for East Texas White-tailed Deer by B. J. Higginbotham and J. C. Kroll, TAEX 4 L12457
- Supplemental Feeding by J. R. Perkins, TPWD, #PWD-BK-N7100-033-11/91

Squirrel:
- Fox Squirrel Management in East Texas by B. G. Alexander, TPWD #PWD BK W7100-028 (10/94)

Quail:
- Bobwhite Quail in Texas-Habitat Needs and Management Suggestions by A.S. Jackson, Clyde Holt, and Daniel Lay, TPWD, # PWD Brochure 7000-37 5/84
- The 182 page book "Beef, Brush and Bobwhites - Quail Management in Cattle Country" by Fred S. Guthery. Published by the Caesar Kleberg Wildlife Research Institute, Texas A&M University (now Texas A&M at Kingsville), Kingsville, Texas in 1986.

Dove:

Turkey:
- The Eastern Wild Turkey in Texas by J. J. Campo and J. G. Dickson, TPWD, # PWD-BR-71-137B-2/90
- Rio Grande Turkey Habitat Management by G. W. Litton and F. Harwell, TPWD, #PWD RP W7100-263 (10/95)

Feral Hog:
- The Feral Hog in Texas by R. Taylor, TPWD, #PWD-BK-7100-195-10/91

Other Non-game:
- Texas Wildscapes Program. Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, Texas, 78744.

Many of the above mentioned publications can be found at the following web site.
http://www.tpwd.state.tx.us/publications/wildlife_habitat/habitat_mgmnt/index.htm
Herpetofauna — Amphibians and Reptiles

Herpetology: The study of amphibians and reptiles.

Amphibians: From the Greek - amphibios - leads two lives. This refers to the fact that most amphibians have an aquatic, gilled larval stage (the familiar tadpoles of frogs and toads) which then undergoes metamorphosis to become the terrestrial adult stage. Because amphibian eggs lack a protective shell, most adult amphibians must return to the water to lay their eggs, which are fertilized externally. Amphibians are vertebrates (animals with backbones) whose body temperature is under control of the external environment. In common language, they are cold-blooded; but more correctly, they are ectothermic. They possess a soft glandular skin that lacks scales and their toes lack nails or claws. The most common amphibians are the salamanders and frogs and toads.

Classification: The taxonomic classification of amphibians is as follows:

- Kingdom – Animalia
- Phylum – Chordata Subphylum – Vertebrata
- Class – Amphibia
  - Order Caudata – Salamanders 390 spp worldwide
  - Order Anura – Frogs and Toads 4000 spp worldwide
  - Order Apoda – Caecilians 163 spp worldwide

Caecilians are tropical slender worm-like amphibians lacking limbs and possessing only rudimentary eyes. All but one species are fossorial, living in burrows in damp earth. There are no species in the United States. There are 24 species of salamanders, all of which have tails and 46 species of frogs and toads, all of which lack tails, in Texas.

Evolution: Amphibians were the first terrestrial vertebrates. They evolved from lobe-finned fishes around 400 million years ago and were a very diverse group by 345 million years ago. Their numbers declined markedly with the rise of the reptiles some 280 million years ago.

Skin: Amphibian skin is unique among all vertebrates. It is water permeable, highly glandular and often colorful. Most amphibians will quickly dry out and die if they aren't able to keep their skin moist. Terrestrial adults don't have to drink; they can absorb water directly into their body through their skin from any moist or wet surface. For that reason, they are most commonly found in moist, humid environments. However, a few species, such as our spadefoot toads, can be found in arid desert environments. These species must still keep themselves moist, so they stay burrowed underground for most of the year, emerging to feed and breed only after heavy rains when the humidity is high. The "slimy" texture often associated with amphibian skin is the result of various skin secretions. This mucus layer helps keep the skin moist, aids in respiration and helps protect them from abrasions. Most amphibians also have a variety of poison glands found in their skin. These glands produce secretions that protect them from various pathogens as well as acting as a deterrent to would be predators. You may be familiar with the oval-shaped parotoid glands found behind the head of many toads. If a predator, like a dog, attempts to eat a toad, these glands release a toxin that is quite distasteful and usually causes the animal to release the toad, often with much frothing at the mouth. You may also be familiar with the poison dart frogs of South America, whose skin produces a toxin that can be lethal if it enters the bloodstream or is ingested. Many adult anurans (the term used for frogs and toads) are very colorful and some, such as tree frogs, are capable of changing color. Color patterns may aid in concealment, temperature regulation or as a warning to would be
predators in the case of toxic species.

**Respiration:** Respiration takes place via gills in the aquatic larval stage. While some amphibians retain gills as adults (waterdogs, sirens), most develop lungs and breathe air. However, amphibians can’t draw air into their lungs like we do. Because they lack a diaphragm, they can’t expand their chest cavity; instead they gulp and swallow air, forcing it into their relatively primitive lungs. Because their skin is moist and highly permeable, many amphibians are actually capable of "breathing" through their skin. In fact, for one large group of terrestrial salamanders, this is their only means of respiration; they don’t have any lungs at all!

**Circulation:** The circulatory system of amphibians shows many improvements over that of fishes. Of primary importance is the presence of 3-chambered heart, two atria and one ventricle, compared to the 2-chambered heart of fishes. Because the ventricle is not divided as it is in birds and mammals, some mixing of oxygen rich blood from the lungs and oxygen poor blood coming from the rest of the body does occur. This is less efficient, but because most amphibians lead rather sedentary lives, it doesn’t really pose a problem.

**Locomotion:** As the first terrestrial vertebrates, it is not too surprising to find that amphibians, as a group, exhibit rather modest abilities when it comes to locomotion. Salamanders, more primitive than anurans, have relatively small legs which extend to the sides of the body, offering little in the way of body support. Their main form of locomotion is still very fish-like, writhing through a series of s-shaped curves aided with minimal thrust from the legs. The hind limbs of anurans are more highly developed, especially in frogs, and they are capable of both hopping and jumping. Some anurans, such as the tree frogs, have well-developed toe pads or discs, which allow them to climb and cling to vertical surfaces, even glass! As you might guess from their common name, spade-foot toads have a broad, sharp-edged tubercle (or spade) on the inside of their hind foot with which they can dig themselves out of sight in short order.

**Reproduction:** As stated earlier, most amphibians must return to the water for breeding. This most often occurs in the spring or early summer, often with the onset of warm, rainy weather. Anuran males often gather first to form breeding choruses at pools, ponds or other wet areas and make their presence known by loud calls that seem to attract females of the same species. Mating takes place in the water, with the male fertilizing the eggs externally after they are released by the female. Frog eggs are usually seen in large gelatinous masses, while toads usually lay their eggs in strings. Eggs hatch anywhere from several days to a month later. The gilled larvae or tadpoles feed on algae and other organic matter until they undergo metamorphosis, sprouting legs, absorbing their tails and undergoing significant internal change to emerge as little froglets or toadlets. Salamanders usually breed during the same timeframe, but without all the fanfare. Males don’t vocalize; instead breeding often occurs only when a significant number of males and females have gathered at the bottom of shallow ponds or pools. Depending on the species, breeding may occur in shallow, temporary pools, rivers or streams, or lakes and ponds. As more native habitat undergoes development, many original breeding sites are either no longer suitable or are disappearing altogether. A marked decline in many amphibian populations has been noted not only in the United States, but also worldwide.

**Ecological Importance:** In many moist, terrestrial habitats, amphibians may be the most important links in the food chain. Amphibians may exceed in numbers and biomass each of the vertebrate groups (reptiles, birds, mammals), and their annual production of new tissue
may also exceed that of either birds or mammals. For example, salamander population densities in New England were 7-10 individuals per square meter; representing twice the biomass of breeding birds and the same biomass as small mammals. In some Texas ponds, the biomass of the Lesser Siren, a gilled aquatic salamander, was greater than that of the total of seven species of fish found in the same habitat.

Amphibians, which are almost entirely carnivorous as adults, are the primary vertebrate predators on small invertebrates in many freshwater and moist terrestrial environments. A small pond population of cricket frogs, a species common throughout most of Texas, was estimated to consume around 4.8 million arthropods per year.

**Reptiles:** Reptiles (from Latin - reptiles - to creep) are ectothermic vertebrates differentiated from amphibians by the presence of dry, scaled skin, clawed toes, and, most importantly, a large-yolked, shelled egg. The most common groups of reptiles include turtles, lizards, snakes, and crocodilians.

**Classification:** The taxonomic classification of reptiles is as follows:

- Kingdom - Animalia
- Phylum - Chordata Subphylum - Vertebrata
- Class - Reptilia
  - Order Chelonia - Turtles, tortoises 240 species worldwide
  - Order Squamata - Lizards and Snakes
    - Suborder Lacertilia - Lizards 3700 species worldwide
    - Suborder Serpentes - Snakes 2300 species worldwide
  - Order Crocodylia - Crocodiles, alligators, caimans and the gavial 21 species worldwide

**Evolution:** Reptiles diverged from amphibians some 280 million years ago. Once they solved the problem of life away from water, by developing an impermeable skin and a shelled egg that could be laid on land, they became the first vertebrates truly adapted to the terrestrial environment. They spread rapidly, diverging into many different forms and occupying virtually all available habitats. Some took to the air and some even returned to the water. Interestingly, most aquatic reptiles must reverse the pattern we observed in amphibians and return to the land to lay their eggs. One group of reptiles became the dominant life form on the planet for over 100 million years, the dinosaurs. Not until they went extinct, some 65 million years ago, do we see the rise in importance of the other two groups of terrestrial vertebrates, the birds and the mammals. Those reptiles that survived to the present represent just a small fraction of the great diversity of reptiles that once "ruled the world".

**Skin:** All reptiles possess dry, impermeable (waterproof) skin that is usually covered with scales. Contrary to common belief, snakes are not slimy! Turtles are unique in having a protective bony shell covered by scaly plates, or scutes that easily distinguishes them from any other animal. The upper shell is called the carapace and the lower shell is known as the plastron. Because their skin is covered with scales, most reptiles must periodically shed their skin in order to grow. Lizards usually shed their skin in patches, while snakes shed their skin whole.

**Respiration:** Reptiles breathe much as we do, expanding their chest cavity to draw air into their lungs, which are more advanced than those found in amphibians. Most snakes differ from other reptiles in having only one lung instead of a pair. Interestingly, some aquatic turtles can actually remain under water for prolonged periods of time by breathing through their
cloaca (the common opening for the digestive, urinary and reproductive tracts)!

**Circulation:** Like amphibians, most reptiles have a 3-chambered heart. In reptiles however, the ventricle is partially divided, thereby more efficiently separating oxygenated blood from the lungs from blood coming in from the rest of the body. Crocodilians have a fully divided ventricle, making them the only reptiles with a true 4-chambered heart like ours.

**Locomotion:** Reptiles exhibit a wide variety of limbs and means of locomotion. Although flying forms are all extinct, there are some tropical lizards and snakes capable of gliding, much like flying squirrels. Marine turtles (terrapins) possess flippers that propel them rapidly through the seas. Crocodilians primarily use their powerful tails in the water, but are capable of surprisingly fast movement over land. However, both crocodilians and lizards still have their limbs attached to the sides of their bodies, as we saw in the salamanders, and usually don't support their bodies above the ground when at rest. As a group, lizards occupy a diversity of habitats. Most are terrestrial, but there are many arboreal (tree dwelling) species as well as a few that spend time in the water. Snakes, of course, are different; they have no limbs. We know they evolved from lizards with limbs, as there are still remnants of the pelvic girdle in the more primitive boa constrictors, which exhibit an external portion of the hind limb in the form of a spur. Snakes also occupy a wide variety of habitats, including some forms that remain entirely underground. A snake's ability to move rapidly over land, water or climb over vertical structures is a remarkable feat accomplished by the coordinated movement of many individual ribs connected to the belly scales.

**Reproduction:** While most reptiles lay leathery eggs, some species retain the eggs within the body of the female until they hatch (water snakes, rattlesnakes) while others, such as the garter snake, actually form a placenta and nourish their young internally, much like mammals. An interesting facet of reptilian reproduction is the fact that for some species, the sex of an individual is determined by temperature at which the eggs are maintained. Among crocodilians, embryos developing under warmer temperatures turn out predominantly male, while the reverse is true among many different species of turtles; warmer egg temperatures lead to mostly females.

**Ecological Importance:** Reptiles are important members of most terrestrial and aquatic ecosystems. Most lizards are active predators of insects and other invertebrates. Turtles frequently consume a wide variety of both plant and animal food. A few like the alligator snapping turtle and soft-shell turtles are primarily carnivorous while others, like the red-eared slider, are primarily herbivorous. Snakes are all carnivorous. Depending on the size and habitat of the species, their diets range from small invertebrates to fish, amphibians, reptiles (including other snakes!), birds and mammals. There are 13 species of venomous snakes in Texas, the Texas Coral Snake, the Copperhead (3 recognized subspecies), the Western Cottonmouth and 10 species of Rattlesnakes, the most common and widespread of which is the Western Diamondback.

Once on the endangered species list, the American Alligator has made a strong comeback throughout its range and is now commonly found in river swamps, lakes, and bayous throughout the eastern and east-central part of Texas. The largest reptile in North America, adults may grow to more than 19 feet long. Strictly carnivorous, alligators eat most anything in their habitat, from crustaceans to any and all vertebrates. In northern parts of its range, alligators dig deep holes in the mud along banks where they will hibernate during the coldest months. They will also enlarge water holes during dry periods. These so-called "gator holes" are often important refugia for many other forms of aquatic life in times of drought.

W-25
Students should be familiar with the life histories of the herptiles from the following list. They should also be to identify these species by sight.

**Amphibians**

Southern Leopard Frog _Rana sphenoecephala_  
Green Tree Frog _Hyla cinerea_  
Tiger Salamander _Ambystoma tigrinum_  
Spring peeper _Pseudacris crucifer crucifer_

**Crocodilians, Turtles and Lizards**

Alligator _Alligator mississippiensis_  
Ornate Box Turtle _Terrapene ornata ornata_  
Alligator Snapping Turtle _Macrolemys temminckii_  
Texas Spiny Soft-shell _Trionyx spiniferus_  
Map Turtle _Graptemys pseudogeographica kohii_  
Woodhouse's Toad _Bufo woodhouseii_  
Texas Horned Lizard _Phrynosoma cornutum_  
Five-lined Skink _Eumeces fasciatus_  
Northern Fence Lizard _Sceloporus unciulatus_

**Snakes**

Texas Ratsnake _Elaphe obsoleta_  
Eastern Hognose _Heterodon platirhinos_  
Western Cottonmouth _Agkistrodon piscivorus_  
Western Diamondback Rattler _Crotalus atrox_  
Copperhead _Agkistrodon contortrix_  
Timber Rattler _Crotalus horridus_  
Eastern Coral Snake _Alicurus fulvius tener_

**References:**


**Web Sites**

www.naherpetology.org Center for North American Herpetology  
www.discovery.com/exp/lizards.html Good general information site for lizards  
vwww.zo.utexas.edu/research/texherps Info and range maps of most Texas herps  
www.yahoo/reptiles  
www.yahoo/amphibians  
http://www.fлимnh.ufl.edu/natsci/herpetology/brittoncroc/cnhc.html Crocodilians Natural History & Conservation
Avifauna (Birds)

Bills and Feeding

Bills serve its owners with a variety of uses. It is a structure with which a bird scratches itself and can reach almost every part of its body. It is used to preen its feathers, collect nesting material and build its nest, and can be also be used as a weapon. But its most basic use is to get its food and to break up food into sizes it can swallow. The bill is both a hand and mouth. When used as a hand it takes, holds and carries food or nesting material, and is often used to feel. As a mouth it tears, cuts or crushes according to what it eats. It acts as both lips and teeth. Woodpeckers use the bill as a chisel to dig out its home or locate insects. The oystercatchers use it as a pry when opening shellfish. The bill has two parts, an upper and lower mandible.

When describing a bill, it is long when it is longer than the head, as in the bittern; short when it is shorter, as in a cardinal; compressed when it is higher than wide for the most part of its length, as in a kingfisher; depressed when wider than high, as in a duck; re-curved when curved upward, as in an American avocet; de-curved when curved downward, as in the brown creeper; terete when round, as in the hummingbird; bent when curved upward or downward at an angle, as in the American flamingo; straight when in line with the axis of the head, as in a bittern; and spatulate when flat and spoon-shaped, as in the roseate spoonbill.

In a great majority of birds, including almost all songbirds, the bill covering is hard and horn-like. The softest bills are probably found in the snipes and woodcocks. These birds have a bill that is thin along its entire length and is sensory at the tip. It is a true organ of touch that is used to feel for worms as they probe the mud.

Ears and Hearing

Hearing in birds is acute and ranks next to sight in its importance to birds and their survival. The ear openings are on the sides of the head and hidden under feathers on most birds. There is no outer fleshy ear as in mammals, but owls have a movable skin fold that reflects sound from behind. There are no barbules on the feathers that cover the ears and these feathers do not interfere with a bird's hearing. In owls, these feathers may help them detect sounds. Birds are highly social and depend on hearing for communicating with other birds, especially those of their own species. Hearing also helps them detect prey and alert them to dangers that threaten them. Owls, pheasants and parrots have especially acute hearing, and most birds can locate sound sources with great accuracy. Great horned owls, barn owls and other owls that hunt mostly at night hear exceptionally well. The right and left ears of these owls are very often shaped differently and usually one ear is placed above and the other below the horizontal. This asymmetrical development is helpful in locating their prey in the dark.

Eyes and Eyesight

Birds have a highly developed sense of sight. Birds have faster vision (quickness in picking up details) and greater sensitivity for detecting movement than man. Usually the eyes of a bird are the largest part of the head and often weigh more than its brain. The eyes of birds are fixed in the sockets and usually are moved by turning the head.

The field of vision varies greatly among different species of birds. This depends on the
placement of the eyes and the angle of view. All birds have binocular (two-eyed vision) that provides depth of field and monocular (one-eyed vision) that allows each eye to see independently. Hawks have eyes that are set more forward than songbirds and have a smaller range of monocular (side) vision. They cannot see beside them without turning their head, but they have a wider range of binocular vision. Owls, with their eyes placed in the front of the head, have a greater area of binocular vision than other birds, but must turn its head swiftly to see beside and behind them. The American woodcock has eyes located near the top of its head, and can see binocularly backward and upward, and forward and upward. Its monocular field on vision is nearly 180 degrees on each side.

Feathers

Only birds grow feathers. These serve as an insulator in retaining body heat, to assist in flying, in protective coloration and in a bird's behavior. The total feathering is generally waterproof and protects the tender skin from injuries.

Feathers are generally classified by their uses and location on the body of a bird. These are (1) contour feathers, which have a stiff shaft and a complete inner and outer vane, and are moved by a series of muscles attached to the feather follicle walls. Contour feathers include the outer body feathers and those of the wing and tail. The flight feathers of the wings and tail are contour feathers that are large, stiff and modified for flight. Wing feathers include the primaries, secondsaries and tertials. Together these feathers are called the remiges (rowing feathers). The long quill feathers of the tail are called rectrices (steering feathers). (2) Semiplumes combine large shafts with completely downy vanes. These feathers fill out the contours of the body, insulate it, provide flexibility at constricted places at the base of moving parts (like the wings) and in water birds, increase their buoyancy. (3) Down feathers are small, soft, fluffy feathers with or without a shaft that are concealed beneath the contour feathers. The main function of down feathers seems to be insulation of the bird's body. They are especially well developed in water birds. (4) Filoplumes are specialized, hair-like feathers that are sparsely distributed over a bird's body and are associated with contour feathers. They are most often seen on the nape and upper back of a bird. Any slight movement or vibration of the contour feather seems to be transmitted to receptors in the skin by the filoplumes. (5) Powder (down) feathers are so modified they do not resemble normal feathers at all. They appear as a powdery substance. Some ornithologists believe herons use powder feathers to remove fish slime and oil from the feathers. Powder feathers may also protect the feathers from moisture. Most birds have powder feathers but their highest development is in herons and bitterns.

Some feathers have become modified to be ornamental. Among American birds the simple elongation of the feathers on the top of the head is the most common example of modified feathers. The tufted titmouse has a topknot, the blue jay and pileated woodpecker have crests, California quail have ornamental plumes, and some owls have two tufts on the side of their heads called horns.

Woodpeckers and chimney swifts have specialized spine-tipped tail feathers to help them prop against vertical surfaces.

Feet

When using their feet, most birds are actually standing on their toes, rather than the flat of the foot. When walking or hopping on the ground, what appears to be its knee bending backwards is actually its heel.
The feet of birds are adapted to their various ways of life. The feet of water birds are either webbed or lobed for swimming; long-toed in some marsh birds to support their weight walking over water plants, as in the purple gallinule; strong in ground-dwelling birds such as quail, with three toes forward and the fourth elevated off the ground; powerful in hawks and owls that grab prey with their feet (with a reversible toe in the osprey to catch slippery fish); yoke-toed in owls and woodpeckers, with two toes forward and two pointed backward; and in perching birds that have three toes forward and the long hind toe pointed backwards to provide a strong grip on a tree branch. Claws are specialized scales that form a hard sheath at the end of each toe. The claws grow continuously and are worn down by use. Claws, like toes, are often adapted to the bird's needs. The claws, called talons, in birds of prey are long and sharp. In many ground-feeding birds the claws are strong and are useful in scratching the ground for food. The strongly curving claws of woodpeckers and nuthatches help them in climbing. In grebes, the claws are flattened and incorporated into the foot, and used as a paddle. The nails are long and slender in gallinules, and support the bird like snowshoes as it runs over the floating leaves of water plants.

Tongues

The structure and function of a bird's tongue varies greatly, because it is often adapted to aid in obtaining food. It may be used by birds to identify food by taste; or touch, as in ibises, sandpipers, and finches. Some birds such as geese and swans may use it a tearing tool when grazing on plants. Some fish-eating birds, such as mergansers, have backward pointing structures on the tongue that may hold slippery fish; in woodpeckers, the pointed tip is often used as a spear; in ducks the serrated edges are used as a sieve; in hummingbirds the edges can be rolled to be used as a trough to trap insects and nectar; in sapsuckers it has brushy hairs to collect sap by capillary action, in hawks the rough surface can be used as a rasp, in sparrows it can be used like a finger to manipulate a seed. Birds such as crossbills and goldfinches use their tongues to extract seeds cracked with the bill.

Wings and Flying

The main use for wings is flight, but they are also used solely for swimming by penguins. Some birds, such as cormorants, use their wings for diving and swimming underwater. Wings are also used defensively to strike an opponent.

Different wing shapes are determined by the lengths of the primary feathers and by the curvature of the wing's undersurface. In pointed wings, such as gulls, the outermost primaries are the longest. Pointed wings are most suited for covering long distances over water. Birds such as turkeys and quail have very concave, cupped wings which allow them to take off rapidly and cover short distances very quickly. Swifts and falcons have very flat wings, which gives them very fast and maneuverable flight. Soaring birds such as red-tailed hawks, red-shouldered hawks and vultures have long, broad, slightly concave wings with light wing-loading.

Students should be familiar with the life histories of the birds from the following list. They should also be to identify these species by sight.

- Red-tailed hawk
- Red-shouldered hawk
- Barred owl
- Great homed owl
- Dark-eyed junco
- Carolina wren
- Greater roadrunner
- Painted bunting
Wild turkey  American woodcock
Northern bobwhite  Wood duck
Dickcissel  Canvasback
Scissor-tailed flycatcher  Red-cockaded woodpecker
Bell's vireo  Pileated woodpecker
Prothonotary warbler  Northern cardinal

Information on these species can be found at:

http://www.mbr.nbs.gov/id/framlist/infocenter.html

References


Mammals

Mammalogy – Study of mammals.

Mammal – a warm-blooded, hair producing animal that suckles their young from milk producing mammary glands.

Coat or pelage – The coats of mammals are made of two main types of hair; (1) under-hair or fur – the thick, soft hair that lies next to the skin. Its primary function is insulation. (2) guard hair - the relatively long and course hair that lies over the underhair. Many mammals shed hair seasonally having a winter and summer coat which have different insulating qualities. Mammals also have special sensory hairs such as whiskers. The armadillo is an exception. Covered by a bony carapace, hair is almost entirely absent on the upper body, and only sparsely scattered on the underbody.

The color of a mammal's hair, or pelage, may be related to the environment in which it lives. Most small, terrestrial mammals have pelage that closely resembles the color of the soil where they live. The color patterns of the pelage of mammals serve several purposes. Counter-shading is common in mammals and other vertebrates, where the back and sides are darkly colored and the undersides and the insides of the legs are white or lightly colored. This color pattern allows the form of the animal to become obscured to some degree making the animal less conspicuous. The coats of other mammals may possess spots or stripes to break up the shape or silhouette of the body. This can provide benefits for the predator (bobcat) or the prey (fawn). Color patterns on some mammals such as the skunks serve to remind other predators of their well-endowed defensive capabilities. The eyes of mammals are one of their most prominent facial features. Often, the eyes will be made less conspicuous by some type of
facial marking, such as the mask of the raccoon.

**Limbs** – Mammals typically have 4 limbs ending in nails, claws, hoofs or even flippers. The structure of the appendage (foot) at the end of the limb will provide some evidence as to how the mammal gathers food, where the mammal lives or its method of locomotion. Marine mammals and some freshwater mammals (manatees) have appendages (flippers) designed to provide propulsion and steering while submerged in water. Other mammals like moles, pocket gophers and armadillos have feet specially adapted for digging or tunneling through the soil. Cats have retractable claws to aid in climbing and capturing live prey. Aquatic mammals like the beaver and river otter have webbed feet to aid it in moving through its watery environment. Deer and pronghorn antelope possess long limbs ending in hooves to promote increased running speed.

**Circulatory system** – Mammals possess a four chambered heart that functions as a double pump. The right side of the heart receives venous blood from the body and pumps it to the lungs where it is oxygenated. The left side of the heart receives oxygenated blood from the lungs and pumps it to the body.

**Teeth** – Unlike other vertebrates, whose teeth are basically all alike, mammals possess teeth that are modified in shape and size to serve specialized functions. Differences in the number, size and shape of teeth reflect differences in food habits and are often helpful in distinguishing one species from another.

The bulk of the tooth is composed of dentine, a bone-like material. Inside the dentine is a central soft pulp that is well supplied with nerves and blood while the tooth is growing. Covering the dentine is a thin layer of hard enamel, which is mainly calcium phosphate. The tooth is bound to the jaw by cement, a relatively soft material that may also form part of the crown of the tooth.

Mammals possess anterior teeth called incisors and canines, which serve to gather or kill food items. Cheek teeth known as molars and premolars are used to grind or slice food in preparation for digestion.

**Teeth Types:**

- **Incisors**: front cutting teeth usually used for nipping, biting or holding.
- **Canines**: fangs or enlarged stabbing teeth
- **Premolars**: cheek teeth usually located behind the canines (shearing or crushing)
- **Molars**: posterior-most teeth usually designed for grinding or crushing

Most mammals have two sets of teeth. The milk teeth, consisting only of incisors, canines and premolars, are lost and replaced by permanent teeth consisting of all four types of teeth.

**Dental Formula**: The number of teeth a mammal possesses can be expressed as a formula as in the example for foxes below. The number of incisors, canines, premolars and molars contained on the top and lower jaw on one side of the skull is documented in the formula and multiplied by two to calculate the total number of teeth.
Foxes

\[3/3, 1/1, 4/4, 2/3 \times 2 = 42\]
\[13/3, C1/1, Pm4/4, M2/3 \times 2 = 42\]

Where I = incisors, C = canines, Pm = premolars and M = molars

Mammal groups based on feeding habits

Herbivore – plant eating mammal.

Carnivore – flesh eating mammal.

Omnivore – a mammal that eats both plant and animal matter.

Skulls – A wide variety of skull types can be found among the many mammals found in North America. Dental composition, skull configuration and structure will provide insight as to a particular mammal's diet, habits and habitat requirements. For example, mammals that capture live prey typically rely on binocular vision. The eyes of such mammals will be facing forward to provide depth perception. Herbivores on the other hand often have eyes that are set further apart, on each side of the head such as a rabbit. This provides the rabbit with the greatest field of vision to detect potential threats. The types and number of teeth will also indicate how that particular mammal makes a living. Herbivores such as cattle and deer possess crushing and grinding type teeth to handle their diet of herbaceous vegetation. Carnivores possess teeth suited for capturing, shearing and tearing their prey. The size of the brain case will infer information about the intelligence of the animal. All aspects of a mammal's skull will provide details about that animal to the observant investigator.

Additional information on skulls can be found at the following web sites.

http://www.csusb.edu/fact/skulls.html
http://www.lclark.edu/~clifton/landverts/labstuff/mamlab.htm

Bats - Order Chiroptera

Bats are the most diverse order of mammals second only to rodents. Bats belong to the order Chiroptera which means "hand-wing". The order consists of two suborders: Megachiroptera and Microchiroptera. The two suborders are separated based on morphological differences relating to the number of digits that possess claws. Bats belonging to Megachiroptera typically have claws on the thumb and second digit. The suborder possesses only one family with 161 species found in the tropical and subtropical regions of the Old World. Flying foxes belong to this suborder. Bats belonging to the suborder Microchiroptera have claws only on the thumb. The suborder has 17 families, 175 genera and about 919 species. All of the bats of Texas belong to this suborder.

Bats are the only mammals that possess true flight ability. The power of flight allows bats to exploit food sources, such as flying insects that are for the most part unavailable to other terrestrial mammals. Flight also reduces predation potential and enables bats (as a group) to possess large geographical ranges. They can be found almost everywhere in the world except in the Polar Regions, highest mountains and some remote islands.
Bats produce a wide variety of sounds both for communication and navigation. Low frequency "squeaks and squawks" are typically used for social interactions. High frequency, ultrasonic sounds are utilized for navigation, avoiding obstacles and capturing prey. The ability to produce ultrasonic pulses and interpret the rebounding echoes is called echolocation. The maximum functional range of echolocation is about 15 meters. Within that distance bats are able to determine direction, distance, velocity, shape, size and even texture of prey species.

Bats utilize roost sites for resting, grooming and interacting with other bats. Roost sites are as diverse as the number of bat species. Caves, rock crevices, hollow trees, foliage and man made structures can all serve as roost sites.

Bats are small animals with large relative surface area for their size. Because of this, energy in the form of heat is lost at a rapid rate. Thus bats are very 'sensitive to climatic changes in their environment. They respond by migrating to more favorable areas or by hibernating.

Reproduction in bats that hibernate is characterized by two phenomena - delayed ovulation and over-winter storage of sperm in the female reproductive tract. Mating usually occurs in the fall prior to hibernation. The sperm is stored in the uterus over winter until the following spring after hibernation. At this time eggs are shed and fertilized. This process increases the amount of time for the young to mature, learn to fly and store fat for the next winter. The annual litter is usually produced in May or June, with litter size ranging from 1 to 5; however, most species of bats have one young per litter.

Collectively, bats have the most diverse food habits of any group of mammals. Various species of bats feed exclusively on insects and other arthropods, flesh, fish, fruit and flowers, pollen and nectar, and blood. Texas bats are predominantly insectivores or insect eaters.

TPWD Web Site relating to bats:

http://www.tpwd.state.tx.us/nature/wild/mammals/txchirop.htm

Students should be familiar with the life histories of the mammals from the following list. They should also be able to identify these species by sight, skull, and tracks.

Virginia Opossum - Didelphis virginiana
Eastern Gray Squirrel - Sciurus carolinensis
Eastern Fox Squirrel - Sciurus niger
Eastern Flying Squirrel - Glaucomys volans
Bobcat - Lynx rufus
River Otter - Lutra canadensis
Eastern Cottontail - Sylvilagus floridanus
Striped Skunk - Mephitis mephitis
White-tailed Deer - Odocoileus virginianus
Deer mouse - Peromyscus maniculatus
Baird's Pocket Gopher - Geomys brevicaudus
Plains Pocket Gopher - Geomys bursarius
Nine-banded Armadillo - Dasypus novemcinctus
American Beaver - Castor canadensis
Nutria - Myocastor coypus
Common Raccoon - Procyon lotor
Southern Short-tailed Shrew - Blarina carolinensis
Hispid Cotton Rat - Sigmodon hispidus
Eastern mole - Scalopus aquaticus
Feral hog - Sus scrofa
Common Gray Fox - Urocyon cinereoargenteus
Coyote - Canis latrans

Additional information on mammal biology, life history and characteristics can be obtained from the references listed below.
Books


Glass, Bryan P. 1981. A Key To The Skulls Of North American Mammals. Department of Zoology, Oklahoma State University, Stillwater, Oklahoma. 59 pp. Ordering information for this source can be found at: http://www.shsu.edu/~bio_mli/SkullKey.html#ORDERING


Web Sites

http://pc65.frontier.osrhe.edu/hs/science/zomammal.htm

http://www.nsrl.ttu.edu/tmotl – The Mammals of Texas on line edition

GLOSSARY

alticrual — Pertaining to young born in a very underdeveloped condition, requiring extended development and parental care.

blastocyst — An early embryo consisting of 8 to 16 cells that is characteristic of placental mammals.

canines — The teeth next to the incisors in mammals. Often referred to as the fangs.
carnassial pair — Pair of large bladelike teeth (last upper premolar and first lower molar) that occlude with scissor-like (shearing) action, possessed by most modern carnivores.

carnivore — A flesh eating animal.

cranium — Collectively, bones that form upper part of skull (contains upper teeth and braincase). Lower part of skull is the mandible.

crepuscular — Pertaining to activity during the twilight periods of dusk and dawn.

delayed implantation — Situation found in several mammals whereby the embedding of the embryo into the lining of the uterus and consequent growth is delayed for several months.

dentine — Calcareous material, harder than bone but softer than enamel, which makes up much or most of a tooth. Typically brown in color.

enamel — Layer of material (usually outermost layer) covering a tooth. It is the hardest substance in the body. Typically white in color.

foramen — Opening in bone through which passes nerves, blood vessels, or muscles.

foramen magnum — Large opening on the posterior of a cranium through which passes the spinal cord.

forb — A broad leaved herbaceous (non-woody) plant.

fossorial — Pertaining to life under the surface of the ground.

gestation period — The length of time from fertilization until birth of a fetus. The period of pregnancy.

herbivore — A plant eating animal.

incisors — The front or cutting teeth between the canines.

infraorbital foramen — A foramen in the skull through the zygomatic process of the maxilla (in front of the orbit to the side of the rostrum).

insectivorous — Eating insects; preying or feeding on insects.

invertebrates — Animals not possessing a backbone.

mammal — Warm-blooded, fur-bearing animals that suckle their young.

mandible — Lower jaw, formed by paired dentary bones.

mast — Nuts, fruits, or other fruiting structures that serve as forage for various wildlife species.

molars — Any of the posterior-most cheek teeth behind the premolars on each side of the jaws that have no deciduous precursors (milk teeth).
omnivore – An animal that eats either plant or animal material.

orbit – Space in the skull of a mammal comprising the socket for the eye.

precocial – Pertaining to young at birth that are capable of moving about and feeding with little parental assistance.

premolars – The cheek teeth located anterior to the molars and posterior to the canine. Present in both permanent and milk dentition.

process – A small bony projection.

rostrum – Portion of cranium anterior to orbit.

sagittal crest – Raised bony ridge on mid-dorsal aspect of cranium, especially well developed in carnivores.

temporal ridges – A pair of ridges on top of the braincase which usually arise on the frontal bones near the postorbital processes and converge posteriorly to form the medium sagittal crest.

zygomatic arch – Arch of bone protecting orbit; formed by jugal and compliments of maxillary and squamosal bones.
CLASSIFICATION OF MAMMALS

Kingdom: Animalia

Phylum: Chordata
Subphylum: Vertebrata
Class: Mammalia

Order: Didelphimorphia
  Family: Didelphidae.....opossum

Order: Insectivora
  Family: Soricidae shrews
  Family: Talpidae.....moles

Order: Chiroptera.....bats

Order: Xenarthra
  Family: Dasypodidae.....armadillo

Order: Lagomorpha.....
  Family: Leporidae.....rabbits and hares

Order: Rodentia
  Family: Castoridae.....beaver
  Family: Geomyidae.....pocket gophers
  Family: Heteromyidae.....pocket mice
  Family: Muridae.....mice and rats
  Family: Myocastoridae.....nutria
  Family: Sciuridae.....squirrels

Order: Carnivora
  Family: Canidae.....coyotes, foxes, wolves
  Family: Felidae.....cats
  Family: Mustelidae.....mink, otter, skunk
  Family: Procyonidae.....raccoons, ringtails
  Family: Ursidae.....bears

Order: Artiodactyla
  Family: Cervidae.....deer
  Family: Suidae.....feral hog

Endangered Species

Why do some species become rare and go extinct while others thrive? First, we must remember that extinction is a natural process. The species that exist today represent only a tiny fraction of all the species that have ever existed. Aside from geologically rare instances of mass extinction (such as the apparent asteroid impact that brought an end to the 140 million year reign of the dinosaurs), extinction rates for any given group are usually low. For mammals, the fossil record indicates this rate was between .002 and .02 species per year. In the 20th century, 25 mammals are known to have gone extinct, or .25 per year, or 12.5 to 125 times the "background" rate. In fact, given the current rate of loss of all species worldwide, we may be in the midst of one of the fastest extinction rates of all time. The primary cause of this sharp rise in extinction rates is, first and foremost, habitat loss. As already mentioned our burgeoning human population continues to occupy, clear and degrade more and more previously undisturbed land. Other factors, all related to human activity, include commercial hunting and fishing, predator and pest control, the exotic pet and plant trade, the introduction of alien species and pollution.
Which species are we losing? Primarily those species at the top of food chains, primarily large carnivores for reasons we have already discussed, and a diverse group of species that share the trait of being habitat specialists. Texas examples include the horned lizard, or "horney toad" which feeds almost exclusively on declining harvester ants, and the black-capped vireo, golden-cheeked warbler and red-cockaded woodpecker, all of which have declined with the loss of their very specific nesting habitat requirements. In contrast, generalists, those species with broad diets capable of surviving in a wide variety of habitats (especially those created by human activity), are common and often increase under conditions of disturbance.

So why should we care? What difference could it possibly make if we lose the horned toad or the black-capped vireo? There are three broad categories of arguments that are usually made to address such questions — aesthetic, practical and moral or ethical.

The aesthetic argument is simply that the natural world has much to offer in terms of beauty, inspiration and wonder. John Burroughs said, "I go to nature to be soothed and healed, and to have my senses put in tune once again." Destroying the natural world impoverishes us all. A 1993 survey by the U.S. Fish and Wildlife Service found that over 76 million Americans (39%) identify themselves as "wildlife watchers" and spent over 18 billions dollars in pursuit of their hobbies. There are more active birders than golfers and birding has become one of the country's fastest growing outdoor activities. The state of Texas has four of the recognized top 12 birding sites in North America and The Great Texas Coastal Birding Trail, which includes 308 sites and 100 participating local communities, attracts thousands of avid birders annually. Given its tremendous success, Texas Parks and Wildlife is working on creating additional birding and wildlife trails throughout the state.

On the practical side, all species are part of the web of life that sustains human life. There is no such thing as an "unnatural resource". Nature is the ultimate provider of all the goods and services that make our highly technological lifestyle possible. Despite our ability to manufacture synthetic compounds, over 25% of all prescription drugs still rely on compounds derived directly from plants. A much higher percentage of drugs we have developed to treat everything from various types of cancer to HIV to malaria are modified derivatives of naturally occurring substances. An antiviral drug proven effective against a previously lethal form of herpes encephalitis was derived from a previously obscure Caribbean sponge, and is now saving thousands of lives annually. When we lose any species, we lose forever the genetic information that is uniquely theirs and the opportunities to even test them for potentially useful compounds. As far as services are concerned, there is simply no replacing the roles countless organisms and communities play in maintenance of the atmosphere, biogeochemical cycling, soil formation, watershed management, pest control and pollination.

Finally, there is a moral or ethical argument that can be made. Whether or not it is deemed "beautiful" or economically beneficial" the decision to destroy another species can be thought of as simply, "not the right thing to do", in the same way that murdering another human is morally and/or ethically wrong. If we come to the understanding that humans are a part of nature, not apart from nature, we will appreciate the fact that all living things are members of one biotic community. In Aldo Leopold's words, "we are all kin".

**Threatened and Endangered Species Lists**

The federal Endangered Species Act of 1973 committed the United States to preventing the extinction of plant and animal species. Most states, including Texas, have enacted their own legislation with similar provisions. Endangered species are those in imminent danger of
extinction throughout their range. Threatened species are those likely to become endangered within the foreseeable future. Many states also include a third category, rare species, which recognizes species that, because of their low or declining numbers and other special features, such as shrinkage of critical habitat, need special attention.

At the federal level, the primary authority to list, de-list or change the status of any species resides with the Secretary of the Interior. In Texas, the Executive Director of the Texas Parks and Wildlife Department determines which species are "threatened with statewide extinction", while the TPW Commission determines those "likely to become, endangered in the future."

Protection

Under both state and federal law, it is illegal to take, possess, transport or sell any animal species designated as endangered or threatened without the issuance of a permit. State laws and regulations also prohibit commerce in threatened and endangered plants and the collection of listed plant species from public land without a permit issued by TPWD. Endangered species receive additional federal attention. Their essential habitats are also protected and a recovery plan is supposed to be devised, based on knowledge of the ecology of the species. It outlines procedures designed to build up populations to a level where the chance of extinction is minimal, allowing the species to be de-listed. Well-known success stories include the Bald Eagle, American Alligator and Peregrine Falcon.

Endangered and Threatened Species List for East Texas

**Pineywoods**

- Rafinesque's big-eared bat (*Plecotus rafinesquii*)
- Wood stork (*Mycteria americana*)
- American swallow-tailed kite (*Elanoides forfatus*)
- Red-cockaded woodpecker (*Picoides borealis*)
- Bald eagle (*Haliaeetus leucocephalus*)
- Bachman's sparrow (*Aimophila aestivalis*)
- Northern scarlet snake (*Cemphora cocinea copei*)
- Louisiana pine snake (*Pituophis melanoleucus rutilvensis*)
- Timber rattlesnake (*Crotalus horridus*)
- Louisiana black bear (*Ursus americanus luteolus*)
- Alligator snapping turtle (*Macrolemys temminckii*)
- Texas trailing phlox (*Phlox nivalis ssp. texensis*)

**Oaks Woods and Prairies**

- White-faced ibis (*Plegadis chihi*)
- Wood stork (*Mycteria americana*)
- Bald eagle (*Haliaeetus leucocephalus*)
- Alligator snapping turtle (*Macrolemys temminckii*)
- Texas horned lizard (*Phrynosoma cornutum*)
- Brazos water snake (*Nerodia harteri harteri*)
- Timber rattlesnake (*Crotalus horridus*)
- Houston toad (*Bufo houstonensis*)
- Louisiana black bear (*Ursus americanus luteolus*)
- Large-fruited sand-verbenae (*Abronia macrocarpa*)
- Navasota ladies'-tresses (*Spiranthes parksi*)
- Navasota ladies'-tresses (*Spiranthes parksii*)

For more information concerning Texas endangered and threatened species see

http://www.tpwd.state.tx.us/nature/endang/
Wildlife's Requirements for Survival

All animals have three basic needs: food, water and shelter. These basic needs must be met during the time of the year when the animal is present. It is important that the food, water and shelter be arranged in such a way that they are available to the animal.

Providing the correct combination of these necessities increases the chance of attracting desirable wildlife. If any of an animal's basic needs are not met, they will not use the site.

Food

Natural food sources such as leaves, nectar, fruits, seeds, berries, nuts and insects are necessary for attracting and keeping wildlife. Natural food can be supplemented through the use of feeders. Seed eating animals are drawn to seed feeders and to native seed producing plants. Nectar feeding animals are attracted to sugar water feeders and native plants that produce nectar rich flowers. Insect eating animals examine plants and sift through mulch and leaf litter that hold high insect populations. Avoid using pesticide that kills the insects that these animals feed on.

Increasing the variety of plants at a site attracts a greater diversity of wildlife. The greater the diversity of plants that are available at a site the more leaves, seeds, flowers, fruits and berries that are available to wildlife and to the insects and other small organisms on which they feed. Different plants grow, bloom and produce seeds and fruit at different times of the year. These differences between plant species help to provide year-round food for animals.

Water

All animals need water. A year round source of safe, fresh water will draw more wildlife to a site than any other single improvement. A water source can be something as simple as a shallow container set on the ground or as elaborate as a pond with a pump that filters and re-circulates the water. Water sources are unusable if they are out of reach of wildlife. A toad cannot get a drink or lay its eggs in a bird bath. Water sources that have steep slick sides or are located near heavy cover where predators can hide are actually very dangerous for wildlife. The ideal water source has accessible shallow areas where wildlife can drink and bathe, but is not located near cover where predators can hide.

Shelter

Animals need protection from predators and bad weather and a safe place to raise their young. Animals also prefer habitats that provide safe routes between their food and water supplies and other cover. Different species of animals use different levels in the vegetation. If some levels of vegetation are removed, then so are the homes and travel routes for these animals. It is important that wildlife be provided with protection from bad weather in the form of evergreen trees and shrubs, hollow trees, brush and stone piles. Woodpecker holes in dead trees are used by a variety of wildlife for homes and nesting places. Bird houses can help to replace the loss of these dead trees.
Causes for Species Decline

The greatest cause of species decline is loss of habitat, or living space. Every organism needs a unique combination of food, water and living space if it is to survive and reproduce. If any one of these needed elements is lost, the organism leaves the area or dies. Since different species need different combinations of food, water and space it is a rare site that does not to support some kind of organism.

Those organisms that are able to use the greatest variety of food, water and types of living spaces are called generalists. They tend to be widespread and numerous. Generalists are able to handle moderate changes in their environment.

Specialists are organisms that have very specific living requirements. They are often very successful at making use of something in their environment that other organisms do not or cannot use. Most specialists are found in very limited areas. Their numbers may be large where they are found but a loss of any part of their unique habitat causes a rapid decline in their population. Endangered species are usually specialists.

Where do humans come into this picture? Needless to say, humans are generalists. They eat many different kinds of food and live in many different kinds of habitat. Humans alter their environment in ways to make life more comfortable for themselves and to supply their own needs for food, water and living space. Prairies are cleared for farms that produce food. Forests are cut for wood products and additional living spaces. Rivers are dammed for water, flood control and the production of electricity. Wetlands are drained for farmlands and the construction of roads and homes. Mountains are mined for their minerals. Humans are able to alter their environment more than any other organism. In doing so they produce even more habitat suitable for themselves.

All of these changes have impacts on the other organisms that share those spaces and get their food and water from them.

Often, in the process of creating more human habitat, humans alter the environment enough to eliminate the food, water or living spaces needed by other organisms to survive. We as humans have recently discovered that, for the environment to function properly, the activities of many other organisms are needed. Habitat destruction and pollution threaten the organisms that remove carbon dioxide from the air and supply the oxygen most organisms need to live.

Fortunately, it is not too late to start repairing the damage that has been done to the environment. Knowledge is the key and each of us has our own part to play in protecting and restoring habitat to its former diversity. For more information on what you can do, please refer to the information on habitat management practices found elsewhere in this packet.
INTRODUCTION

The concept of ecosystems is not new. In fact, it is very old. In simple language, the ecosystem concept means that everything in a landscape is connected, that nothing exists by itself. Many ancient civilizations held this viewpoint of nature. Unfortunately, much of our modern society lacks this understanding of nature. We have come to believe that man is separate from, rather than a member of, ecosystems. As a result, we routinely destroy ecosystems because we do not understand their value. Therefore, it is essential that each of us learn about the structure and function of ecosystems and how to involve the ecosystem concept in our everyday activities. Ecosystems operate by an orderly process that involves interactions of matter and energy. The process includes all non-living and living things, including humans. When ecosystems operate naturally, there is harmony and balance. Even when ecosystems are disturbed, the components readjust to regain balance. However, our growing human population can disturb this process and destroy ecosystems. Examples include air, soil, and water pollution and over-use and waste of our natural resources.

We cannot continue to disturb ecosystems without consequences. However, we can prevent further destruction of many ecosystems and we can restore many ecosystems to natural conditions. Each of us must understand and apply the principles of ecology (the interaction of organisms and their environments). We must take responsibility for our actions. The future depends on today's wise planning for conservation and management of our natural resources.
THE ECOSYSTEM CONCEPT

Ecosystem Components
An ecosystem is an ecological unit that involves five fundamental interacting
components (Figures 1 and 2). They are:
1. Plants, animals, and microorganisms, both living and dead.
2. Chemical elements necessary for life, e.g., oxygen, hydrogen, carbon, and
   nitrogen.
3. An energy source, usually solar energy.
5. Controlling or regulating mechanisms involving organisms and environments,
   e.g., population changes, precipitation, food availability.

Figure 1: Major components of forest and grassland ecosystems

Figure 2: Major components of a freshwater pond ecosystem.

B. Ecological Principles
Operation of ecosystems involves 6 fundamental ecological principles. These
are:

1. Energy Fixation and Transfer
   Energy fixation is accomplished when green plants (producers) absorb
   solar energy and transform it (photosynthesis) into biochemical
   compounds. This energy is transferred through the food chain from
   producers to consumers (herbivores, predators, and eventually
   parasites, scavengers, and decomposers). However, energy
   transfer involves much heat loss; so, at each successive level of
   transfer, less energy is available for transfer. Therefore, there is a limit
   to the number of links in a food chain as well as the number of
   individuals at each level of transfer (see Energy section of
   Landscape Component brochure).
2. Competition Between Organisms

Places to live (habitat) and food are limited; so, species and individuals in ecosystems must compete for these resources.

3. Survival

Death of organisms in ecosystems results from competition, predation, disease, or other factors. Some individuals are better able to compete or are more fortunate; so, they survive whereas others do not.

4. Reproduction

Species produce new individuals to replace those that die or leave to populate other geographic areas. But, species survive only if the number of individuals produced is equal to or greater than the number of those that die or leave.

5. Biodiversity

An ecosystem contains many species, each of which uses strategies that minimize competition and provide advantages. Therefore, each species is adapted to a unique way of life and has a specific role (niche) in the ecosystem.

6. Recycling Nutrients

All biodegradable materials (those that can be decomposed by organisms) are recycled within ecosystems, i.e., from living organisms to dead organisms, to the environment, and back again.
Life History of Acorns
(Ecosystems in Nutshells)

Less than one acorn in a hundred takes root as an oak. However, all acorns are used in the forest ecosystem in some way. The acorn that does not sprout, or does not make a meal or home for some animal helps to nourish the forest when it decays and enriches the soil. Acorns may be thought of as small ecosystems that progress through different stages. During these stages they are used by various organisms from large to microscopic. The following is an outline of these stages.

1. Fresh Acorns
Acorns are rich in fats and carbohydrates and thus are a prized forest food of many animals. More than 80 species of North American birds and mammals eat acorns. Some acorns are eaten while still attached to the tree whereas others are eaten only after falling to the ground. Some are eaten immediately; others are buried by squirrels and jays for later use.

Fresh acorns are also eaten by some insects. While an acorn is still on the tree, a weevil may bore a hole in it and deposit an egg inside. The egg hatches into a larva that begins to feed on the nutmeat. After the acorn falls, the larva gnaws a circular hole in the outer shell, emerges, and then enters the soil where it remains dormant for 1-5 years. This irregular timing is in response
to acorn production, which varies year to year. This ensures that weevils will emerge as adults in years when acorns are plentiful. Attached acorns are also hit by some moths which lay eggs on the outside of the nut hatching, the moth larva eats through the shell and feeds the nut embryo.

**Damaged or Sprouting Acorns.** Acorns that are damaged by insects or fungi are discarded by squirrels. Also, squirrels can not really digest sprouted acorns, so these are discarded as well. However, damaged and sprouting acorns are eaten by other animals such as deer, mice, and many birds.

**Early Decay**
Acorns that are not eaten by large animals continue to be eaten by insect larvae or microbial organisms. After devouring the shell, mature larvae bore exit holes. Certain small wasps then use the bore holes to enter the acorn and lay their eggs. In doing so they also bring in molds and lichen that break down the inner shell layers.

4. **Advanced Decay**
The gradual breakdown of the acorn produces a hollow shell that provides a home for such scavengers and predators as millipedes, slugs, snails, centipedes, and ants.

5. **Final Decay**
Finally, when the weakened shell collapses, earthworms and sow bugs convert the remaining fragments into the organic matter (humus) of the forest soil.

Adapted from St. Regis Paper Co. 1969. New York, New York W-46
HUMAN USE OF ECOSYSTEMS

Over a period of thousands of years, humans have learned to manipulate ecological principles to develop herding animals, agriculture, forestry, industry, and urbanization. These activities channel the energy in ecosystems to a small number of plant and animal species. To sustain our ever-growing human population, these processes require increasing amounts of land, water, fertilizers, pesticides, machinery, and fuel; and, often, result in over-exploitation and pollution. Therefore, developed countries should strive for balance between 4 types of interrelated ecosystems (Figure 3) to maintain their civilization.

1. Urban-industrial Systems
   These are the environments where most people live and work. These areas are rapidly increasing.

2. Production Systems
   These areas produce food, fiber, and fuels, most of which are sent to the urban industrial areas. Examples are farms, ranches, and oil fields. Production demands are rapidly increasing.

3. Managed Natural Systems
   These are our parks, forests, and wildlife areas. These systems are primarily used for recreation and production of forest products. They are affected by the abuse and effects of increased use when the urban-industrial system continues to expand.

4. Wilderness Systems
   These are remote areas that are generally unused and uninhabited by humans because they are too hot, cold, dry, wet, rocky, or steep. These areas are very important for atmospheric cleansing, climatic control, conducting scientific investigations, and limited human recreation. However, as the human population grows, and the demand for resources increases, these remote areas are being altered and damaged.

Figure 3: Four types of interrelated ecosystems.
PROBLEMS AND SOLUTIONS

We must realize that although many natural resources are renewable, they are not exhaustible. Some are being destroyed and consumed. The ultimate conflict involves creasing human population and decreasing resources. Therefore, our solutions to maintain an ecological balance must include: 1) human population control, proved management of renewable resources, 3) recycling, 4) waste reduction, (logical orientation in all fields of education, and 6) economic reassessment of the of our natural resources and their uses.

The ecosystem concept is the only reasonable way to approach and coordinate conservation and management. It requires understanding the fundamental ecological pies that explain the structure, function, dynamics, history, and predictability of resources. Ecological balance must become an international concern. Only with side cooperation can ecological solutions be developed and implemented.

LANDSCAPE ECOLOGY

Notice the natural land features and patterns around you such as grassland, forest, wetland. These, as well as man-influenced features such as roads, agricultural fields, housing developments, make up the landscape. So, a landscape is a mosaic composite of many pieces) of different ecosystems and land uses. Ecology is the study of interactions between organisms and their environments. So, landscape ecology is a discipline of maintaining ecological balance while planning land use changes over a area. The principles of landscape ecology can be applied to any land mosaic from urban tracts to wilderness areas. If these principles are taken into account — during planning, design, conservation, management, and policy-making — the delicate balance and preservation of natural ecosystems may be enhanced.

Landscape ecology is the discipline of maintaining ecologic balance with planning land use changes over a large area.

A landscape is a living system which exhibits three major characteristics:

1. Structure: A spatial pattern or arrangement of landscape elements.
2. Function: A flow of energy and movement of plants, animals, water, wind, and materials.

Landscape ecologists working with these characteristics and using careful planning will maintain and/or increase diversity in the landscape by providing important habitat. For plants and animals, habitat is the environment which provides resources and conditions that allow individual organisms to survive and reproduce.

A. Elements of Landscape

There are three major elements which make up the structure of a landscape or region: patches, corridors, and matrices. These elements can be used to compare different landscapes and to develop principles for land-use planning. The whole landscape is a mosaic of different land uses. But, there are specific patterns of patches, corridors, and matrices. The characteristics of a landscape influence habitat diversity, ecosystem integrity, and species populations within these mosaics. The principles that have been developed by landscape ecologists enable land-use planners to make wise decisions when dealing with these areas.

Vegetative patches can be as large as a National Forest or as small as one tree. The edge of a patch is the outer boundary which is very different from the interior. Patches are areas which form as:
1. **Remnants**: areas remaining after some land use change.
2. **Introductions**: areas added during land use change.
3. **Disturbances**: areas which develop after a natural or manmade disruption, e.g., fire and land conversion (agriculture and urbanization).
4. **Environmental Resources**: undeveloped areas, e.g., a wetland in an urban area.

Corridors can be natural (streams and rivers) or manmade (roadways, railroads, sewers, lines, trails, fences, and canals). Some corridors are important for connecting riches; others can become habitat for certain species. However, others may prevent species movement.

The matrix is a network where corridors connect various patches to maintain effective species movement. The following principles are only some of the many utilized by wildscape ecologists to determine the optimum mosaic for a specific landscape.

**Principles of Landscape Ecology**

1. **Patch Size and Number**
   The desirable patch size depends on the specific species being managed. In general, large patches of natural vegetation are important in protecting water sources and providing protective cover. Large patches have more interior habitat which would be desirable for some species (e.g., Eastern Meadowlark (grasslands) and Pileated Woodpecker (forests)). Large patches also tend to have more plant and animal diversity (Figure 4). Numerous small patches often provide more edge habitat than one large patch which may be preferred by other species (e.g., Northern Bobwhite and Eastern Cottontail). These small patches can also be important for species movement by providing "stepping stones" of habitat between large patches.

2. **Patch Location**
   Species survive much better if patches are located close to each other or close to a large habitat area. This allows movement of species between habitat areas.

3. **Patch Orientation**
   Species dispersal routes (e.g., migration, feeding, and wind direction for seed dispersal) should be taken into account when orienting patches. A patch perpendicular to the route of dispersal (right diagram) will be (re)colonized more quickly (Figure 5).
4. **Edge Structure**
Vegetative edges with a high structural diversity, either horizontally (e.g., convoluted stream-sides) or vertically (e.g., gradually sloping hillsides) generally have higher edge species diversity. Edge width will be different around a patch depending on such factors as: solar exposure, predominant wind direction, drainage, etc. Edges can act as a buffer or filter zone to dampen influences from surrounding land uses.

5. **Edge Shape**
If the edge of a patch is straight (Figure 6), there will generally be more interior habitat and such patches will tend to have greater populations of interior species. The more irregular the edge of a patch, the more edge area and so, the greater number of edge species in that particular patch. There also tends to be more movement and interaction with the surrounding environment when the patch edge is more irregular (Figure 7).

![Figure 6: Straight-edged patch (left). Irregular-edged patch (right).](image)

![Figure 7: Ecological "optimum" patch shape.](image)

6. **Corridors**
Corridors are long narrow areas which have five major functions: habitat, source, connector, filter, and sink. River and stream systems are corridors of great importance in a landscape, providing habitat as well as water and food sources for many species. Some corridors provide a connection between patches which can be very important for species movement. Windbreaks, power line rights-of-way, and greenbelts are corridors which provide a protective buffer or filter to nearby patches as well as providing some erosion control. Roadways and railroads may be considered barriers to species movement and are often a sink, where species populations decrease in number (i.e. road kills). These barriers effectively divide a landscape and provide habitat only for disturbance tolerant species (e.g., Mourning Doves and White-tailed Deer). Often erosion, exotic species (non-native), and other ill-effects are introduced (Figure 8).
7. **Stepping Stone Patches**

A row or grouping of small patches (stepping stones) is an intermediate or semi-corridor between patches and can help provide for species movement (Figure 9). The distance between these stepping stones is important. If they are too far apart, they cannot be utilized by all species. Ideally, there would be a cluster of stepping stones between large patches to provide alternative routes.

---

8. **Matrix Structure**

A network of patches and corridors form the matrix (Figure 10). By providing alternative routes for species movement, the negative effects of gaps, disturbances, and predation will be reduced. As the matrix size decreases, species survival and diversity also decrease.

---

*Figure 8: Corridors.*

*Figure 9: Stepping stone patches.*

*Figure 10: Matrix networks.*
Table of Contents

Overview
Before You Begin
Wildlife in Urban Areas
Characteristics of Wildlife Habitat in Urban Areas
Encouraging and Discouraging Wildlife
Case Study
Next?
For More Information
Checking Your Answers
Overview

As areas in this region become increasingly urbanized, land that wildlife once had to itself must now be shared with people. So, it is important to understand the relationship between the urban environment and wildlife so that you can offer recommendations to homeowners, planners, developers, and others on general wildlife issues.

This unit begins by defining urban wildlife and describing its needs. Then ways the various species have adapted to living in an urban area and the characteristics of urban wildlife habitats are discussed. Finally, suggestions for encouraging or discouraging wildlife are given.

Give Me Liberty!

A Peaceful Solution

Early this spring Ray, the county forester, got a call from Jane, a homeowner, asking him to look at a couple of liberty elms she said were not growing. Upon examination Ray found that the local deer were using the trees as a sort of salad bar and had pruned them back severely. He checked with the Cooperative Extension Service's wildlife biologist who offered no easy solution short of shooting the deer, which was not an option for Jane, the property owner. Ray hit on the idea of building cages around the trees to keep the elm-munching critters away long enough for the little trees to get a bit of growth.

Over several days, Jane and Ray constructed two frames 3 x 3 feet across and about 6-feet high from ½-inch PVC (poly vinyl chloride) pipe. They wrapped chicken wire around each frame and secured it with small cable ties. The tops were left open, and there was space at the bottom to allow for weeding and other maintenance. How well these odd structures work will not really be known until around this time next year. Meanwhile, Jane has a lot of fun telling her friends at work about her adventures in caging her wild elms.

A tree that may in Summer wear
A nest of robins in her hair
Joyce Kilmer, "Trees"
Before You Begin

This unit provides information useful in answering questions about urban wildlife issues when you work with individuals or groups in the community. Think about the wildlife in your community and how you can use this information in your work.

- What kinds of urban wildlife habitats are in your community?

- What do you know about the needs of urban wildlife where you live and work?

- How will your understanding of the habitat and problems associated with urban wildlife help in the management of the urban forest?

On a separate piece of paper describe the wildlife in your area, and think about how this information will assist you in your job.
Wildlife in Urban Areas

Urban wildlife is any wild creature that lives in an urban environment or an urban-rural interface, including birds, reptiles, amphibians, mammals, fish, insects, and worms. There are native species, such as squirrels, millipedes, and cardinals, and non-native species, such as pigeons and starlings. Our shift from a rural to an urban society has caused many changes in land use across the country as farms, forests, and grasslands become subdivisions and shopping centers. These changes greatly impact the habitat that wildlife depends on for food, water, cover, and living space.

The challenge is to work within the community to enhance those parts of the urban environment that contribute to wildlife survival and diversity while eliminating or minimizing as many of the negative aspects as possible. Participating in the planning process, especially in situations where urban and rural areas come together, can help prevent unnecessary destruction of wildlife habitat. Working with property owners and the public can encourage appropriate wildlife. Methods to discourage nuisance wildlife can also be recommended. There are various to provide assistance related to urban wildlife (table 1).

Table 1. Examples of urban wildlife assistance and potential recipients

<table>
<thead>
<tr>
<th>Technical/Educational Assistance</th>
<th>Planning Assistance</th>
<th>Potential Recipients</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Native plants and animals</td>
<td>- Establishment and maintenance of urban wildlife habitats</td>
<td>- Local nature groups and associations</td>
</tr>
<tr>
<td>- Urban wildlife habitat</td>
<td>- Protection of natural wildlife corridors</td>
<td>- Developers and home builders</td>
</tr>
<tr>
<td>- Needs and habits of urban wildlife</td>
<td>- Water management program</td>
<td>- Businesses and homeowners</td>
</tr>
<tr>
<td>- Urban environmental and contamination problems</td>
<td>- Maintenance of native vegetation</td>
<td>- Parks and recreation boards and staff</td>
</tr>
<tr>
<td>- Tree protection techniques</td>
<td>- Habitat management to control nuisance wildlife</td>
<td>- Rural landowners</td>
</tr>
<tr>
<td>- Techniques to encourage wildlife</td>
<td>- Comprehensive planning</td>
<td>- Neighborhood associations</td>
</tr>
<tr>
<td>- Techniques to discouraging wildlife</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Benefits and Costs of Urban Wildlife

Urban wildlife can add to the enjoyment of everyday life. Watching a squirrel grind away on a nut or listening to a dove coo offers moments of relaxation. Wildlife provides opportunities for observing and photographing animals that live near and in urban areas. Urban wildlife also serves as an educational stimulus by stirring people’s curiosity about the natural world. Wildlife in the urban environment can also cause problems by destroying property, carrying disease, producing unsanitary waste, and conflicting with human activities. Wildlife that is forced to live in urban areas may displace other species of animals that are already living there.

Four Basic Needs

Wildlife has four basic needs: food, water, cover and living space.

Food

Plants, whether in a backyard, a park or a large urban forest, are vital food sources for wildlife. Trees and other vegetation provide fruit, nuts, foliage, bark, and roots as part of the diet of many animals. Decaying wood is also a source of food for many small organisms, such as earthworms, millipedes, and mites, that are in turn eaten by animals higher on the food chain. Each animal is an important link in the food chain, with the existence of some species dependent on the presence of others.

Water

Wildlife species must have fresh water to live. Wildlife can find water in various places, such as puddles, gutters, birdbaths, ponds, creeks, wetlands, lakes, and rivers. In some urban areas, water pollution from pesticides, fertilizers, oil, and other materials may adversely affect wildlife.

Cover

Cover provides a place of safety for wildlife. Examples include tree litter, grasses, shrubs, understory trees, and tree canopies. Some wildlife species prefer cover adjacent to open spaces, while others prefer cover near a river. In some areas, development has changed
the natural areas that provide cover, so wildlife must adapt to the new environment, migrate to more habitable surroundings, or perish.

**Living space**

All animals need living space. This is the place where an animal finds food, water, cover, and a place to reproduce. The size of the living space varies with each species. For example, a house sparrow requires less living space than a migratory bird. The amount and type of living space influence which animals live in an area. Williamson (1973) found that inner-city neighborhoods with few trees had exotic bird species, such as pigeons and house sparrows, while suburban areas with many trees supported more native species. He attributed this difference to the amount of vegetation available for cover.

**Desirable urban wildlife can be encouraged by knowing their specific habitat needs and managing for those needs.**

**How Wildlife Adapts to an Urban Area**

Habitats are always changing due to land development, floods, fire, and other occurrences. Species of wildlife that adjust easily to a variety of habitats are called habitat generalists. Generalist species in urban areas adapt to living near humans and to utilizing artificial habitats. Conditions or characteristics that enable many species to live in an urban community include cover, nocturnal behavior, and diet. Knowledge of how animals adapt to a new environment helps in managing them.

**Cover**

Many places in urban areas offer shelter for wildlife. Parks, greenspaces, and backyards are places where animals often find cover. Property owners can encourage specific types of wildlife by constructing birdhouses and small ponds and planting dense ground covers. Other wildlife can be more opportunistic; finding cover in places rarely visited by people. Attics and backyard storage sheds sometimes offer unintentional cover for animals. Warehouses, sewers, railroad yards, and the lofts and rafters of large buildings may also provide shelter and breeding places for many species.

**Nocturnal behavior**

Wildlife species that are nocturnal (night animals) or have secretive behavioral patterns have obvious advantages that help them survive. Because owls, raccoons, opossums, skunks, and rodents move around at night, they often exist in surprising numbers but remain unknown to many people in the community.

**Diet**

Animals that eat both meat and vegetation can take advantage of a wide variety of foods. Many urban homeowners encourage certain types of wildlife by feeding them in their backyards. Other species, such as raccoons and opossums, have successfully adapted to the urban environment, learning to survive on pet food left outside and food discarded by humans.
The National Wildlife Federation's "Backyard Wildlife Habitat Program" can provide information for creating an urban wildlife environment.
Characteristics of Wildlife Habitat in Urban Areas

Wildlife habitats exist everywhere within a community and its vicinity. They include parks, natural areas, golf courses, airport grounds, industrial parks, schools, hospitals, churches, cemeteries, backyards, university campuses, railways, roads, streams, and rivers. Some species take advantage of man-made structures, while others adapt to the existing ecosystems in urban areas. Several common characteristics of urban environments that influence wildlife habitats are described below. Each of these factors is important to consider in planning for wildlife in urban areas.

Fragmentation
Habitat fragmentation occurs when streets and highways, shopping centers, and other large-scale developments are built. The change in land use breaks up large habitat areas into many small ones, which influences the types and numbers of animals that can now live in these smaller habitats. Fragmentation creates more edge habitats, along the edge of a forest but decreases the forest's interior habitats. Such fragmentation benefits species that thrive on habitat edges, such as deer and skunks, but is detrimental to animals that live in interior habitats, such as bobcats and wood thrushes (Barnes 1998).

Corridors
Corridors are areas that wildlife, such as migratory birds and mammals, use to move from one location to another. Natural corridors, such as rivers and streams within a city, are valuable for wildlife. There are also human-made corridors, such as railroads, utility rights-of-way and greenways that can connect nature preserves, parks, and other sites. However, these corridors need to be wide enough to provide food, water, and cover for the wildlife (Barnes and Adams 1999). Land development can disrupt corridors, such as when a migration route is interrupted by an interstate highway.

Changes in Soil and Vegetation
Most of the soil in an urban environment has been disturbed by land development such as
grading and paving. These activities can change soil conditions, influencing the plant species that can grow there. And, in turn, this influences the wildlife habitat at the site. Changes in habitat may occur when—

- forests are cleared during land development.
- native vegetation is removed, mixed, or replaced with exotic or undesirable species, which may impact the density and diversity of the vegetation.
- drainage patterns and soil conditions are changed.

**Poor Water Quality**
Various forms of waste, including industrial chemicals and fertilizer nutrients, found in urban streams, lakes, ponds, wetlands, and rivers can damage aquatic wildlife, such as insects, fish, and salamanders. The increased amount of impervious surfaces, such as roads and parking lots, increases storm-water runoff that may increase in sedimentation and change nutrient levels in the water.

**Loud Noises**
Loud noises in urban areas, such as mass transit systems, automobiles, and airplanes, can disturb wildlife although wildlife usually adapts to these noises.

**Structures**
The urban environment is full of artificial structures used by wildlife: buildings, bridges, highway overpasses and underpasses, culverts, radio towers, utility lines, and light fixtures. These structures may provide cover and a place to reproduce for many species, for example the nighthawk that nest on the roofs of buildings and the painted turtle that survives in artificial impoundments. Some of these, such as utility lines and locations near highways, can also be dangerous for animals.

*How do these factors affect the wildlife in your community?*
Encouraging and Discouraging Wildlife

Wildlife management is basically habitat management to encourage or discourage animal populations. There are several ways to encourage appropriate wildlife or to discourage nuisance species.

Wildlife management begins with habitat management.

Enhancing Wildlife Habitat

Encouraging wildlife consists largely of providing food, water, cover, and living space for specific types of animals. Techniques that can enhance wildlife habitats in urban areas include the following.

Plan cooperatively

Cooperation between planners and developers during the initial phases of development is perhaps the best way to assure the enhancement or preservation of wildlife habitat. Identifying critical wildlife habitats so that they can be considered for preservation through comprehensive planning or acquisition of land is the first step toward protecting the land that is most valuable for wildlife. It is important to work cooperatively with the community to preserve identified areas, such as natural ponds, lakes, and wetlands, from development.

Land can be developed to include open green spaces and undisturbed areas.

Preserve native vegetation

Try to use native vegetation whenever possible. During land development, as much as possible of the native vegetation suitable for habitat should be left undisturbed, particularly trees and shrubs. Exotic vegetation that has displaced native plants can be removed to encourage native plant growth.
Reduce turf grass
Replace turf grass with trees, shrubs, and flowers.

Create buffer strips
Buffer strips of vegetation can be created along the banks of natural waterways. These habitats serve as corridors for wildlife and help control soil erosion. Different animals require different amounts of space, so the width of the buffer strips depends on the species that will be using the area.

Encourage habitat diversity
Different wildlife species require different habitats (figure 1). The urban forest can contain a variety of tree species of different ages and heights, creating a multi-layered system of vegetation, including ground cover, understory, and canopy. Plant species can be selected to encourage specific types of wildlife, such as species with different flowering and fruting seasons.

Retain snags
Snags (dead trees and limbs) should be allowed to remain in the urban forest if they do not endanger people or property.

Utilize sand and gravel pits and quarries
In formerly rural areas, sand and gravel pits and quarries are sometimes common. These have potential for fish and wildlife habitat as well as recreational opportunities.

Make use of storm-water basins
Properly designed storm-water detention areas can function as wildlife habitat. The USDA Natural Resource Conservation Service can assist in designing storm-water basins.

Contact the U.S. Fish and Wildlife Service, State Department of Natural Resources or Cooperative Extension Service for assistance with managing urban wildlife.

Discouraging Nuisance Wildlife
Habitat management can also help control individuals or populations of wild animals that damage property, threaten human health and safety, or otherwise become nuisances. Eliminating one or more of the needs of wildlife (food, water, cover, or living space) will usually induce the problem animals to leave. Four basic ways to control unwanted wildlife are habitat modification, exclusion, repellents, and, as a last resort, elimination. Often a combination of methods is most effective. Ideally, the approach should be safe, selective, effective, and humane.

It is often easier to prevent nuisance animals than deal with them after they arrive.
Habitat modification

- Plant alternative species
  Animals are attracted to certain kinds of plants, particularly well-fertilized ones in urban areas. Planting species known to be unattractive to a particular type of nuisance animal may serve as a deterrent. However, in times of extreme weather conditions, drought, or overpopulation, the animals will eat even those plants that otherwise they would reject.

- Design and modify buildings
  Design and construct buildings to avoid places likely to be occupied by unwanted house sparrows, starlings, pigeons, bats, and other undesirable species. These places include exposed beams, ledges, unscreened ventilation holes, and other nooks, holes, and crannies. In existing buildings, screen beams, ledges, and other openings to prevent access by birds, squirrels, bats, and other animals. Install heavy screen or other devices on chimneys to deny access to raccoons, squirrels, and birds.

- Trim and thin trees
  Large roosts of starlings, grackles, and blackbirds may be reduced by trimming or thinning trees where they roost.

- Squirrel-proof feeders
  Bird feeders that are counter balanced or in some other way "squirrel-proofed" can reduce pilfering by squirrels.

- Secure garbage cans
  Outdoor garbage containers need to be tightly covered and secured to prevent raccoons, dogs, rats, and other animals from invading them.

Learn about various animal-resistant plants in your area from your local Cooperative Extension Service.

Exclusion

- Install fencing or wire netting
  Entire areas or individual trees can be protected with fencing or netting. Where deer are a problem, consider installing deer-proof fencing around the property. Screens or individual guards around young fruit trees can prevent damage by rabbits. Fencing can also be used to prevent beaver damage to trees.

- Use noise makers
  Loud noises typically scare off wildlife, but this may only be a short-term solution. For example, noise machines and firecrackers have been used to scare sparrows from buildings and trees, and wind chimes can discourage woodpeckers from pecking on the side of a house. A tape recording of "seagulls" in distress has been used successfully to ward off gulls, grackles, and crows.
Repellents
Offensive tastes, smells, or feel typically repel animals. Repellents can be homemade or purchased commercially. Some are applied directly to the plant leaves, creating a bitter taste when eaten. Others are simply placed in the general area where the animals feed. There is disagreement about the effectiveness of these methods.

Trapping
As areas become urbanized, animals lose their living space, and natural enemies that control population in the wild are often lacking. Under these circumstances, it may be necessary to physically remove the animals when other means have failed. Live trapping and removal of the animals to another area is one option. This may, however, only transplant the problem. Some animals need to be trapped and eliminated because they are dangerous or diseased.

Trapping, poisoning, and killing animals, particularly game species, should be done only with legal authority. Property owners need to contact county or state officials before taking any action. The local health department should also be contacted if animals are suspected to be rabid.

Dealing with nuisance wildlife can result in negative public relations. Are you prepared to deal with this situation and communicate the necessary information to the community?

When humans change rural landscapes into urban ones, many types of wildlife find a livable habitat within this altered environment. For the most part, people who live in urban areas find it beneficial to share this environment with wildlife, except for the occasional nuisance species or individual. Foresters can enhance the interaction between humans and wildlife by learning how to improve and increase habitat for wildlife and educating the public on how to maintain a quality environment.
Checking Your Understanding of Urban Wildlife

On a separate sheet of paper, briefly answer the following questions.

1. How do you define urban wildlife? What native species live in your area, and what exotic or non-native animals are also present?

2. What does an animal need to survive in an urban setting?

3. As habitats change from rural to urban, what adaptations have some animals made to survive?

4. What are two ways you might suggest to encourage urban wildlife, and what are two ways that you would try to discourage unwanted wildlife?

Answers are at the end of the unit.
Case Study

It Is Always Greener on the Other Side
Donna is a forester with the State forestry agency. She recently received a request from the homeowners association of a planned community about 20 miles outside a major southeastern city. Among the many attractive features of the area are open and forested natural areas. Most people who move here appreciate the benefits of living in a forested area and usually are happy to share this environment with animals such as rabbits, deer, and raccoons. Recently, a colony of beavers moved into one of the stream valleys.

Chances are, the humans would not have been too upset if the beavers had stayed out of people's yards. However, the beavers began cutting down trees in the yards of residents along the west bank of the stream while largely ignoring the trees on the east bank. Not surprisingly, the attitudes of the homeowners on either side of the stream were quite different. People on the relatively unscathed east side adopted the position that beavers were an integral part of the natural environment that had attracted them to this community and should be able to chew on any tree. People who lived on the west bank regarded these zealous aquatic woodcutters as oversized, flat-tailed nuisances with no respect for private property. One group of neighbors was threatening to dynamite the beavers, while the other group threatened to sue the dynamiters. In an effort to resolve the issue, Donna was called in to help devise a solution to the beaver conflict.

You and the Beavers and the Neighbors at Odds
You are the forester who has been asked to help resolve the problem with the beavers. What would you propose? Decide what solution you would offer and then write your answers to the questions below, explaining your solution.

- Knowing that tempers are hot, what is the first thing you would do?
- What options can you offer to the homeowners?
- Are there legal issues you may need to consider?
- What are the main things you hope to accomplish with the solution you are proposing?

After you have answered the challenge questions, read the rest of the story to compare your solutions with what really happened.
The Rest of the Story

It was a Done “Deed”
As often happens with beaver problems, tempers were running high. Donna knew she had to act fast. She called both sides together for a meeting and asked the wildlife biologist from the State forestry agency to attend. A wildlife story such as this one does not always end happily for all parties involved, but this one did. The solution that Donna proposed was accepted by both groups of neighbors, quickly implemented, and it worked!

The first order of business was accomplished when all the neighbors agreed that a peaceful outcome was best -- as long as it kept the beavers out of their yards. The solution Donna then worked out with the community was simple, but it did require waiving the neighborhood covenant against fences. It was decided to “deed” certain portions of the natural habitat to the beavers. A green, welded, wire fence was installed along the stream bank to prevent the beavers from entering people’s yards. The same fence was also used to encircle and protect some of the specimen trees within the newly defined beaver zone. Both sets of neighbors were content with this solution, and within two years the beaver colony moved farther downstream.

Note: No one ever figured out why the beavers only attacked the trees on the west bank of the stream.

Beaver to Beaver Comparison

- How did your solution compare to what the neighbors actually did?
- If you suggested something different, what did you see as the advantages that your solution offered?
- This particular encounter between homeowners and wildlife ended positively. Have you ever been in a situation in which the results were not positive? How have you handled it?
- What could you recommend to property owners that might prevent a similar situation?
Next?

Understanding the relationship between the urban environment and wildlife is important in planning for and managing the urban forest. The questions on this page will help you incorporate this knowledge into your work with the local community.

- How will you use this information to help the people in your community solve problems concerning urban wildlife?

- What are some of the characteristics and location of wildlife habitats in your community? How can this knowledge help to better manage the urban forest?

- What is the best way for you to communicate this information to the community and help them use it in their planning?

- What other information will you need to improve your understanding of urban wildlife in your area?
For More Information

Literature Cited


Other Books and Resources


Cerulean, S.; Botha, C.; Legare, D. [no date] Planting a refuge for wildlife: how to create a backyard habitat for Florida's birds and beasts. Tallahassee, FL: Florida Game and


**Web Sites**

National Wildlife Federation

The Internet Center for Wildlife Damage Management, University of Nebraska

The U.S. Geological Survey’s Northern Prairie Wildlife Research Center - Online Guide for the United States and Canada

Urban Wildlife Resources
Checking Your Answers

Checking Your Answers about Urban Wildlife

1. How do you define urban wildlife? What native species live in your area, and what exotic or non-native animals are also present?

Urban wildlife is any wild animal that lives in an urban environment or in an urban/rural interface. Examples include birds, reptiles (such as snakes and turtles), amphibians (such as frogs), mammals, fish, rodents, insects and spiders, and worms.

Native species may include the gray squirrel perhaps the most common wild mammal in North America (Miller 1988). What other species have you listed for your area? Non-native species may include the pigeon, commonly found in downtown areas, and the house sparrow, found in neighborhoods. What other non-native animals have you come across in your work?

2. What does an animal need to survive in an urban setting?

An animal has four basic requirements for survival, whether in an urban or rural location:

- Food
- Water
- Cover or shelter
- Living space

3. As habitats change from rural to urban, what adaptations have some animals made to survive?

Some animals have adapted to urban conditions by modifying their living and eating habits.

- Cover – Man-made structures often provide shelter and breeding places.
- Nocturnal behavior – Feeding and moving about at night is a means of protection for the animals.
- Diet – meat and vegetation diet, being fed by humans, and taking advantage of a wide variety of foods allow animals to take advantage of whatever food sources are available at any particular time.

4. What are two ways you might suggest to encourage urban wildlife, and what are two ways that you would try to discourage unwanted wildlife?

Habitat management is the key to encouraging or discouraging wildlife in an urban location. There are a number of specific things that make an area better for wildlife:
• Working with others during land development planning for the preservation of natural habitat
• Preserving and planting native vegetation
• Creating and preserving buffer strips and corridors for animals
• Reducing turf grass and replacing it with trees, shrubs, and flowers
• Ensuring a wide variety of plant species, flowering and fruiting seasons, heights and ages of trees
• Using natural and man-made elements of the land, such as snags, gravel pits, and storm-water basins, for wildlife habitat

To discourage wildlife, eliminating one or more of the needs of wildlife (food, water, cover or living space) will usually cause the problem animals to leave. There are four primary ways to control unwanted wildlife, each offering different options:

• Habitat modification
  - planting alternative tree species
  - modifying buildings, including screening
  - trimming or thinning trees to remove roosting or nesting places
  - using squirrel-proof bird feeders
  - securing garbage cans
• Exclusion
  - fencing
  - netting
  - using noise or other distractions
• Repellents that create
  - a bitter taste
  - an unpleasant odor
  - an uncomfortable touch or feel
• Elimination
  - live trapping for relocation
  - elimination because of health concerns
  - other means of removal based on legal considerations
SOUTHERN COPPERHEAD
*Agkistrodon contortrix contortrix*
*Hooked Fang*  *contort*
This is the most common venomous snake in the area but also the least toxic. In fact, no fatalities from this inoffensive snake have been recorded in Harris County for decades, due primarily to its low venom toxicity and the availability of prompt medical attention. Adults average three feet in length. They prefer larger wooded areas. Easily identified by the dark brown “Hershey’s Kiss” shaped markings on the side of the body. Shy and non-aggressive, it will usually only defend itself if threatened.

WESTERN COTTONMOUTH
*Agkistrodon piscivorus leucostoma*
*Hooked Fang*  *Big fish eater  white mouth*
This is the snake that people often incorrectly refer to as a ‘water moccasin.’ It should not be called by this name primarily because most people refer to any dark-colored snake seen near water as a ‘water moccasin,’ and this is rarely the case. They can be distinguished from other local snakes by the wide, dark raccoon-like mask running straight down the side of the head. Adults average over three feet in length. Found in and around natural water areas such as ditches, creeks and ponds and lakes. They will defend themselves if threatened.

TEXAS CORAL SNAKE
*Micrurus fulvius tener*
This snake is the most venomous snake in the area, and is in the same family of snakes as cobras, mambas, taipans and other deadly neurotoxic snakes. Fatalities from this timid inhabitant of rotten logs and underground forest burrows are almost unheard of, due to this snake’s preference to flee rather than hold its ground. They are easily identified by their red, yellow and black rings and the fact that they are diurnal (day-active). People often pick these up because they resemble the harmless milksnakes. However, they rarely bite unless they are being harmed.
WESTERN DIAMONDBACK RATTLESNAKE
*Crotalus atrox*

Historically found in Harris County, but not found here nowadays. This is due primarily to habitat destruction during development. Considered the most dangerous snake in Texas due to its aggressive nature and ability to deliver a potentially serious bite. Most snakebite fatalities in Texas are due to this snake, so it’s just as well we don’t have it around here any more! Notice black and white rings on tail before rattle.

WESTERN PYGMY RATTLESNAKE
*Sistrurus miliarius streckeri*

Also historically found in Harris County, but not found here nowadays. This is due primarily to habitat destruction during development. This is probably just as well, since pygmy rattlesnakes seldom reach two feet in length and have tiny rattles that can hardly be heard. In fact, a string of seven or eight rattles may only be ¼ inch long!

TIMBER RATTLESNAKE
*Crotalus horridus*

Another rattlesnake once found in Harris County, but extirpated (wiped out by humans). They were once referred to as Canebrake Rattlesnakes, but most herpetologists now refer to them as Timber Rattlesnakes. These non-aggressive snakes are on the state Threatened Species List, but can still be found in undisturbed areas of the dense East Texas Piney Woods.
TEXAS TRACKS
DO YOU KNOW THEM?

BOBCAT

RACCOON

FOX SQUIRREL

RINGTAIL

COYOTE

CUNK

WHITE-TAILED DEER

DEWSCLAWS SHOW WHEN RUNNING

COLLARED PECCARY (Javelina)

OPOSSUM
You may know Texas wildlife, but do you know their tracks? Some like the rabbit and opossum are easily recognized. Others such as the coyote, collared peccary, and bobcat may be confused with their domestic look-alikes the dog, pig, and house cat. Tracks are easily followed in snow or loose sand. Prints made in soft mud are best for study.
Ambystoma tigrinum tigrinum

Eastern Tiger Salamander

- Diagnostic Features:
  - Size: 7-13 inches
  - Color:
    - Black or very dark brown with olive or yellow irregular markings
  - Other:
    - Large salamander
    - Broad head
    - Small eyes
    - Four toes on front feet, and five on hind feet
    - Olive-yellow ventral surfaces with darker marbled pattern

- Natural History:
  - Habitat:
    This salamander can be found in moist environments or near water, wooded areas with loose soil, in cultivated lands near water, and in mammal or crawfish burrows.
  - Behavior:
    Nocturnal, it remains underground or under cover near water during the day. It feeds on earthworms, insects, and small vertebrates. Several may congregate near ponds during breeding times.
  - Breeding:
    Breeding typically occurs after late winter rains, but may occur anytime with sufficient rain. Eggs are attached to submerged vegetation and rocks singly or in masses.

- Range:
  - In North America, the range of this salamander is broken and scattered from the U.S. East Coast to Minnesota down to the Gulf Coast.
  - In Texas, it is found only in the eastern quarter of the state.
This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 6/26/97.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
**Bufo woodhousii**

**Woodhouse's Toad**

1. *Bufo woodhousii* woodhousii
2. *Bufo woodhousii* velatus

Photo credits

- **Diagnostic Features**
  - **Size:**
    - *Bufo woodhousii woodhousii*- 2 1/4 - 4 inches
    - *Bufo woodhousii australis*- 2 1/2 - 5 inches
    - *Bufo woodhousii velatus*- 2 - 3 inches
  - **Color:**
    - *Bufo woodhousii woodhousii*- yellow-brown or gray with olive cast with pale chest
    - *Bufo woodhousii australis*- varies from yellow to brown to green with dark markings on chest, sides, and back, ventral surfaces pale yellow
    - *Bufo woodhousii velatus*- yellow-brown, green-brown, or brown, with dark spots on pale chest
  - **Other:**
    - Light middorsal stripe present
    - *Bufo woodhousii woodhousii* and *Bufo woodhousii australis*- dark dorsal spots with one to several warts
    - Cranial crests prominent
    - Parotoid glands elongate
  - **Sexual Dimorphism:**
    - *Bufo woodhousii australis*- dark throat on males
- Natural History
  - Habitat:
    This frog prefers sandy areas near marshes, riverbottoms, desert streams, canyons, irrigated fields, and suburban backyard gardens.
  - Behavior:
    It is nocturnal and feeds on insects near light sources. During the day it shelters in burrows or among vegetation.
  - Breeding:
    Breeding occurs from March to August. Males call from pools of water.

- Range:
  - In North America, the range is from the East Coast west as far as Nevada and then south into Mexico.
  - In Texas, it is found throughout the state, excluding the south-west region of Texas.
Hyla cinerea

Green Treefrog

Photo credits

- Diagnostic Features:
  - Size: 1 1/4-2 1/4 inches
  - Color:
    - Typically bright green
    - Lateral stripes of white or yellow coloration
  - Other:
    - Slim, smooth body
    - White lips
    - Lateral stripes usually extend to groin, but may be much shorter, or lacking
    - Many have small yellow dorsal spots
    - Large toe pads present

- Natural History:
  - Habitat:
    This frog prefers wet or moist areas such as swamps, lake sides, and the edges of streams. It is occasionally found in brackish water.
  - Behavior:
    It is nocturnal and walks, rather than jumps. It feeds on various insects.
  - Breeding:
    Breeding occurs form March to October. Males call just before dark. Eggs are laid in a jelly envelope attached to floating plants.

- Range:
  - In North America, this treefrog is found in the deep South, from Maryland to Texas.
  - In Texas, it is found in the eastern third of the state.
This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 11/25/98.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Pseudacris crucifer crucifer

Northern Spring Peeper

- Diagnostic Features:
  - Size: 1 1/4-2 inches
  - Color:
    - Varies from yellow, brown, olive, to gray
  - Other:
    - Small, slender body
    - Dark cross on dorsal surface in shape of an 'X'
    - Plain ventral surface
    - Large toe pads
    - Unwebbed toes
  - Sexual Dimorphism:
    - Females are generally lighter in coloration

- Natural History:
  - Habitat:
    - This frog prefers woodland areas and areas of brushy growth near small temporary ponds.
  - Behavior:
    - It is nocturnal and is rarely seen except during breeding season. It hibernates in very cold weather.
  - Breeding:
    - Breeding occurs from November to February, depending on the temperature. Single eggs are laid among underwater vegetation.

- Range:
  - In North America, this treefrog is found from the southern parts of eastern Canada, south to the Gulf of Mexico.
  - In Texas, it is found in the eastern quarter of the state.
This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 11/25/98.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Rana sphenoecephala

Southern Leopard Frog

- Diagnostic Features:
  - Size: 2-3 1/2 inches
  - Color:
    - Brown or green, or combination
  - Other:
    - Long, pointed head
    - Dark spots on dorsum between light dorsolateral ridges and on sides of body
    - Spots are round and outlined by lighter color
    - Distinct light spot on tympanum
    - Light line on upper jaw

- Natural History:
  - Habitat:
    This frog prefers shallow, freshwater habitats. It is sometimes seen in brackish waters along the coasts. It is well camouflaged in vegetated areas.
  - Behavior:
    Nocturnal, it hides during the day in vegetation at the edge of the water. It avoids predators by entering the water and swimming away underwater.
  - Breeding:
    Breeding occurs all year. Eggs are laid in shallow water.

- Range:
  - In North America, this frog is found in southeastern United States, from as far north as New Jersey south and east to Texas, Oklahoma, and Nebraska.
  - In Texas, it is found in the eastern third of the state.
This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 11/25/98.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Eumeces fasciatus

Five-lined Skink

- Diagnostic Features:
  - Size: 5 - 8 inches
  - Color:
    - The dorsal ground color varies with age and sex. Juveniles are deep black with bright blue tails. Adult females are olive brown with gray tails. Adult males are brown or olive brown.
    - The dorsal pattern, if present, consists of five light stripes down the length of the back and onto the tail.
  - Other:
    - Small, cylindrical lizard
    - Pale, unmarked ventral surface
    - Glossy scales
    - Long tail
    - Often confused with Eumeces laticeps, but has 26-30 scale rows at the middle of the body, 4 supralabials, and 2 enlarged postlabial scales.
  - Sexual Dimorphisms:
    - Males tend to be larger than females
    - Males tend to lose their markings
    - Males have red coloration on head during breeding season

- Natural History:
  - Habitat:
    This skink is seen in urban areas, but is more commonly seen in damp, wooded areas with leaf litter and decaying logs.
  - Behavior:
    This diurnal skink forages for insects, insect larvae, spiders, and small vertebrates on rotting trees.
  - Breeding:
Breeding occurs in the spring. Females lay 6-12 eggs in rotting wood or under a rock. Female brooding is exhibited. Hatchlings appear in June.

- Range:
  - In North America, this skink has a broad range from the East Coast west to Kansas and from the Great Lakes region to the Gulf Coast.
  - In Texas, it is found in the eastern third of the state.

This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 11/25/98.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Phrynosoma cornutum

Texas Horned Lizard

- **Diagnostic Features:**
  - **Size:** 2 1/2 - 4 1/4 inches
  - **Color:**
    - Dorsal ground color varies with environment, but may be tan or gray with white and red or yellow tones
    - The dorsal pattern consists of dark brown spots with pale posterior borders behind the head, on body, and tail on each side of light middorsal line
  - **Other:**
    - Flat, broad lizard
    - Dark lines downward from eyes and across head
    - Pointed snout
    - Crown of spines on the back of the head, with the two center ones enlarged resembling horns
    - Row of spines projecting from both sides of throat
    - Two rows of spiny scales on sides of body
    - Large spines on dorsal surface surrounded by dark pigment
    - Keeled ventral scales
    - Short tail

- **Natural History:**
  - **Habitat:**
    This lizard prefers warm, sandy, arid environments and is typically found in flat, open areas with little vegetation.
  - **Behavior:**
    This diurnal lizard is quick. It seeks shelter among brush or in animal burrows. It may also cover itself in loose sand. It is only seen on warm days of late Spring or Summer. It feeds on large ants and squirts blood from its eyes under stress. It hibernates from late Summer to late Spring.
- **Breeding:**
  Breeding occurs in late spring upon emergence from hibernation. Females lay eggs in burrows.

- **Range:**
  - In North America, the range of this lizard extends from a line from Kansas to Louisiana through Texas to New Mexico and northern Mexico.
  - In Texas, it was originally seen throughout the state, but numbers dropped dramatically in the fifties and sixties with pesticide use. Today, they are only seen in the western third of the state.

This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 11/25/98.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Sceloporus undulatus

Prairie and Fence Lizards

1. Sceloporus undulatus consobrinus
2. Sceloporus undulatus hyacinthinus
3. Sceloporus undulatus consobrinus
4. Sceloporus undulatus consobrinus

Photo credits

- Diagnostic Features:
  - Size: 3 1/2 - 7 inches
  - Color:
    - Sceloporus undulatus consobrinus and Sceloporus undulatus garmani: Dorsal ground color is light brown. The dorsal pattern consists of 2 light stripes, one from each side of the neck, down each side of the back and dark spots and/or bands in the middorsal region.
    - Sceloporus undulatus hyacinthinus: Dorsal ground color is gray or light brown. Dorsal surface with a light dorsolateral stripe from the neck onto the tail and a light stripe on each side between the front and rear legs. Dark spots and broken wavy stripes on dorsum, as well. Both sexes have blue throats and two blue belly patches rimmed in black.
  - Other:
    - Long tail, up to 1 1/2 times the head-body length
- **Sceloporus undulatus hyacinthinus** has black line on back of thighs
  - Sexual Dimorphisms:
    - **Sceloporus undulatus consobrinus** - Males have two blue patches rimmed in black on the belly and throat. Females tend to be slightly larger than males and lack ventral colorings, but may have pale blue on throat.

- **Sceloporus undulatus garmani** - Males have two blue patches rimmed in black on the belly and plain blue patches on the throat. Females lack ventral colorings.
- **Sceloporus undulatus hyacinthinus** - Blue colorings more vivid on males, but dorsal markings more prominent on females. Males have wide dark patch between dorsolateral stripe and side stripes. Females may have orange coloration on the back of their thighs near the base of the tail.

- **Natural History:**
  - **Habitat:**
    - **Sceloporus undulatus consobrinus** - This lizard prefers rocky areas which provide shelter and basking surfaces.
    - **Sceloporus undulatus garmani** - This lizard prefers sandy areas with brushy vegetation.
    - **Sceloporus undulatus hyacinthinus** - This lizard is commonly seen on fences, logs, and stumps.
  - **Behavior:**
    - These are diurnal lizards that feed on a variety of insects. **Sceloporus undulatus consobrinus** is terrestrial in open areas and arboreal in wooded areas of its range. **Sceloporus undulatus garmani** is terrestrial and seeks shelter in animal burrows when threatened. **Sceloporus undulatus hyacinthinus** is arboreal and climbs to avoid predators. It hibernates during the coldest part of the winter.
  - **Breeding:**
    - **Sceloporus undulatus consobrinus** and **Sceloporus undulatus garmani** breed in spring and summer. More mature females may lay several egg clutches per year. **Sceloporus undulatus hyacinthinus** breeds after emerging from hibernation.

- **Range:**
  - In North America, these three lizards are found from parts of New York to South Carolina to South Dakota, Arizona, and northern Mexico.
  - In Texas, they cover the state with their individual ranges illustrated below.
Sceloporus undulatus consobrinus in green
Sceloporus undulatus garmani in blue
Sceloporus undulatus hyacinthinus in yellow

This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 6/14/99.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Agkistrodon contortrix

Copperhead

Broad-banded Copperhead
Trans-Pecos Copperhead
Southern Copperhead

1. Agkistrodon contortrix pictigaster from Brewster Co., TX
2. Agkistrodon contortrix laticinctus from Bastrop Co., TX

Photo credits

The Copperhead is a colorful snake that is frequently seen throughout much of the eastern half of Texas. The contrasting pattern of reddish or brown saddle-shaped crossbands on a light tan background make the copperhead readily identifiable. Copperheads are venomous, and are therefore highly dangerous if approached or handled. But they are not generally aggressive and will most likely flee any confrontation if given a chance. Adult copperheads measure between 51-91.5 cm (20-36 in).

Similar species. -- Agkistrodon contortrix may be mistaken for other venomous and non-venomous snakes in Texas. Of the non-venomous snakes, the hognose snakes (Heterodon), in particular the Eastern Hognose Snake (H. platyrhinos), make look strikingly similar to A. contortrix. The Hognose's upturned snout, blotches that do not reach the ventral surface, round pupils, and divided anal plate distinguish it from A. contortrix, which lacks an upturned snout, has crossbands, elliptical pupils and an undivided anal plate. Adult A. contortrix are usually not confused with the Cottonmouth, yet the juveniles of both species are very similar. Young A. contortrix lack the chocolate cheek stripe seen in A. piscivorus, instead having the a light tan area below the eye to the corner of the mouth.

Natural history. -- These snakes make use of their coloration by living in partly shaded habitats. Living in leaf piles beneath trees, or alongside logs and stones in wooded forests, the Copperhead is able to elude predators because of its camouflage. This cryptic behavior also allows copperheads to strike at unsuspecting prey. The pale gray or olive-colored tail of the Copperhead is sometimes used to lure prey to within striking distance. Prey includes rodents, birds, lizards, frogs and other amphibian species. Habitats of the Copperhead do not generally include standing or running water; in fact, the trans-Pecos form (A. c. pictigaster) can be found in relatively dry desert canyons in west Texas. Being nocturnal
during the hotter summer months, *A. contortrix* is active during the day only during the cooler spring and fall months. Copperheads may breed in April and May, giving birth to as many as eight live young in August and September, with the young snakes measuring 18.0-25.5 cm (7-10 in). There is also evidence that copperheads may only give birth to young every other year.

Subspecies. -- There are five recognized subspecies of *Agkistrodon contortrix*, three of which are found in Texas. The distinctions between these are based on color variations, yet some of these variations have been shown to be variable within the range of a single subspecies. *Agkistrodon c. pictigaster* (Trans-Pecos Copperhead) is distinguished by strongly patterned belly and crossbands which have a light spot near their base. Pale "inverted U's" are also seen on the belly surface at the base of each dark crossband. It is the smallest of the Texas subspecies. *Agkistrodon c. laticinctus* (Broad-banded Copperhead) is similar to *A. c. pictigaster* in having wide broad dorsal crossbands, yet lacking the distinctly pigmented belly of *pictigaster* (though it is somewhat pigmented) and the pale area at the base of each crossband. *Agkistrodon c. contortrix* (Southern Copperhead) is identified by its crossbands which are distinctly constricted at the dorsal midline. In *A. c. contortrix*, these bands are additionally constricted near their bases, and at times may not be as distinct from the background coloration as in the other subspecies.

Distribution. -- The U.S. populations range from Texas and Oklahoma in the southwest, Iowa to the northwest, New York and Massachusetts to the northeast, and Florida to the southeast. In Texas, *A. c. pictigaster* is found in the Big Bend as well as in adjacent portions of the eastern trans-Pecos. The range of *A. c. laticinctus* covers much of central Texas, including heavily wooded portions of the Edwards Plateau and drier areas near San Antonio. *Agkistrodon c. contortrix* is found in the woodlands and mixed forests of the eastern quarter of the state.

(Text by Travis J. LaDuc)
Agkistrodon contortrix laticinctus in green
Agkistrodon contortrix pictigaster in purple
A. c. contortrix and A. c. laticinctus Hybrid in yellow
A. c. laticinctus and A. c. pictigaster Hybrid in light blue

This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 6/14/99.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Crotalus atrox

Western Diamondback Rattlesnake

Photo credits

The Western Diamondback Rattlesnake is the most commonly encountered rattlesnake in Texas. The Western Diamondback is the longest rattlesnake in the state, and one of the two heaviest (the other is the Timber Rattlesnake). The record length is over 213 cm (84 in); adults found in the wild typically measure between 0.91-1.21 m (3-4 ft). Its common name does not come unearned; a series of diamond-shaped blotches runs down the length of its back, and each blotch is surrounded by a light border. A background coloration of tan or brown surrounds the blotches, and the dorsal coloration varies tremendously over its distributional range. This rattlesnake can easily be distinguished by its black and white tail, which also earns the western diamondback the name "coontail" (also, see below). Its off-white belly is usually unmarked, its anal scale is undivided, and its dorsal scales are extremely keeled, often in rows of 25 to 27 near midbody.

Similar species. -- Crotalus atrox may be confused with a number of snakes found in Texas, most of which are non-venomous. The majority of these snakes, however, lack the key feature of a rattle found at the end of the tail. Many snakes, including gopher snakes (Pituophis) and hognose snakes (Heterodon) may show an impressive threat display and have similar brown and tan markings, but lack the rattles. Some rattle-less snakes such as rat snakes and copperheads may vibrate their tails. Like all rattlesnakes, Crotalus atrox has a heat-sensing pit between the eye and nostril. The dorsal markings of rattlesnakes range from the distinct diamond-shaped (rhomboid) marks in Crotalus atrox and the Mojave Rattlesnake (Crotalus scutulatus), to dorsal blotches in the Prairie Rattlesnake (Crotalus viridis) and the Western Massasauga (Sistrurus catenatus), to narrower crossbands extending down the sides of the body in the Rock Rattlesnake (Crotalus lepidus). The pattern of the Western Diamondback is most similar to that of the Mojave Rattlesnake and the Prairie Rattlesnake. The color of the tail is a useful key to discriminate C. atrox from most other rattlesnakes. In C. atrox, the tail is completely encircled with white and black bands of equal widths. The Mojave Rattlesnake, Crotalus scutulatus, is the only other Texas rattlesnake with such prominent black and white bands around its tail, but the white bands are twice as wide as the black bands. Crotalus scutulatus does have similar dorsal rhomboid markings running the length of its body, yet these blotches flatten into bands in the posterior third of the body; the diamond markings of C. atrox do not flatten into bands. Adult Mojave
Rattlesnakes usually reach lengths of only about three feet, so any very large rattlesnakes are most likely Western Diamondbacks.

Natural History. -- All rattlesnakes are venomous, and therefore potentially dangerous if approached or handled. Rattlesnakes are not generally aggressive and will most likely flee if given a chance to retreat. Found from the flatlands and prairies to the rocky hills and low mountains, the Western Diamondback is a key participant in the food web; it is an important predator of many small rodents, rabbits, and birds. The Western Diamondback is in turn preyed upon by a variety of larger mammals and birds, such as coyotes, foxes, and hawks. It is primarily a nocturnal animal, hunting for its prey on warm summer nights. It is, however, seasonally diurnal, moving between hunting sites during the day during the cooler spring and fall months. The Western Diamondback is usually inactive between late October and early March, though an occasional rattlesnake may be seen sunning itself on warm winter days. Mating occurs in the spring and the females give birth (they are viviparous) to as many as 25 young, which may be as long as 30 cm (12 in) in length. The young are fully capable of delivering a venomous bite hours after their birth.

Distribution. -- *Crotalus atrox* is found in California, Arizona, New Mexico, Oklahoma and Texas. The Western Diamondback also has an extensive range in the northern half of Mexico. In Texas, *Crotalus atrox* is found throughout the state, save the wettest eastern portions of the state. Its relative, the Eastern Diamondback (*Crotalus adamanteus*), is found in eastern Louisiana and ranges from there through Florida to North Carolina.

(Text by Travis J. LaDuc)
Crotalus horridus

Timber Rattlesnake

Crotalus horridus from Tyler Co., TX
Photo credits

The rattlesnake made famous by the Revolutionary War flag "Don't Tread on Me" is the Timber Rattlesnake, Crotalus horridus. Unfortunately, in many of the northern states where the flag was flown during the Revolutionary War, populations of the Timber Rattlesnake are now severely threatened (see below). Crotalus horridus is an attractive snake, with its dark crossbands covering a gray background. A light cinnamon-colored vertebral stripe in turns covers a portion of each crossband. Its tail is black and its belly is mostly white with areas of pigment found near the border between ventral and dorsal scales. In certain populations, the background color may be a shade of yellow, or even darkly pigmented, obscuring the distinction between the blotches and the background. As adults, C. horridus are heavy-bodied animals, and may reach to 152 cm (60 in) in length. The anal plate is undivided, as in other rattlesnakes, and the keeled dorsal scale rows are either in rows of 25 or 27 near midbody.

Similar species. -- Crotalus horridus may be confused with a few other species of snakes in Texas, though the presence of its rattle will distinguish it from all other snakes, save other rattlesnakes. The two species of Sistrurus can be identified most easily by their small size as adults (45.5-76 cm; 18-30 in) in comparison to adult C. horridus (91.5-152 cm; 36-60 in). An additional character is the arrangement of head scales (Sistrurus with nine symmetrical head plates, C. horridus with many small scales), but this is difficult to determine without unnecessary risk. Another large rattlesnake, C. atrox, differs from C. horridus by its white and black banded tail and the diamond markings on the back. The tail of the Timber Rattlesnake is charcoal black, and its crossbands are in the shape of chevrons.

Natural History. -- Like all rattlesnakes the Timber Rattlesnake is venomous, and therefore dangerous if disturbed. If encountered in the wild, they are better left alone. Crotalus horridus can be found in the wooded forests, as well as the well-vegetated lowlands. In Texas, it can be found associated along heavily vegetated riparian waterways found in the eastern part of the state. Feeding primarily on rodents and rabbits, C. horridus is a sit-and-wait predator, often found lying adjacent to rodent paths that weave through the vegetation. They may lie in wait for several days for the chance to capture a meal.
Because *C. horridus* often congregate in large numbers at den sites for their winter hibernation, they are highly susceptible to human interference. In fact, many populations in the northeastern U.S. have been eliminated as a result of overcollection and unnecessary killing by humans. These snakes are an important part of the food web because they limit rodent populations, as well as being a source of food to several large mammal and bird species. Conservation efforts have been implemented in many states in an effort to learn more about these important predators and to protect those remaining populations from further human-induced problems. Females give live birth to an average of ten young in the late summer months. These young rattlesnakes may measure between 20-40 cm (8-16 in) at birth.

**Distribution.** -- The range of *Crotalus horridus* extends through much of the United States, including most of the states east of the Mississippi River. West of the Mississippi, the Timber Rattlesnake is found as far west as Nebraska, Kansas, Oklahoma and Texas, and as far north as Minnesota. It is not found in Mexico, and only a single small population is found in Canada. In Texas, *Crotalus horridus* is found only in the wetter portions of the eastern quarter of the state. Across much of its range, *C. horridus* is protected from collection by state regulations. Texas is no exception, and the Timber Rattlesnake is classified as a threatened species by the Texas Parks and Wildlife Department and is fully protected under the law.

(Text by Travis J. LaDuc)

![Map of Texas showing the range of *Crotalus horridus*](image)

This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 6/14/99.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Elaphe obsoleta

Eastern Rat Snake

- Diagnostic Features:
  - Adult Size: 42-72 inches
  - Color:
    - *Elaphe obsoleta lindheimeri* Dorsal color is gray or yellowish with blue-black or brown blotching. Red coloration between the scales. Ventral surface with clouded checkerboard pattern. Underside of tail unmarked.
    - *Elaphe obsoleta obsoleta* Dorsal color shiny and black. Light color between the scales. Ventral surface with clouded checkerboard pattern. Underside of tail unmarked.
  - Other:
    - Scales are faintly keeled along spine
    - 27 scale rows at midbody
    - Divided anal plate

- Natural History:
  - Nonvenomous
  - Habitat:
    - *Elaphe obsoleta lindheimeri* Swamps and marshes in the eastern part of its range to stream valleys and rocky habitats in the western parts of its range.
    - *Elaphe obsoleta obsoleta* is seen in a wide range of habitats from grassy prairies to coastal plains to rocky slopes.
  - Behavior:
    - These Rat Snakes very aggressive for nonvenomous snakes and will bite if threatened. They are adept climbers and the spiny belly scales "grab" the tree trunk as they climb. They are sometimes seen swimming. They feed on small mammals, birds, frogs, and lizards by swallowing; bigger prey is first killed by constriction.
  - Breeding:
    - Egg-bearing. Hatchlings measure 12-14 inches.
- Range:
  - In North America, Elaphe obsoleta is found from the Canadian border of New York to the southeast corner of Minnesota and throughout the South.
  - In Texas, it is found in the eastern two-thirds of the state.

This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 11/30/98.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
Heterodon platirhinos

Eastern Hognose Snake

1. Heterodon platirhinos
2. Heterodon platirhinos from Travis Co., TX

Photo credits

- Diagnostic Features:
  - Adult Size: 20-33 inches
  - Color:
    - Dorsal ground color is variable. May be yellow, orange, olive, brown, or gray.
    - Typically blotched with another color, but some all black specimens are possible.
    - Ventral surface is gray and unmarked. Underside of tail is lighter than belly.
  - Other:
    - Upturned snout with keel (as opposed to being flat as in Hooknose Snakes)
    - Ridges line the upper lip
    - Dark blotch on each side of neck
    - Scales are strongly keeled
    - 23-25 scale rows at midbody
    - Divided anal plate

- Natural History:
  - Nonvenomous (mildly venomous to its prey)
  - Habitat:
    - This snake is commonly seen in sandy habitats, woodlands, or or grasslands near a water source.
  - Behavior:
    - Diurnal; burrows well; if molested or threatened it will hiss, flatten the area posterior to its head and assume a cobra-like pose, make pseudo-strikes, coil up and writhe, regurgitate and release musk, and feign death by turning itself over; unlikely to bite if held; feeds mostly on toads and frogs.
  - Breeding:
    - egg-bearing; breeding occurs March-May; 4-61 eggs laid 6 weeks later; hatchlings
are 6 1/2-9 1/2 inches.

- Range:
  - In North America, Eastern Hognose Snakes are found from New Hampshire to Minnesota to Texas and throughout the South.
  - In Texas, they are found in the eastern two-thirds of the state.
Alligator mississippiensis

American Alligator

Juvenile Alligator mississippiensis.

Photo credits

- Diagnostic Features:
  - Size: 6-16 feet
  - Color:
    - Dark, appearing black
  - Other:
    - Largest reptile in North America
    - Large head
    - Rounded snout with long jaws
    - Protruding eyes and nostrils
    - Several rows of scales on body are strongly keeled
    - Ventral scales soft, rectangular
    - Tail has two rows of keeled scales that converge to form one strong keel at the midpoint of the tail
    - Strong, stout legs
    - Front feet with 5 toes
    - Webbed hind feet with 4 toes

- Natural History:
  - Habitat:
    This reptile can be found in a variety of freshwater habitats, including swamps, lakes, and bayous. It also occurs in the brackish waters of coastal marshes.
  - Behavior:
    Semiaquatic, this crocodilian basks on land near water. It swims with just its eyes and nostrils above water. During colder months, it hibernates in burrows dug in the mudbanks. It feeds on anything in its habitat, including crustaceans, fish, snakes, waterfowl, lizards, and small mammals. It can drown larger prey by holding and twisting it under water.
Breeding:
Breeding occurs in April and May, after hibernation. The female lays up to 60 hard-shell eggs in a large nest of mud and leaves and remains with the young for about one year.

Range:
- In North America, the American Alligator is found in the southern coastal states, from North Carolina to Texas.
- In Texas, it is found in the eastern third of the state and in the extreme southern tip.

This project funded by the University of Texas College of Natural Sciences and the Texas Memorial Museum.

Last revised 11/25/98.
Comments welcome.
Texas Memorial Museum at UT Austin
Copyright 2000
APPENDIX II

MAMMALS
The Mammals of Texas

Online Edition

By William B. Davis and David J. Schmidly

In *The Mammals of Texas*, Drs. William B. Davis and David J. Schmidly bring together over 70 years of experience in the study of Texas mammals. A completely revised and updated version of William B. Davis's classic text, which was first published in 1947, *The Mammals of Texas* is a perennial favorite, going through four reprints and revisions during the past 47 years. A basic reference for the wildlife enthusiast, the book contains information on the distribution, physical characteristics and life histories of the 181 species of Texas mammals. Included are photographs, a comprehensive set of distribution maps and identification keys to the orders and species of mammals found in Texas. Also included is a brief introduction to the study of mammals.

This online edition of *The Mammals of Texas* incorporates the complete text and graphics content of the 1994 revision published by the Texas Parks and Wildlife Department. This site is keyword-searchable or may be browsed by selecting from the options to the left. Please read the explanation of copyright and citation concerns before making use of any information found on this site.

Preface | Acknowledgements | About the Authors
The Mammals of Texas - Online Edition

Preface

This book is devoted to mammals, which are the class of vertebrate animals possessing hair, with the females having milk-secreting glands. One group of mammals, the cetaceans (whales and dolphins) have a layer of blubber instead of hair. This class, having among its representative genera certain species that fly, others that glide, swim, climb, burrow, leap, or run, is perhaps the most versatile and adaptable of the vertebrate animal groups.

Texas, with its variety of soils, climate, vegetation, and topography, as well as extensive coastline, is the home of more than 181 distinct species of mammals. The locomotive versatility of the various members of the class is responsible in part for the occurrence of mammals in our deserts, forests, mountains, prairies, high plains, and waters.

This book represents the fifth account published by the Texas Parks and Wildlife Department detailing the kinds of mammals that occur in Texas with information about their lives and economic importance. Dr. W. P. Taylor and Dr. W. B. Davis collaborated to prepare The Mammals of Texas, published by the former Texas Game and Fish Commission as Bulletin No. 27, in August 1947. Recognizing the growing interest in Texas mammals and the expanding knowledge about the many kinds of mammals in the state, Dr. Davis in 1960 wrote an entirely new bulletin, designated as Bulletin No. 41, which served as an identification key to Texas mammals and also provided information on their distribution and life histories. Dr. Davis revised Bulletin No. 41 in 1966 and again in 1974.

Dwindling supplies and increasing popularity of Bulletin No. 41 prompted the Texas Parks and Wildlife Department to seek an updating of this informative publication. For this purpose, wildlife expert and mammalogist Dr. David J. Schmidly very graciously agreed to update Dr. Davis’ publication and make needed revisions in the species distribution maps and other portions of the bulletin. Most of the changes were made to update the identification keys and geographic ranges of mammals in Texas and its adjacent waters. The natural history descriptions, for the most part, remain essentially as detailed by Dr. Davis in Bulletin No. 41.

Simplicity is the basic goal in organizing this book. Accounts for each species are arranged so that they contain in sequence (1) a brief description of the mammal, with special emphasis given to distinguishing features, accompanied in most cases by a photograph; (2) a description of the geographic distribution of the species in Texas, with reference to a map; and (3) a discussion of some of the basic life history of the mammal, including habitat preferences, reproduction, behavior, and food habits. This information has been taken from observations recorded by other researchers and reported in the scientific literature as well as the personal experiences of the authors based on more than 50 years of field work in Texas. On the distribution maps, counties where specimens of mammals have been reported, either in the literature or represented by a scientific specimen located in a museum collection, are indicated by black dots; the probable range
for most species is shaded in.

Students of wildlife and citizens interested in conservation and natural history will find much help in this revision of *The Mammals of Texas*, by Dr. W. B. Davis (Professor Emeritus of Wildlife and Fisheries Sciences), and Dr. David J. Schmidly (Professor and Curator of Mammals in the Department of Wildlife and Fisheries Sciences) of Texas A&M University, both of whom are recognized internationally as authorities on mammals.

Andrew Sansom
Executive Director
TEXAS MAMMALS

The importance of Texas in relation to geography and wildlife is no accident. Within the state is such a wide variation of soils, climate, and topography that the resultant vegetation and animal life are unusually rich. This diverse environment supports a resident fauna of 141 species of native terrestrial mammals, a number exceeded in the United States only by California and New Mexico. In addition to the native species that occur in the area naturally, there are also 12 exotics or nonnative species that have been introduced accidentally (house mouse, roof rat, Norway rat) or intentionally (nutria, red fox, feral pig, axis deer, fallow deer, sika deer, nilgai, barbary sheep, and blackbuck) by man and have become established as a part of the freeliving fauna. An asterisk (*) beside the common name in the species accounts indicates a nonnative species.

Terrestrial mammals in Texas belong to the orders Didelphimorphia (opossums), Insectivora (shrews and moles), Chiroptera (bats), Xenarthra (armadillos), Lagomorpha (hares and rabbits), Rodentia (rodents), Carnivora (carnivores), and Artiodactyla (even-toed ungulates). In addition, Texas is bounded by the waters of the Gulf of Mexico and 28 marine mammals of the orders Cetacea (whales and dolphins), Pinnipedia (seals), and Sirenia (manatees) enter the coastal waters of the state. The number of genera and species of Texas mammals in each of these groups is given in Table 1. This total of 181 mammals does not include several large, exotic ungulates that recently have been brought into the state and are kept for the most part under high fence and two domesticated species (dog and cat) which have taken up life in the wild state in many places and have significant impacts on other mammals living in those areas.

TABLE 1. The number of genera and species of mammals in Texas.

<table>
<thead>
<tr>
<th>Order</th>
<th>Genera</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didelphimorphia (Opossums)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Insectivora (Shrews and Moles)</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Chiroptera (Bats)</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Xenarthra (Armadillos)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lagomorpha (Hares and Rabbits)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Rodentia (Rodents)</td>
<td>28</td>
<td>68</td>
</tr>
<tr>
<td>Carnivora (Carnivores)</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>Pinnipedia (Seals)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Artiodactyla (Even-toed Ungulates)</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Sirenia (Manatees)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cetacea (Whales and Dolphins)</td>
<td>17</td>
<td>26</td>
</tr>
<tr>
<td>Totals</td>
<td>97</td>
<td>181</td>
</tr>
</tbody>
</table>

Texas is a keystone in understanding the distributional patterns of Recent mammals in the
United States. Several species reach distributional limits within the state. The mammalian fauna includes many species that occur throughout the central United States, especially those associated with the central grasslands, others with the southeastern deciduous forests, many characteristic of the desert regions of the Mexican Plateau and the southwestern United States, and a few associated with the mountain regions of the western United States and the tropical regions of northeastern Mexico.

Other important features of the terrestrial mammalian fauna of Texas are the number of endemic species and the variability within species as reflected by the number of described subspecies. Five species are virtually confined in their distribution to Texas. There are 243 described taxa (species and subspecies) of native land mammals in the state, and 55 of the 141 species (39%) are represented by more than one subspecies.

Topics under this heading:

- Diversity of Land Mammals
- Geographic Distribution of Land Mammals
- Critical Species
- Conservation Strategies
- Key to the Major Groups (Orders) of Mammals in Texas
DIVERSITY OF LAND MAMMALS

There is considerable change in the diversity of Texas mammals with geography. To illustrate this, species diversity has been depicted along a series of quadrats positioned along two transects that traverse the state (one stretching in a west to east direction from El Paso to Beaumont and another beginning at Dalhart in the northern part of the state and continuing southeastward to Brownsville) (Figure 1). Species diversity exhibits a general decrease along the transect from El Paso to Beaumont (Figure 2, transect A). The lowest diversity is in the Blackland Prairies region (quadrats 12 and 13) and the highest is in the Guadalupe Mountains of the Trans-Pecos (quadrant 3). Major shifts in the diversity pattern are evident on either side of the Balcones Escarpment (between quadrats 10 and 12), and between the western portion of the Edwards Plateau (quadrant 4) and the Guadalupe Mountains in the Trans-Pecos (quadrant 3).

The pattern is much more irregular, without any general trend, along the north to south transect (Figure 2, transect B). Diversity is highest in the Escarpment Breaks of the High Plains (quadrant 5), the Balcones Canyonlands of the Edwards Plateau (quadrants 10 and 11), and the subtropical brushlands of the South Texas Plains (quadrant 17). Diversity along this transect is lowest in the Rolling Plains region (quadrant 7) and the coastal sands of the South Texas Plains (quadrant 15).

Species diversity can also be viewed in terms of habitat diversity and land area. To evaluate this, the diversity of Texas mammals was examined with respect to the 10 major vegetation regions in the state. Figure 3 shows the plot of the number of species in each vegetative region versus the log of the land area for that vegetative type. The regions of lowest mammalian diversity in Texas are in the eastern half of the state (Pinewoods, Gulf Prairies and Marshes, Post Oak Savannah, Blackland Prairies, and Cross Timbers region) and on the High Plains. Areas of highest mammalian diversity are in the Trans-Pecos, Edwards Plateau, South Texas Plains, and Rolling Plains.

Two important generalizations are evident about the diversity of Texas mammals. First, there is no strong correlation between land area of the vegetation regions and species diversity. For example, the High Plains region is slightly larger in area than the Trans-Pecos region yet it supports only about half as many species of mammals. Second, those natural regions of Texas where vegetative and topographic heterogeneity are the greatest provide a broader spectrum of potential mammalian habitats and thus support a greater number of mammalian species.

Other topics under Texas Mammals:

Geographic Distribution of Land Mammals
Critical Species
Conservation Strategies
Key to the Major Groups (Orders) of Mammals in Texas
GEOGRAPHIC DISTRIBUTION OF LAND MAMMALS

Texas may be conveniently arranged into four regions based on the ecological distribution of mammals. These are the Trans-Pecos, Plains Country, East Texas, and the Rio Grande Plains (Figure 4). The Trans-Pecos region includes the mountain and basin country west of the Pecos River. The Plains Country includes the High Plains, Rolling Plains, Cross Timbers area, and the Edwards Plateau. Included within the East Texas region are the Pineywoods, central Texas Woodlands, Blackland Prairies, and Coastal Prairies and Marshes. The Rio Grande Plains encompasses the South Texas brushlands. The Balcones Escarpment serves as the major physiographic barrier separating the Plains Country from East Texas and the Rio Grande Plains. The boundary between East Texas and the Rio Grande Plains is positioned between the Guadalupe and San Antonio rivers where pedocal and pedalfar soils meet.

The distributional patterns of land mammals in Texas conform to five major patterns. These are: ubiquitous species that range throughout most, or all, of the state (included in this group are seven species that are now extinct or whose distributions have shrunk markedly in the past 150 years); species that are distributed primarily in one of the four divisions of the state; (3) western species distributed in the Trans-Pecos and Plains Country; (4) western species distributed in the Trans-Pecos and Plains Country, but which also occur on the South Texas Plains; and (5) eastern species distributed principally east of the 100th meridian. Mammals assigned to each of these categories listed. It should be noted that certain species occur slightly outside of the boundaries of the category to which they have been assigned.

The greatest number of unique elements in the mammal fauna of Texas occur in the Trans-Pecos region. Almost one-third of the 92 species of mammals that occur in the Trans-Pecos are primarily restricted in distribution to that region. Most of these mammals are species characteristic of the Mexican Plateau and southwestern United States or the montane woodlands of the western United States. The fewest number of unique elements is found in the Plains Country. The 15 mammals unique to East Texas are species characteristic of the deciduous forests and coastal prairies of the southeastern United States, which reach their western distributional limits in Texas. The Rio Grande Plain supports 11 unique elements, most of which are characteristic of the tropical lowlands of northeastern Mexico and reach their northern distributional limits in south Texas.

MAMMALS GENERALLY DISTRIBUTED THROUGHOUT THE STATE:

<p>| Virginia Opossum          | Didelphis virginiana          | (absent from portions of the Trans-Pecos) |
| Silver-haired Bat         | Lasionycteris noctivagans     |                                            |
| Big Brown Bat             | Eptesicus fuscus              | (not in Rio Grande Plains)                |
| Eastern Red Bat           | Lasiurus borealis             |                                            |
| Hoary Bat                 | Lasiurus cinereus             |                                            |
| Brazilian Free-tailed Bat | Tadarida brasiliensis         |                                            |</p>
<table>
<thead>
<tr>
<th>Species</th>
<th>Scientific Name</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Cottontail</td>
<td>Sylvilagus floridanus</td>
<td>(not in the Big Thicket of East Texas)</td>
</tr>
<tr>
<td>Black-tailed Jackrabbit</td>
<td>Lepus californicus</td>
<td>(not in the Big Thicket of East Texas)</td>
</tr>
<tr>
<td>Hispid Pocket Mouse</td>
<td>Chaetodipus hispidus</td>
<td>(not on the High Plains)</td>
</tr>
<tr>
<td>American Beaver</td>
<td>Castor canadensis</td>
<td></td>
</tr>
<tr>
<td>Fulvous Harvest Mouse</td>
<td>Reithrodontomys fulvescens</td>
<td></td>
</tr>
<tr>
<td>White-footed Mouse</td>
<td>Peromyscus leucopus</td>
<td></td>
</tr>
<tr>
<td>Deer Mouse</td>
<td>Peromyscus maniculatus</td>
<td></td>
</tr>
<tr>
<td>Hispid Cotton Rat</td>
<td>Sigmodon hispidus</td>
<td></td>
</tr>
<tr>
<td>Coyote</td>
<td>Canis latrans</td>
<td></td>
</tr>
<tr>
<td>Common Gray Fox</td>
<td>Urocyon cinereoargenteus</td>
<td></td>
</tr>
<tr>
<td>Black Bear</td>
<td>Ursus americanus</td>
<td>(now extinct except for remnant populations in the Trans-Pecos)</td>
</tr>
<tr>
<td>Ringtail</td>
<td>Bassariscus astutus</td>
<td></td>
</tr>
<tr>
<td>Common Raccoon</td>
<td>Procyon lotor</td>
<td></td>
</tr>
<tr>
<td>Long-tailed Weasel</td>
<td>Mustela frenata</td>
<td></td>
</tr>
<tr>
<td>Striped Skunk</td>
<td>Mephitis mephitis</td>
<td>(now gone from much of the range except South Texas and the Trans-Pecos)</td>
</tr>
<tr>
<td>Mountain Lion</td>
<td>Felis concolor</td>
<td></td>
</tr>
<tr>
<td>Bobcat</td>
<td>Lynx rufus</td>
<td></td>
</tr>
<tr>
<td>White-tailed Deer</td>
<td>Odocoileus virginianus</td>
<td>(now extinct in the wild in Texas)</td>
</tr>
<tr>
<td>Bison</td>
<td>Bos bison</td>
<td></td>
</tr>
</tbody>
</table>

**MAMMALS OCCURRING PRINCIPALLY IN THE TRANS-PECOS:**

<table>
<thead>
<tr>
<th>Species</th>
<th>Scientific Name</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexican Long-nosed Bat</td>
<td>Leptonycteris nivalis</td>
<td></td>
</tr>
<tr>
<td>California Myotis</td>
<td>Myotis californicus</td>
<td>(disjunct record from Rolling Plains)</td>
</tr>
<tr>
<td>Fringed Myotis</td>
<td>Myotis thysanodes</td>
<td>(disjunct record from Rolling Plains)</td>
</tr>
<tr>
<td>Long-legged Myotis</td>
<td>Myotis volans</td>
<td>(disjunct record from Rolling Plains)</td>
</tr>
<tr>
<td>Yuma Myotis</td>
<td>Myotis yumanensis</td>
<td></td>
</tr>
<tr>
<td>Western Red Bat</td>
<td>Lasius rossetti</td>
<td></td>
</tr>
<tr>
<td>Spotted Bat</td>
<td>Euderma maculatum</td>
<td></td>
</tr>
<tr>
<td>Pocketed Free-tailed Bat</td>
<td>Nyctinomops</td>
<td></td>
</tr>
<tr>
<td>Western Mastiff Bat</td>
<td>Eumops perotis</td>
<td></td>
</tr>
<tr>
<td>Animal</td>
<td>Scientific Name</td>
<td>Notes</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Gray-footed Chipmunk</td>
<td><em>Tamias canipes</em></td>
<td></td>
</tr>
<tr>
<td>Texas Antelope Squirrel</td>
<td><em>Ammospermophilus interpres</em></td>
<td>(also in western part of Edwards Plateau)</td>
</tr>
<tr>
<td>Desert Pocket Gopher</td>
<td><em>Geomys arenarius</em></td>
<td></td>
</tr>
<tr>
<td>Rock Pocket Mouse</td>
<td><em>Chaetodipus intermedius</em></td>
<td></td>
</tr>
<tr>
<td>Nelson's Pocket Mouse</td>
<td><em>Chaetodipus nelsoni</em></td>
<td></td>
</tr>
<tr>
<td>Desert Pocket Mouse</td>
<td><em>Chaetodipus penicillatus</em></td>
<td></td>
</tr>
<tr>
<td>Merriam's Kangaroo Rat</td>
<td><em>Dipodomys merriami</em></td>
<td></td>
</tr>
<tr>
<td>Banner-tailed Kangaroo Rat</td>
<td><em>Dipodomys spectabilis</em></td>
<td>(also in southern part of High Plains)</td>
</tr>
<tr>
<td>Brush Mouse</td>
<td><em>Peromyscus boylii</em></td>
<td>(also on Escarpment breaks of Rolling Plain)</td>
</tr>
<tr>
<td>Northern Rock Mouse</td>
<td><em>Peromyscus nasutus</em></td>
<td>(also in extreme western part of Rio Grande Plain)</td>
</tr>
<tr>
<td>Cactus Mouse</td>
<td><em>Peromyscus eremicus</em></td>
<td></td>
</tr>
<tr>
<td>Mearns' Grasshopper Mouse</td>
<td><em>Onychomys arenicola</em></td>
<td></td>
</tr>
<tr>
<td>Tawny-bellied Cotton Rat</td>
<td><em>Sigmodon fulviventer</em></td>
<td></td>
</tr>
<tr>
<td>Yellow-nosed Cotton Rat</td>
<td><em>Sigmodon ochrognathus</em></td>
<td></td>
</tr>
<tr>
<td>Mexican Woodrat</td>
<td><em>Neotoma mexicana</em></td>
<td></td>
</tr>
<tr>
<td>Mexican Vole</td>
<td><em>Microtus mexicanus</em></td>
<td></td>
</tr>
<tr>
<td>Hooded Skunk</td>
<td><em>Mephitis macroura</em></td>
<td></td>
</tr>
<tr>
<td>Wapiti or Elk</td>
<td><em>Cervus elaphus</em></td>
<td>(native population extinct; reintroduced into Guadalupe Mountains)</td>
</tr>
<tr>
<td>Mountain Sheep</td>
<td><em>Ovis canadensis</em></td>
<td>(native population extinct; reintroduced into several mountain ranges)</td>
</tr>
</tbody>
</table>

**MAMMALS OCCURRING PRINCIPALLY IN THE PLAINS COUNTRY:**

<table>
<thead>
<tr>
<th>Animal</th>
<th>Scientific Name</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thirteen-lined Ground Squirrel</td>
<td><em>Spermophilus tridecemlineatus</em></td>
<td>(also in a narrow strip through Central Texas from the Red River and Dallas region south to Corpus Christi; east to Colorado County)</td>
</tr>
<tr>
<td>Plains Pocket Gopher</td>
<td><em>Geomys bursarius</em></td>
<td></td>
</tr>
<tr>
<td>Jones' Pocket Gopher</td>
<td><em>Geomys knoxjonesi</em></td>
<td></td>
</tr>
<tr>
<td>Llano Pocket Gopher</td>
<td><em>Geomys texensis</em></td>
<td></td>
</tr>
<tr>
<td>Plains Pocket Mouse</td>
<td><em>Perognathus flavescens</em></td>
<td>(also in El Paso County)</td>
</tr>
</tbody>
</table>
Texas Kangaroo Rat  
Dipodomys elator

Texas Mouse  
Peromyscus attwateri

Prairie Vole  
Microtus ochrogaster  (subspecies haydeni)

Black-footed Ferret
Mustela nigripes  (now extinct in Texas)

**MAMMALS OCCURRING PRINCIPALLY IN THE RIO GRANDE PLAINS:**

Mexican Long-tongued Bat  
Choeronycteris mexicana

Southern Yellow Bat  
Lasius ega

Texas Pocket Gopher  
Geomys personatus

Gulf Coast Kangaroo Rat  
Dipodomys compactus

Mexican Spiny Pocket Mouse  
Liomys irroratus

Coutes’ Rice Rat  
Oryzomys couesi  (also in Big Bend region of the Trans-Pecos)

White-nosed Coati  
Nasua narica

Eastern Hog-nosed Skunk  
Conepatus leuconotus

Ocelot
Felis pardalis  (formerly more widely distributed)

Margay  
Felis wiedii  (now extinct in Texas)

Jaguarundi
Felis yagouaroundi

**MAMMALS OCCURRING PRINCIPALLY IN EAST TEXAS:**

Southern Short-tailed Shrew  
Blarina carolinensis

Southeastern Myotis  
Myotis austroriparius

Seminole Bat  
Lasius seminolus

Rafinesque’s Big-eared Bat  
Plecotus rafinesquii

Swamp Rabbit  
Sylvilagus aquaticus

Eastern Gray Squirrel  
Sciurus carolinensis

Eastern Flying Squirrel  
Glaucomys volans  (barely enters the Cross Timbers area of the Plains Country)

Attwater’s Pocket Gopher  
Geomys attwateri

Baird’s Pocket Gopher  
Geomys breviceps

Marsh Rice Rat  
Oryzomys palustris  (also in coastal region of Rio Grande Plain)

Eastern Harvest Mouse  
Reithrodontomys humulis
Cotton Mouse  
Peromyscus gossypinus

Golden Mouse  
Ochrotomys nuttalli

Prairie Vole  
Microtus ochrogaster  (subspecies ludovicianus)

River Otter  
Lutra canadensis

**MAMMALS OCCURRING PRINCIPALLY IN WEST TEXAS (PLAINS REGION AND TRANS-PECOS):**

Western Small-footed Myotis  
*Myotis ciliolabrum*

Western Pipistrelle  
Pipistrellus hesperus

Townsend’s Big-eared Bat  
Plecotus townsendii

Rock Squirrel  
Spermophilus variegatus

Black-tailed Prairie Dog  
Cynomys ludovicianus

Botta’s Pocket Gopher  
Thomomys bottae

Yellow-faced Pocket Gopher  
Cratogeomys castanops

Plains Harvest Mouse  
Reithrodontomys montanus  
(also in the Blackland Prairies of East Texas)

Silky Pocket Mouse  
Perognathus flavus

Western Harvest Mouse  
Reithrodontomys megalotis

White-ankled Mouse  
Peromyscus pectoralis

Piñon Mouse  
Peromyscus truei

White-throated Woodrat  
Neotoma albigula

Porcupine  
Erethizon dorsatum

Swift or Kit Fox  
Vulpes velox

Grizzly or Brown Bear  
Ursus arctos  
(now extinct)

Mule Deer  
Odocoileus hemionus

**MAMMALS OCCURRING PRINCIPALLY IN WESTERN TEXAS (TRANS-PECOS AND PLAINS REGION) AND RIO GRANDE PLAINS:**

Desert Shrew  
Notiosorex crawfordi

Ghost-faced Bat  
Mormoops megalophylla

Cave Myotis  
Myotis velifer

Pallid Bat  
Antrozous pallidus

Big Free-tailed Bat  
Nyctinomops macrotis  
(two records from East Texas)

Desert Cottontail  
Sylvilagus audubonii

Mexican Ground Squirrel  
Spermophilus
<table>
<thead>
<tr>
<th>Mammal Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spotted Ground Squirrel</td>
<td><em>Spermophilus spilosoma</em></td>
</tr>
<tr>
<td>Merriam’s Pocket Mouse</td>
<td><em>Perognathus merriami</em></td>
</tr>
<tr>
<td>Ord’s Kangaroo Rat</td>
<td><em>Dipodomys ordii</em></td>
</tr>
<tr>
<td>Northern Grasshopper Mouse</td>
<td><em>Onychomys leucogaster</em></td>
</tr>
<tr>
<td>Southern Plains Woodrat</td>
<td><em>Neotoma micropus</em></td>
</tr>
<tr>
<td>Gray Wolf</td>
<td><em>Canis lupus</em></td>
</tr>
<tr>
<td>American Badger</td>
<td><em>Taxidea taxus</em></td>
</tr>
<tr>
<td>Western Spotted Skunk</td>
<td><em>Spilogale gracilis</em></td>
</tr>
<tr>
<td>Common Hog-nosed Skunk</td>
<td><em>Conepatus mesoleucus</em></td>
</tr>
<tr>
<td>Collared Peccary</td>
<td><em>Tayassu tajacu</em></td>
</tr>
<tr>
<td>Pronghorn</td>
<td><em>Antilocapra americana</em></td>
</tr>
</tbody>
</table>

**(now extinct in Texas)**

**(relict population in the Big Thicket probal extinct)**

**(now extinct in Rio Grande Plains)**

**MAMMALS OCCURRING PRINCIPALLY EAST OF THE 100TH MERIDIAN:**

<table>
<thead>
<tr>
<th>Mammal Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elliot’s Short-tailed Shrew</td>
<td><em>Blarina hylophaga</em></td>
</tr>
<tr>
<td>Least Shrew</td>
<td><em>Cryptotis parva</em></td>
</tr>
<tr>
<td>Eastern Mole</td>
<td><em>Scalopus aquaticus</em></td>
</tr>
<tr>
<td>Eastern Pipistrelle</td>
<td><em>Pipistrellus subflavus</em></td>
</tr>
<tr>
<td>Northern Yellow Bat</td>
<td><em>Lasiurus intermedius</em></td>
</tr>
<tr>
<td>Evening Bat</td>
<td><em>Nycticeius humeralis</em></td>
</tr>
<tr>
<td>Nine-banded Armadillo</td>
<td><em>Dasypus novemcinctus</em></td>
</tr>
<tr>
<td>Eastern Fox Squirrel</td>
<td><em>Sciurus niger</em></td>
</tr>
<tr>
<td>Northern Pygmy Mouse</td>
<td><em>Baiomys taylori</em></td>
</tr>
<tr>
<td>Eastern Woodrat</td>
<td><em>Neotoma floridana</em></td>
</tr>
<tr>
<td>Woodland Vole</td>
<td><em>Microtus pinetorum</em></td>
</tr>
<tr>
<td>Common Muskrat</td>
<td><em>Ondatra zibethicus</em></td>
</tr>
<tr>
<td>Red Wolf</td>
<td><em>Canis rufus</em></td>
</tr>
<tr>
<td>Mink</td>
<td><em>Mustela vison</em></td>
</tr>
<tr>
<td>Eastern Spotted Skunk</td>
<td><em>Spilogale putorius</em></td>
</tr>
<tr>
<td>Jaguar</td>
<td><em>Panthera onca</em></td>
</tr>
</tbody>
</table>

**(has spread to Plains regions)**

**(also in Canadian, Pecos, and Rio Grande drainages)**

**(now extinct in Texas)**

Five species of mammals (all rodents) are unique to Texas in the sense that most, or all, of their known geographic range is confined to the mainland part of the state. These are:

*Dipodomys elator* — known from a few counties in the mesquite plains of north-central
Texas and one county in Oklahoma;

*Dipodomys compactus* — known from the barrier islands of Texas and Tamaulipas, Mexico, and the South Texas Plains;

*Geomys attwateri* — known from East Texas (between the Brazos and San Antonio rivers);

*Geomys personatus* — known from the barrier islands of Texas and Tamaulipas, Mexico, and the South Texas Plains; and

*Geomys texensis* — known from eight counties in the Texas Hill Country.

There are three species of mammals (*Diphylla ecaudata, Myotis lucifugus, Myotis septentrionalis*) whose occurrence in Texas may be regarded as accidental. Resident breeding populations of these species probably never existed within the state. The Texas records for all three are far outside of their main range and only a single record exists for each in the state. Furthermore, all three are b which are well known for their wandering movements.

Other topics under Texas Mammals:

Diversity of Land Mammals
Critical Species
Conservation Strategies
Key to the Major Groups (Orders) of Mammals in Texas
CONSERVATION STRATEGIES

The 20th century has proven as significant for changes made by humans in the landscape — its soils, waters, atmosphere, climate, habitats, and wildlife — as for its technological advancements. The risks as we progress toward the 21st century are not just with extinction or restriction of wildlife; there are serious economic ramifications associated with the continued loss of biological diversity. As species disappear, man’s capacity to maintain and enhance agricultural, forest, and rangeland productivity decreases. And with the degradation of ecosystems, the valuable services that natural and semi-natural systems provide will be lost.

It seems inevitable that the 21st century will be as different from today’s world as the current one has been from the 19th century, perhaps more so given the accelerating pace of change in lifestyle and technology. The next hundred years is likely to decide the future of wildlife in Texas and other states. Decisions will be made, directly or indirectly, as to how much and what kind of nature survives. Conservation pressures in the next century will come from a variety of sources. Habitat loss and degradation are the most important causes of wildlife decline, but overharvesting and poaching, trade in wild animal products, introduction of exotic species, pollution from pesticides and herbicides, and other causes also take a significant toll. Global warming or climate change could exacerbate the loss and degradation of biodiversity by increasing the rate of species extinction, changing population sizes and species distributions, modifying the composition of habitats and ecosystems, and altering their geographic extent.

Essentially the problem involves proliferating human populations and associated land conversion which is powerfully changing the form and shape of the landscape. People now constitute a pressure on the global environment that is evident everywhere. There are no longer any unoccupied frontiers; every square centimeter of the earth’s surface is affected by the activities of human beings. This results in insufficient habitat for many species or situations in which habitats are isolated in separate pieces too small or too unstable to sustain viable populations of species and thus biological diversity. The theory of biogeography reveals that species richness is a function of land area. All environmental variables being equal, the greater the area, the more species it supports. Thus, as habitats are fragmented and isolated into small islands, they lose the capacity to support wildlife diversity.

Texas has a great treasure in its mammalian fauna which provides our citizens with important recreational, commercial, aesthetic, and scientific values. We are home to more than 20% of the nation’s total deer population, over three-quarters of the carnivore species, and all but 10 species of bats that occur in the United States. The question is whether or not these resources can be sustained in the future. For this to happen, we must employ several conservation strategies. It has become clear in most cases that single approaches will not work successfully to conserve wildlife diversity. We must build long-range thinking and planning into conservation, and we must find ways for diverse groups, including state and federal agencies, academic institutions, private landowners and organizations, and public groups to network and explore new collaborative ventures that bring separate approaches together in a complementary way. The challenge is daunting. We face a monumental task, far beyond our existing abilities. But now is the time to look ahead, coordinate and plan, before our options are further narrowed.
There are presently about 100 areas in Texas that potentially could serve as biological reserves for the protection of species and the supporting environment. These include national parks, forests, preserves, and recreation areas; national wildlife refuges; state wildlife management areas; state parks; private wildlife foundations; and lands owned by private conservation organizations (for example, Nature Conservancy, Sierra Club, and Audubon Society). Over one million hectares of land are contained in these units which are distributed throughout the state and provide habitat for most Texas mammals.

While protected areas play a key role in the preservation of natural diversity, their ability to preserve our mammalian fauna is limited and sometimes overestimated. Their capacity for preservation is restricted by a number of internal and external factors. First, the parks and preserves of Texas are scattered throughout the state, but the geographical distribution is far from proportional. Thus, they poorly represent many of the natural areas in Texas, such as native grasslands and prairies. Second, most protected areas are too small and widely scattered to effectively preserve biological diversity. A recent publication in the scientific journal *Nature* concluded that the 14 largest national parks in western North America were too small to retain an intact mammalian fauna. No protected area in Texas is as large as the smallest of the 14 parks used in that study. Thus, a major goal of conservation must be to expand the number of protected areas to include a cross-section of all major ecosystems in the state and to link these areas via conservation corridors so they are more effective.

Protected areas alone, however, will not be sufficient to conserve mammalian diversity in Texas. To be effective in the long term, conservation strategies must consider the needs of local residents to maintain or enhance their quality of life. For this reason, conservation-based rural development is indispensable to any successful conservation strategy in Texas. With almost 98% of the state in private land, it will not be possible to conserve mammalian diversity in Texas without the support and participation of landowners. Why? — because the vast majority of wildlife habitat in Texas is privately owned. In order to retain the stability and diversity of this habitat, it must be managed and utilized by landowners in an economically and ecologically viable manner. A system of responsible wildlife management, sportsmanship, and land ethics must be developed. Aldo Leopold, the father of American conservation, recognized this more than 50 years ago when he wrote: "We need to recognize the landowner as the custodian of public game on all private lands ... and compensate him for putting his land in productive condition .... In short, make game management a partnership enterprise to which landowner, the sportsman, and the public each contribute appropriate services, and from which each derive appropriate rewards."

A basic weakness in a conservation system based wholly on economic motives is that most species of a land community have no economic value. Without a land ethic and a stewardship concern for the diversity and integrity of the land, landowners will favor those management practices which make the most money without a consideration of the whole biotic system. Landowner rights and wildlife management, including the protection of endangered species, can and must be integrated to achieve effective conservation of mammals in Texas. We must learn to manage the landscape for sustained local diversity, maintenance of ecosystem function, and renewable yields of natural resources for economic development.

We also must improve our biological knowledge about mammals. We know precious little of the life history of most mammals in Texas. In fact, for many species, our knowledge is insufficient to even accurately assess their status. Decisions as to whether a species is threatened, rare, or endangered are often based entirely on biological "guesswork" without
proper knowledge of the population dynamics, reproduction, food habits, or behavior of the species considered. Future research efforts, whether they involve biologists working for state and federal agencies or scientists associated with academic institutions, should focus on correcting this problem.

Conserving wildlife, which recognizes neither ownership or boundaries, calls for good science, first-rate technology, excellent management, and a broad constituency willing to make some concessions to save it. Whether we act, and how, will depend on factors such as politics, education, socioeconomics, recreation interests, and planning capabilities. Broad-based conservation education programs, designed to diffuse conservation information to the public, must become an important priority. Without understanding of the need for action, and without commitment to that action, citizens will not contribute to the effort, nor will they cooperate with those so engaged. People must be educated to understand what the continuation — or destruction — of wildlife means to their future and that of their descendants, and they must be persuaded to act on their resulting concern in ways respectful to the diversity of wildlife and to their own cultural values.

Other topics under Texas Mammals:

Diversity of Land Mammals
Geographic Distribution of Land Mammals
Critical Species
Key to the Major Groups (Orders) of Mammals in Texas
The Mammals of Texas - Online Edition

KEY TO THE MAJOR GROUPS
(ORDERS) OF MAMMALS IN TEXAS

This key, like those on the pages detailing individual Orders, may be used in the standard manner, or you may advance to the next appropriate section by clicking on the highlighted number or name at the end of a subsection.

1. Body covered dorsally, and tail completely, by bands of bony plates; snout tapering and lacking teeth anteriorly; eight peglike teeth on each side of upper and lower jaws: Order Xenarthra (armadillos, sloths, and allies).
   - Not as above: 2

2. Body torpedo-shaped; hind legs absent; front limbs developed into paddles; hairless or nearly so; live in ocean or coastal waters: 3
   - Not as above: 4

3. Body ending in a broad, horizontally flattened, rounded fluke; no dorsal fin; muzzle squarish, covered with stout bristles; short bristlelike hairs scattered sparingly over rest of body; nostrils terminal; length 2.5 to 4.5 m: Order Sirenia (manatee and allies).
   - Body ending in horizontal, expanded (not rounded) flukes; blowhole (nostrils) on top of head; most Texas forms with dorsal fin; length 2.5 to 30 m: Order Cetacea (whales, porpoises, and dolphins).

4. Hand and arm developed into leathery wing: Order Chiroptera (bats).
   - Hand and arm normal, not developed into a wing: 5

5. Hoofed mammals; two or four toes on each foot: Order Artiodactyla (even-toed ungulates).
   - Toes usually armed with claws, not hoofs: 6

6. Total of 10 upper incisors; big toe of hind foot without claw; tail prehensile: Order Didelphimorphia (opossums).
   - Total of six or less upper incisors; all toes armed with claws; tail not prehensile: 7

7. Snout highly flexible and protruding conspicuously beyond mouth; eyes very small or hidden; length of head and body usually less than 150 mm: Order Insectivora (shrews and moles).
   - Snout normal, or if protruding conspicuously then length of head and body much more than 150 mm; eyes normal: 8

8. Total of two incisors in lower jaw, one on each side: 9
   - Total of four or more incisors in lower jaw (two or three on each side): 10

9. Total of two incisors in the upper jaw, one on each side so that incisor formula is 1/1: Order Rodentia (rodents).
   - Total of four incisors in the upper jaw, two on each side, one in front of the other in tandem; incisor formula 2/1: Order Lagomorpha (hares and rabbits).

10. Marine dwellers, fore and hind limbs developed into flippers; tail normal or vestigial, never developed into flukes: Order Pinnipedia (seals and walruses).
    - Mainly land dwellers, limbs never developed into flippers, but hind feet may have

---

http://www.nsrl.ttu.edu/tmot1/orderkey.htm

10/31/2006
webs between the toes: Order Carnivora (carnivores).

Other topics under Texas Mammals:

Diversity of Land Mammals
Geographic Distribution of Land Mammals
Critical Species
Conservation Strategies
ORDER
DIDELPHIMORPHIA:

OPOSSUM AND ALLIES

Opossums, as a group, are among the oldest, most primitive mammals of the New World. Some scientists call them "living fossils" because they have survived relatively unchanged for at least 50 million years. They are intermediate in many respects between the most primitive of all mammals, the egg-laying monotremes of Australia, and the higher placental mammals. Their chief character is the marsupium or pouch that develops on the abdomen of females. One species occurs in Texas.

Family Didelphidae (opossums)

Virginia Opossum, Didelphis virginiana
Virginia Opossum

Order Didelphimorpha: Family Didelphidae: *Didelphis virginiana* Kerr

**Description.** A mammal about the size of a terrier dog, with long, scaly, prehensile tail; short, black, leathery ears; long, slender snout; five toes on each foot, the "big toe" on hind foot lacking a claw, thumblike and opposable; soles naked; pouch for young developed during breeding season on abdomen of female; pelage of long guard hairs and short soft underfur; two color phases — (1) grayish and (2) blackish; basal fourth or more of tail black, terminal section whitish; legs and feet blackish, toes often white or whitish. Dental formula: I 5/4, C 1/1, Pm 3/3, M 4/4 X 2 = 50. External measurements of males average: total length, 782 mm; tail, 324 mm; hind foot, 66 mm; of females, 710-320-63. Weight, 1.8-4.5 kg; males are usually larger and heavier than females.

**Distribution in Texas.** Occurs statewide except for xeric areas of the Trans-Pecos and Llano Estacado of the Panhandle.

**Habits.** Opossums are primarily inhabitants of deciduous woodlands but are often found in prairies, marshes, and farmlands. In the western part of their native range they generally keep to the woody vegetation along streams and rivers, a habit which permits them to penetrate the otherwise treeless grasslands and deserts of west Texas.

Hollow trees and logs are preferred sites, but opossums will den in woodpiles, rock piles, crevices in cliffs, under buildings, in attics, and in underground burrows. Since they are not adept at digging burrows for themselves they make use of those excavated by other mammals.

Movements of opossums monitored in East Texas showed that these animals typically frequent a home range approximately 4.6 ha in size, although the minimum size of home ranges may vary from 0.12 ha to 23.4 ha. Home ranges tend to overlap considerably. In East Texas woodland habitat the density of opossums is about one opossum every 1.6 ha while in sandy, coastal parts of the state the density is about one opossum every 6 ha.

The opossum is more or less solitary and strictly nocturnal, venturing forth to feed shortly after dark. It feeds on a variety of foods, including rats, mice, young rabbits, birds, insects, crustaceans, frogs, fruits, and vegetables. Analyses of six stomachs from winter-trapped opossums in Texas revealed that the following foods (expressed in percentages) had been eaten: insects (grasshoppers, crickets, beetles, bugs, ants), 62.8; mammals (cottontails), 19.5; birds (sparrow family), 15.5; reptiles (lizards and snakes), 1.0; mollusks (snails), 1.0;
crustacea (crayfish), 0.2. In June the food for four opossums was about the same except that fruits and berries were added and birds were lacking.

Their mating season extends from January or February to June or July. Females, which are in heat for about 30 days, breed the first season following birth. The mating period is not longer than 36 hours and terminates with copulation, which is done in a manner similar to dogs. Young opossums have been observed as early as January 24 and as late as August 15. Usually two litters are produced — in February and June. The young, five to 21 in number, are born after a gestation of 11-12 days and each weighs about 3 grams (1/5 of a gram; 1/2,380 of a pound)! Blind, nearly helpless, hardly larger than honey bees, and embryonic in appearance they crawl unaided into the abdominal pouch of the mother, each attaching itself to a nipple. Shortly after a young one begins to nurse, the nipple swells and completely fills its mouth, thereby firmly attaching it to its mother. It remains attached until it is about 7 weeks of age, at which time it has grown large enough to detach itself. This peculiar adaptation compensates in part for the brief period of uterine development and assumes part of the function performed by the placenta in higher mammals. Since the number of teats is seldom more than 13, young born in excess of that number are doomed to die.

Mortality is high during the first year of life, and population turnover is relatively rapid. Known predators include foxes, coyotes, horned owls, and barred owls. Opossums are commonly seen killed on highways. The normal lifespan may be as low as 2 years.

The opossum is the second most commonly harvested furbearing animal in Texas, but the value of its pelt is low. During the period 1976 to 1982 the average value of an opossum pelt was only $1.83. Many trappers do not consider opossums worth "skinning out." Their fur is used primarily for trim on less expensive coats and hats.

Photo credits: John L. Tveten (top), John Wood (bottom).
ORDER INSECTIVORA:

SHREWS AND MOLES

The name insectivora (insect eater) has reference to the food habits of the group as a whole. Although moles and shrews are not all strictly insectivorous, insects and other small animal life constitute the chief dietary items of most members of the group. Some kinds, the otter shrews of Africa and the star-nosed mole of America, for example, feed also upon fish. The Townsend mole of the Pacific Northwest often is a nuisance to bulb growers because of its fondness for the bulbs of many kinds of plants.

Moles, as a group, are subterranean in habit and spend most of their lives in the darkness of underground tunnels which they usually excavate for themselves. Correlated with this fossorial habit, the eyes of all moles are very small, in some species actually not opening to the outside, and of little value to them. On the other hand, their senses of touch and smell are highly developed.

Most American shrews live on the surface of the ground and occupy burrows only for sleeping or resting. Most of them have a decided preference for damp or boggy habitats where rank vegetation, surface litter, rocks, or rotting logs afford adequate protection. Some species, notably the desert shrew, are adapted to the arid regions of our western deserts. At the opposite extreme are the water shrew and the marsh shrew, neither of which occurs in Texas.

Shrews and moles are active throughout the year; the former often tunnel through snow or walk on top of it in search of food. Some species, notably the short-tailed shrew, store food for winter use, but this habit is not common. Surprisingly little is known regarding the habits of many species. The exact gestation period is not known for most species, and practically nothing is known about the growth and development of the young except that "they grow rapidly" and reach adult proportions in about 6 weeks. The length of life of shrews is thought to be less than 2 years, but specific information is lacking.

One species of mole and four species of shrews occur in Texas.

Family Soricidae (shrews)

Southern Short-tailed Shrew, Blarina carolinensis
Elliot's Short-tailed Shrew, Blarina hylophaga
Least Shrew, Cryptotis parva
Desert Shrew, Notiosorex crawfordi

Family Talpidae (moles)

Eastern Mole, Scalopus aquaticus
KEY TO THE INSECTIVORES OF TEXAS

1. • Front feet broad and paddle-shaped; eyes non-functional: *Scalopus aquaticus* (eastern mole).
   • Front feet normal, not paddle-shaped; eyes small, but functional: 2
2. • Total number of teeth 30 or 32; ears nearly hidden in the fur; tail short, less than twice as long as hind foot: 3
   • Total number of teeth 28; ears rather conspicuous; tail more than twice as long as hind foot; total length about 80 mm: *Notiosorex crawfordi* (desert shrew).
3. • Total number of teeth 30; four upper unicuspids, with only three readily visible in lateral view; color of dorsum brownish or brownish gray: *Cryptotis parva* (least shrew).
   • Total number of teeth 32; five upper unicuspids, with four readily visible in lateral view; color of dorsum dark slate to sooty black or tinged with brown: 4
4. • Restricted to the pine-oak forest and pine forest regions in the eastern one-third of the state; pelage dark gray but often tinged with brown; cranial breadth usually less than 10.5 mm. *Blarina carolinensis* (southern short-tailed shrew).
   • Known only from three counties in the central and coastal regions of the state; pelage not tinged with brown; cranial breadth usually greater than 10.5 mm. *Blarina hylophaga* (Elliot’s short-tailed shrew).
Southern Short-tailed Shrew

Order Insectivora: Family Soricidae: Blarina carolinensis (Bachman)

**Description.** A rather robust, short-legged, short-tailed shrew with long, pointed, protruding snout; external ears short and nearly concealed by the soft, dense fur; tail less than half the length of head and body, usually less than twice as long as hind foot; upperparts dark slate to sooty black; underparts paler; tail black above, paler below. Dental formula: I 4/2, C 1/0, Pm 2/1, M 3/3 X 2 = 32. External measurements average: total length, 88 mm; tail, 17 mm; hind foot, 11 mm. Weight, 18-28 g.

**Distribution in Texas.** Eastern one-fourth of the state with a recent, disjunct record from Bastrop State Park (Bastrop County).

**Habits.** Short-tailed shrews occur in forested areas and their associated meadows and openings. Adequate cover and food appear to be more important in determining their presence than type of soil or vegetation.

Their burrows usually occupy two zones, one several centimeters below the surface or directly upon it and the other at a deep level, often 40-60 cm below the surface. These two levels are joined at irregular intervals. Frequently, their runs follow just beneath a log, sometimes penetrating and honeycombing the log if it is rotten and easily worked.

These creatures are short-legged and slow of gait but they always seem to be in a hurry, running along with their tails elevated at an angle. A slow-walking person can easily overtake them. They are well adapted for digging; the front feet are wide, strong, and slightly larger than the hind feet. Burrowing is accomplished by the combined use of forefeet, head, and nose. Timed individuals were capable of burrowing at the rate of about 30 cm a minute in soft soil.

Like the least shrew (Cryptotis), Blarina seem to be more sociable than long-tailed shrews. Several individuals seem to use a common burrow system and seldom do they fight when two or more are placed in a cage. It appears certain that the male and female remain together during the prebreeding season.

The food habits of these shrews are strangely unshrewlike in that they consume relatively large quantities of vegetable matter (nuts, berries, and so forth). Analyses of more than 400 stomachs from East Texas revealed the following items (expressed in percentages of occurrence): insects 77.6; annelids, 41.8; vegetable matter, 17.1; centipedes, 7.4; arachnids, 6.1; mollusks (mostly snails), 5.4; vertebrates (mice and salamanders), 5.2; crustacea (mostly sowbugs), 3.7; undetermined matter, 2.4. There is considerable evidence that Blarina stores
snails for winter use.

An interesting feature of this shrew is the poison produced by the submaxillary glands, which is present in the saliva and may be introduced into wounds made by the teeth. Injections of 6 mg of an extract prepared from the submaxillary gland are strong enough to kill mice but there is little likelihood of the venom having any serious effect on man.

The breeding season of *Blarina* extends from February through September. There appear to be two and possibly three litters of five to seven young produced in this period. The gestation period is probably between 21 and 30 days. The young are pink, blind, and helpless at birth, and they weigh slightly more than 1 g. They are relatively slow in developing; the eyes of young born in captivity were still closed on the 22nd day. The young are born in a special nest of grasses and other dry vegetation under a rotten log or stump or under the ground. In each instance entrance to it is gained by way of an underground tunnel. These nests are much larger than the more commonly found "resting" nests. Records indicate that very few of these shrews attain an age of 2 years.

Since the reproductive potential is high in this shrew, one can assume that its natural enemies are many. Known predators include the milk snake, black snake, red-tailed hawk, red-shouldered hawk, sparrow hawk, broadwinged hawk, barn owl, short-eared owl, barred owl, horned owl, long-eared owl, screech owl, fox, weasel, and skunk. Doubtless, others could be added to the list.

*Photo credit: John L. Tveten.*
Eastern Mole
Order Insectivora : Family Talpidae : *Scalopus aquaticus* (Linnaeus)

**Description.** A relatively small, robust, burrowing mammal with broadened, shovel-like front feet webbed to base of claws; no visible eyes or ears; sharp-pointed nose; plushlike fur; and short, sparsely haired tail. Dental formula: I 3/2, C 1/0, Pm 3/3, M 3/3 X 2 = 36; middle upper incisors enlarged; canines small and undifferentiated; molars with W-shaped outline when viewed from biting surface. Color brown, often with silvery sheen, with suffusion of orange on nose and wrists; underparts silvery gray, faintly washed with orange. External measurements average: total length, 165 mm; tail, 29 mm; hind foot, 22 mm. Weight, 60-90 g.

**Distribution in Texas.** Eastern two-thirds of the state, including eastern portions of South Texas. In northern Panhandle extends to New Mexico line along Canadian River drainage. Isolated record from Presidio County.

**Habits.** Moles spend most of their life in underground burrows they excavate for themselves or usurp from other mammals, particularly pocket gophers (genus *Geomys*). Because of this, they are restricted in their distribution by the nature of the soil. In Texas, they occur largely in moist (not wet), sandy soils. Deep, dry sands and heavy clays are avoided.

Two types of underground burrows are used: (1) the shallow surface run, which is associated with food-getting activities, and (2) the deep burrow for protection and rearing of the young. The deep burrow is marked by conical mounds of earth the occupant has pushed to the surface, whereas the shallow burrow is marked by a meandering ridge of earth pushed up by the mole as it "swims" through the loose topsoil. Moist, well-drained fence rows, terraces, lawns, and knolls rich in organic matter are favored areas for surface burrows because in these localities food is more abundant. Certain of the surface burrows are used frequently as highways; others, especially intricate side branches, are used but once in the food-getting process and are then allowed to collapse.

Moles cannot see and spend almost all of their time underground. They may be found active at any hour of the day but generally are more active by day than by night in response to the movement of earthworms in and out of the soil. Also, they are active throughout the year.

The mole excavates its burrow by backward strokes and lateral thrusts of the front feet. Loose earth is moved and pushed to the surface by thrusts of the front feet. In excavating shallow runs the earth is merely pushed up to form a ridge, again by lateral thrusts of the front feet while the mole is turned partly on its side.
The home range of individual moles consists of several "hunting grounds" galleried with surface burrows on knolls, terraces, or along fence rows — all of them connected by a single long burrow. One burrow along a fence row in Van Zandt County was 360 m long. Such systems may be in continual use for as long as 5 years, either by one mole or by successive occupants. At times, moles travel overland in search of new locations or, perhaps, of mates. This is evidenced by the occasional appearance of dead moles on the highways.

Throughout most of the year moles are solitary but in late winter and early spring males seek out females. In south-central Texas, the breeding season begins in February, as evidenced by the large testes of males and the swollen uteri of females. Although the breeding period may last from 3-4 months, peak activity occurs in a short period of 3-4 weeks. A single litter of two to five young is produced each year. The gestation period is about 4-6 weeks. The young are born hairless, but otherwise are miniature adults. Females reach sexual maturity in 1 year.

Moles feed largely on earthworms and grubs, although beetles, spiders, centipedes, insect larvae and pupae, and vegetable matter may also be eaten. In captivity, they have consumed mice, small birds, and ground beef.

The average daily food consumption is about 32% of the body weight of the animal, although a mole can consume more than 66% of its body weight in 18 hours. Active prey is killed by crushing it against the sides of the burrow with the front feet or by piling loose earth on the victim and biting it while thus held. Captive moles kill earthworms by biting them rapidly in several places, often nearly cutting the worm in two.

Moles do damage by their burrowing activities, especially on the greens of golf courses, in lawns, and in situations where accelerated soil erosion may result. Also, they may destroy row crops by burrowing along a row and killing the plants. It must be kept in mind, however, that the mole usually is searching out animal food and that often the larval insects taken do far more actual damage to the vegetation than does the mole. Larval June beetles, for example, feed on the roots of grasses and may, if present in large numbers, completely destroy the sod in an area. The burrowing activities of the mole also tend to aerate the soil, with beneficial results to plants.

*Photo credit: John L. Tveten.*
ORDER XENARTHRA:

ARMADILLOS, SLOTHS, AND ALLIES

This Order seems to have developed in South America and only recently invaded North America. Its members are bizarre creatures and highly specialized in structure and habits. The toothless anteaters are provided with heavy claws to tear apart termite nests and a long, slender, prehensile, sticky tongue to capture the insects. The slow-moving, plant-eating sloths are tree dwellers, with a rudimentary tail and only two or three toes on each foot. In the large group of armadillos, the presence of a bony carapace is unique among mammals.

The Order is divided into three families, all of which are restricted to Central and South America with the exception of one species, the nine-banded armadillo, which ranges north to the United States.

Family Dasypodidae (armadillos)  

Nine-banded Armadillo, *Dasypus novemcinctus*
The Mammals of Texas - Online Edition

Nine-banded Armadillo

Order Xenarthra : Family Dasypodidae : Dasypus novemcinctus (Linnaeus)

Description. About the size of a terrier dog, upperparts encased in a bony carapace with large shields on shoulders and rump and nine bands in between; front feet with four toes, middle two longest; hind foot five-toed, the middle three longest, all provided with large, strong claws; tail long, tapering and completely covered by bony rings; color brownish, the scattered hairs yellowish white. There are 30 or 32 peglike teeth. External measurements average: total length, 760 mm; tail, 345 mm; hind foot, 85 mm. Weight of adult males, 5-8 kg; females, 4-6 kg.

Distribution in Texas. Occurs throughout much of the state; absent from the western Trans-Pecos.

Habits. Soil texture exerts a definite influence upon the number of armadillos present in a given area. Those soils that are more easily dug, other factors being equal, will support a greater population density. In the sandy soils of Walker County, a population density of about one armadillo to 1 ha is common; in Brazos County, where the soils are more heavily impregnated with clay and become packed during the dry seasons, density averages one to 4 ha. In the rocky terrain of the Edwards Plateau, the animals tend to concentrate in the alluvial stream bottoms and den in the cracks and crevices of the numerous limestone outcroppings in that area. In the blackland section of Texas, where the soils are heavy clays, the animals are extremely rare and restricted to the vicinity of streams where they can burrow into the banks and probe for food in the relatively soft soils near water. Perhaps the most important factor contributing to the distribution of armadillos is the hardness of the soil during the dry season, because the food of the animal is obtained largely by probing for insects and other forms of animal life in the ground.

Armadillos are fond of water; where climatic conditions tend to be arid, the animals concentrate in the vicinity of streams and water holes. Tracks in the mud around small ponds give evidence that the armadillos visit them not only for purposes of drinking and feeding, but also to take mud baths. Excess water, however, has a limiting effect on them because they avoid marshy areas.

Few animals of comparable size have so many dens per individual as the armadillo. The length, depth, and frequency of occurrence of their burrows depend somewhat upon soil conditions. In sandy areas the animals are extremely active diggers; in addition to numerous
occupied burrows, one finds many that have been abandoned or are used only occasionally as shelters. In central Texas, the majority of their dens are along creek banks whereas in the sandy soils of eastern Texas they are found almost everywhere. On the coastal prairies the sandy knolls are especially sought as den sites more because of protection from floods than because of ease of digging. In the Edwards Plateau natural caves, cracks, and crevices among the limestone outcroppings afford abundant shelter; excavated burrows are few in number and usually shallow.

Dens vary from 1 to 5 m in length and from a few centimeters below the surface to a depth of 1.3 m. Averaging between 17 and 20 cm in diameter, their plan is usually simple, with few turns except those caused by obstacles such as roots, rocks, and so forth. Many of the shallow burrows serve as food traps in which insects and other invertebrates take refuge and to which the armadillo goes on his foraging excursions. Burrows that are used for breeding purposes usually have a large nest chamber 45 cm or more in diameter and containing the rather loosely constructed nest of dried leaves, grasses, and other plant items. These materials are merely stuffed into the chamber and the animal pushes its way in and out each time the nest is used. Usually, each occupied burrow is inhabited by only one adult armadillo.

Because of their almost complete lack of hairy covering, armadillos are easily affected by climatic conditions. In the summer season they are more active in the cool of the evening and at night, but in midwinter their daily activities are reversed and the animals become active during the warmest part of the day, usually in mid-afternoon. They do not hibernate nor are they equipped to wait out long periods of inclement weather. Long periods of freezing weather effectively eliminate armadillos from an area.

Of special interest is the behavior of this animal in the water. Its specific gravity is high and the animal normally rides low in the water when swimming. Apparently, it tires easily when forced to swim for any distance. If the stream to be crossed is not wide, the armadillo may enter on one side, walk across the bottom, and emerge on the other side. If the expanse of water to be traversed is of considerable extent, the animals ingest air, inflate themselves, and thus increase their buoyancy. The physiological mechanism by which the armadillo can ingest air and retain it in its digestive tract to increase buoyancy is not known, but it appears to be under voluntary control.

Many legends have arisen concerning the food habits of armadillos. Among the rural folks in the South they are commonly called "gravediggers" and are thought to dig into human graves and dine upon the contents. Also, they have quite a reputation as a depredator of quail, chicken, and turkey eggs. A study of their food habits by examination of more than 800 stomachs revealed that no fewer than 488 different food items are eaten. Ninety-three percent (by volume) of their food is animal matter, chiefly insects and other invertebrates. Among the insects, nearly 28% were larval and adult scarab beetles — forms that are highly destructive to crops and pastures; termites and ants comprised about 14%; caterpillars nearly 8%; earthworms, millipedes, centipedes, and crayfish appeared conspicuously in their diet at times. Reptiles and amphibians comprised only a small part of their diet; these were captured usually during periods of cold weather. Birds’ eggs were found in only 5 of 281 stomachs.

Observations by field workers strongly indicate that the armadillo, which usually leaves conspicuous signs of its presence, often is accused of the destruction of quail and chicken nests when the culprit is actually some other animal. More than two-thirds of the slightly less than 7% of vegetable matter in the diet was material ingested with other food items and
represents nothing of economic importance. Berries and fungi made up 2.1% of the entire diet. Reports indicate that at times the armadillo may feed on such fruits as tomatoes and melons but the amount of damage done to these crops is relatively small. Carrion is readily eaten when available, and dead carcasses of animals frequently are visited not only for the carrion present but also for the maggots and pupae of flies found on or near them.

Reproduction in the nine-banded armadillo is marked by two distinct and apparently unrelated phenomena: the long period of arrested development of the blastocyst prior to implantation (delayed implantation), and the phenomenon of specific polyembryony, which results in the normal formation of identical quadruplets. In normal years about half of the females become pregnant by the end of July, which is the beginning of the breeding season. At 5-7 days the ovum forms a blastocyst and passes into the uterus. At this point development ceases, and the vesicle remains free in the uterus. Here it is constantly bathed in fluids secreted by the glandular lining of the uterus, which supplies enough nutrition and oxygen for survival. Implantation does not occur until November, about 14 weeks after fertilization. During this process, the blastocyst divides into growth centers, each of which very shortly redvides to produce four embryonic growth centers attached by a common placenta to the uterus. Development of each of the embryos then proceeds normally, and the four young are born approximately 4 months later in March, although some females have been noted with new litters as early as February and as late as the latter part of May. Young are born fully formed and with eyes open. Within a few hours they are walking, and they begin to accompany the mother on foraging expeditions within a few weeks. The nursing period is probably less than 2 months, but the young may remain with the mother even after weaning until they are several months old. Normally the young born in one year mature during the winter and mate for the first time in the early summer of the following year.

This phenomenon of delayed implantation may, in part, account for the successful invasion of the armadillo into temperate regions. Without this characteristic of the reproductive cycle, the young would be born at the beginning of winter, when their chance of survival would be greatly reduced. Apparently, the reproductive cycle is easily affected by adverse environmental conditions, particularly drought conditions. This probably is due to the shortage of ground insects or the difficulty of obtaining these in sandy or hard dried soils.

Armadillos are believed to pair for each breeding season, and a male and a female may share a burrow during the season. Because of the bony carapace and ventral position of the genitalia, copulation occurs with the female lying on her back.

Armadillos are frequently utilized as food in parts of Texas and Mexico. The meat is light-colored and when properly cooked is considered by some the equal of pork in flavor and texture.

Remarks. The common occurrence of this species in eastern Texas is a phenomenon that has developed largely since 1900. When Vernon Bailey published his Biological Survey of Texas in 1905, he mapped the distributorial limits of the armadillo as between the Colorado and Guadalupe rivers with extralimital records from Colorado, Grimes, and Houston counties. By 1914 the armadillo had crossed the Brazos River and moved to the Trinity River, and along the coast had already reached the Louisiana line in Orange County. The northward and eastward range expansions continued over the next forty years, and by 1954 the armadillo was known from everywhere in eastern Texas except Red River and Lamar counties. By 1958 it was known from these latter two counties, and today is abundant everywhere in the region.
Apparently pioneering was most successful in a riparian habitat, and invasion was especially rapid parallel to rivers, which served as dispersal conduits. Average invasion rates have been calculated as from 4 to 10 km per year in the absence of obvious physical or climatic barriers. Possible reasons for the armadillo's northward expansion since the nineteenth century include progressive climatic changes, encroaching human civilization, overgrazing, and decimation of large carnivores.

Photo credit: John L. Tveten.
ORDER CHIROPTERA:

BATS

Chiroptera, "hand wing," alludes to the great elongation of the fingers that support the flying membrane. Among mammals, bats are unique in that they have true powers of flight; other mammals, such as flying squirrels, volplane or glide, always from a higher to a lower elevation.

Bats as a group are crepuscular or nocturnal; their eyes are small and inefficient, but their ears are usually well developed. Experiments suggest that the middle and inner ear and high-frequency vocals are highly important in guiding bats in flight and in their aerial feeding activities. Some bats hibernate in winter; others migrate seasonally.

In the temperate regions, the young are born in late spring; in the tropics there appears to be no definite breeding season — young bats may be found in every month of the year. Most bats feed on insects, but some kinds feed regularly on fruits, nectar, or fish, and some, the vampire bats, are peculiarly adapted to feed on blood.

Bats are nearly worldwide in distribution. The tropical regions are best suited for them, and there the greatest variety is found. The temperate regions are inhabited by fewer species; no bats have been recorded in the Arctic and Antarctic regions. Thirty-two species of bats occur in Texas.

In addition to the 32 species of bats living in Texas today, four others are known from fossil skeletal remains. One of these, Myotis rectidentis, is extinct, but the other three — Myotis evotis, Macrotoius californicus, and Desmodus rotundus — still occur in other parts of the continent. The range of Myotis evotis includes almost all of the western United States from the Great Plains westward; the leaf-nosed bat Macrotoius occupies a range from the southern parts of Arizona, Nevada, and California southward into Mexico; and Desmodus, the common vampire, occurs in Mexico and has been found recently about 200 km south of the Texas border near Jimenez, Tamaulipas. Intensive search may reveal the presence of both Macrotoius and Desmodus in Texas.

Family Mormoopidae (mormoopid bats)

Ghost-faced Bat, Mormoops megalophylla

Family Phyllostomidae (leaf-nosed bats)

Mexican Long-nosed Bat, Leptonycteris nivalis
Mexican Long-tongued Bat, Choeronycteris mexicana
Hairy-legged Vampire, Diphylia ecaudata
Family Vespertilionidae (vespertilionid bats)

Southeastern Myotis, *Myotis australiopitius*
California Myotis, *Myotis californicus*
Western Small-footed Myotis, *Myotis ciliolabrum*
Little Brown Myotis, *Myotis lucifugus*
Northern Myotis, *Myotis septentrionalis*
Fringed Myotis, *Myotis thysanodes*
Cave Myotis, *Myotis velifer*
Long-legged Myotis, *Myotis volans*
Yuma Myotis, *Myotis yumanensis*
Silver-haired Bat, *Lasionycteris noctivagans*
Western Pipistrelle, *Pipistrellus hesperus*
Eastern Pipistrelle, *Pipistrellus subflavus*
Big Brown Bat, *Eptesicus fuscus*
Western Red Bat, *Lasiusus blossevillii*
Eastern Red Bat, *Lasiusus borealis*
Hoary Bat, *Lasiusus cinereus*
Southern Yellow Bat, *Lasiusus ega*
Northern Yellow Bat, *Lasiusus intermedius*
Seminole Bat, *Lasiusus seminolus*
Evening Bat, *Nycticeius humeralis*
Spotted Bat, *Euderma maculatum*
Rafinesque's Big-eared Bat, *Plecotus rafinesquii*
Townsend's Big-eared Bat, *Plecotus townsendii*
Pallid Bat, *Antrozous pallidus*

Family Molossidae (free-tailed bats)

Brazilian Free-tailed Bat, *Tadarida brasiliensis*
Pocketed Free-tailed Bat, *Nyctinomops femorosacca*
Big Free-tailed Bat, *Nyctinomops macrotis*
Western Mastiff Bat, *Eumops perotis*

**KEY TO THE BATS OF TEXAS**

1. • Distinct, upwardly and freely projecting, triangular-shaped nose leaf at end of elongated snout: 2
   • Nose leaf absent, indistinct, or modified as lateral ridges or low mound-like structure; snout normal: 3

2. • Tail evident, projecting about 10 mm from dorsal side of interfemoral membrane; distance from eye to nose about twice distance from eye to ear; forearm less than 48 mm: *Choeronycteris mexicana* (Mexican long-tongued bat).
   • Tail not evident; eye about midway between nose and ear; forearm more than 48 mm: *Leptonycteris nivalis* (Mexican long-nosed bat).

3. • Thumb longer than 10 mm; hair straight, lying smoothly, glossy tipped: *Diphylla ecaudata* (hairy-legged vampire).
• Thumb less than 10 mm; hair slightly wooly, pelage lax, not usually lying smoothly, not glossy tipped: 4

4. • Prominent grooves and flaps on chin; tail protruding from dorsal surface of interfemoral membrane: Mormoops megalophylla (ghost-faced bat).
  • No notable grooves or flaps on chin; lumps above nose or wrinkled lips possible, most faces lacking even these characteristics; tail extending to or beyond the edge of the interfemoral membrane: 5

5. • Tail extending conspicuously beyond free edge of interfemoral membrane: 6
  • Tail extending to free edge of interfemoral membrane: 9

6. • Forearm more than 70 mm; upper lips without deep vertical grooves: Eumops perotis (western mastiff bat).
  • Forearm less than 70 mm; upper lips with deep vertical grooves: 7

7. • Forearm less than 52 mm: 8
  • Forearm more than 52 mm (58-64): Nyctinomops macrotis (big free-tailed bat).

8. • Ears not united at base; second phalanx of fourth finger more than 5 mm: Tadarida brasiliensis (Brazilian free-tailed bat).
  • Ears joined at base; second phalanx of fourth finger less than 5 mm: Nyctinomops femorosacca (pocketed free-tailed bat).

9. • Ears proportionally large, more than 25 mm from notch to tip: 10
  • Ears of normal size, less than 25 mm from notch to tip: 13

10. • Color black with three large white spots on back, one just behind each shoulder, the other at the base of the tail: Euderma maculatum (spotted bat).
  • Color variable, but not black; no white spots on back: 11

11. • Dorsal color pale yellow; no distinctive glands evident on each side of the nose. Antrozous pallidus (pallid bat).
  • Dorsal color light brown to gray; distinctive glands (large bumps) evident on each side of the nose: 12

12. • Hairs on belly with white tips; strong contrast in color between the basal portions and tips of hairs on both back and belly; presence of long hairs projecting beyond the toes; known from eastern one-third of state: Plecotus rafinesquii (Rafinesque’s big-eared bat).
  • Hairs on belly with pinkish buff tips; little contrast in color between basal portions and tips of hairs on both back and belly; absence of long hairs projecting beyond the toes; known from western half of state: Plecotus townsendii (Townsend’s big-eared bat).

13. • At least the anterior half of the dorsal surface of the interfemoral membrane well furred: 14
  • Dorsal surface of interfemoral membrane naked, scantily haired, or at most lightly furred on the anterior third: 20

14. • Color of hair black, with many of the hairs distinctly silver-tipped: Lasionycteris noctivagans (silver-haired bat).
  • Color various, but never uniformly black: 15

15. • Color yellowish: 16
  • Color reddish, brownish, or grayish (not yellowish): 17

16. • Total length more than 120 mm: Lasiurus intermedius (northern yellow bat).
  • Total length less than 120 mm: Lasiurus ega (southern yellow bat).

17. • Forearm more than 45 mm; color wood brown heavily frosted with white: Lasiurus
cinereus (hoary bat).
- Forearm less than 45 mm; upper parts reddish or mahogany: 18
- Upper parts brick red to rusty red, frequently washed with white: 19
- Upper parts mahogany brown washed with white: Lasiurus seminolus (Seminole bat).
- Color reddish with frosted appearance resulting from white-tipped hairs; interfemoral membrane fully haired: Lasiurus borealis (eastern red bat).
- Color rusty-red to brownish without frosted appearance; posterior one-third of interfemoral membrane bare or only scantily haired: Lasiurus blossevillii (western red bat).

18. Tragus (projection within ear) short, blunt, and curved: 21
- Tragus long, pointed, and straight: 23

21. Forearm more than 40 mm: Eptesicus fuscus (big brown bat).
- Forearm less than 40 mm: 22

22. Forearm more than 32 mm; interfemoral membrane naked; color brown: Nycticeius humeralis (evening bat).
- Forearm less than 32 mm; interfemoral membrane lightly furred on anterior third of dorsal surface; color drab to smoke gray: Pipistrellus hesperus (western pipistrelle).

23. Dorsal fur tricolored when parted (black at base, wide band of light yellowish-brown in middle, tipped with slightly darker contrasting color); leading edge of wing membrane noticeably paler than rest of membrane: Pipistrellus subflavus (eastern pipistrelle).
- Dorsal fur bicolored or unicolored with no light band in the middle; leading edge of wing same color as other parts of membrane: 24

24. Calcar with well-marked keel: 25
- Calcar without well-marked keel: 27

25. Forearm more than 36 mm; foot more than 8 mm long; underside of wing furred to elbow; pelage dark brown: Myotis volans (long-legged myotis).
- Forearm less than 36 mm; foot less than 8 mm long; underside of wing not furred to elbow; pelage light brown to buff brown: 26

26. Hairs on back with dull reddish-brown tips; black mask not noticeable; thumb less than 4 mm long; naked part of snout about as long as the width of the nostrils when viewed from above: Myotis californicus (California myotis).
- Fur on back with long, glossy, brownish tips; black mask usually noticeable; thumb less than 4 mm long; naked part of snout approximately 1.5 times the width of the nostrils: Myotis ciliolabrum (western small-footed myotis).

27. Forearm more than 40 mm: 28
- Forearm usually less than 40 mm: 29

28. Conspicuous fringe of stiff hairs on free edge of interfemoral membrane: Myotis thysanodes (fringed myotis).
- No conspicuous fringe of stiff hairs on free edge of interfemoral membrane: Myotis velifer (cave myotis).

29. In Texas occurring west of 100th meridian: 30
- In Texas occurring east of 100th meridian: 31

30. Dorsal fur usually with a slight sheen; forearm more than 36 mm; total length more than 80 mm: Myotis lucifugus (little brown myotis).
- Dorsal fur usually lacking a sheen; forearm less than 36 mm; total length less than
80 mm: *Myotis yumanensis* (Yuma myotis).

31. • Ear more than 16 mm, extending more than 2 mm beyond nose when laid forward; tragus long (9-10 mm), thin, and somewhat sickle-shaped: *Myotis septentrionalis* (northern myotis).
• Ear less than 16 mm, not extending more than 2 mm beyond nose when laid forward; tragus shorter and straight: *Myotis austroriparius* (southeastern myotis).
Southeastern Myotis
Order Chiroptera: Family Vespertilionidae: *Myotis austroriparius* Rhoads

**Description.** A small bat with dense, dull, woolly fur; upperparts brownish to sooty; fur of underparts with white tips and black bases, the general white appearance contrasting sharply with the upperparts; cranium globose and normally with a low sagittal crest. Dental formula as in *M. lucifugus*. External measurements average: total length, 88 mm; tail, 36 mm; foot, 9 mm; forearm, 38 mm. Weight, 5-7 g.

**Distribution in Texas.** Southeastern United States; occurs westward to the Pineywoods region of East Texas.

**Habits.** *M. austroriparius* is predominantly a cave bat in that part of its range where suitable caves occur. But in Texas, and in most of Louisiana, it seeks out roosts in human habitations and structures. Outside of caves, it has been found in crevices between bridge timbers; in culverts and drain pipes; in boat houses, barns, and the attics of houses; and in hollow trees. The bats are usually closely associated with water and when they leave their diurnal roosts late in the evening (usually about dark), they fly to nearby ponds and streams over which they forage and from which they drink. They fly low over the water, usually within 60 cm of the surface, capturing insects. Specific foods are not known but small moths, midges, mosquitoes, and flies are probably of importance.

Where suitable caves are available, both males and females congregate in large numbers in late March and April to bear their young. In caveless areas, old buildings may serve as nursery sites. Parturition occurs in late April to early May and the young are large enough to fly 5 or 6 weeks later. The southeastern myotis is unusual among bats of the genus *Myotis* as it usually gives birth to twin offspring; other *Myotis* usually having only one young per year. At birth, the young bats weigh slightly more than 1 g each. They grow rapidly, and sexual maturity is reached in both sexes before the bats are a year old.

Their most important predators appear to be rat snakes, corn snakes, opossums, and certain species of owls. Large cockroaches may prey on newborn young that fall to the ground.

*Photo credit: Merlin D. Tuttle, Bat Conservation International.*
Seminole Bat

Order Chiroptera: Family Vespertilionidae: *Lasiurus seminolus* (Rhoades)

**Description.** Similar to *Lasiurus borealis* but rich mahogany brown, slightly frosted with whitish. Dental formula as in *L. blossevillii*. External measurements average: total length, 103 mm; tail, 44 mm; hind foot, 10 mm; ear, 11 mm; forearm, 39 mm.

**Distribution in Texas.** From East Texas (oak-hickory, pine-oak, and longleaf pine forest region) eastward along the coast to Florida and the Carolinas.

**Habits.** The distribution of Seminole bats seems to be closely associated with the distribution of Spanish moss, the clumps of which provide roosting sites. The adult bats are solitary and roosts are usually occupied by a single individual, or a female with young. Bat-inhabited moss clumps are usually shaded from the sun and often on the west and southwest exposures of oak trees. Bats have been observed roosting in such clumps from 1 to 5 m above the ground.

The bats emerge from their daytime roosts early in the evening and forage among or above the crowns of the trees, over watercourses, and around clearings. They may occasionally alight on vegetation to capture prey. Their food consists of true bugs, flies, beetles, and even ground-dwelling crickets.

The two to four (normally two) young are born in late May or June. The young bats grow rapidly and are thought to be capable of flight at the age of 3 or 4 weeks.

Seminole bats are thought to be resident within their range in the Deep South. They do not hibernate in the true sense, but rather are active throughout the winter when weather conditions permit. Observations indicate that on days when the ambient temperature is below 20° C the bats do not leave their daytime roosts, but whenever temperatures in the evening exceed 20° C they emerge and take wing.

*Photo credit: John L. Tveten.*
Rafinesque’s Big-eared Bat
Order Chiroptera: Family Vespertilionidae: Plecotus rafinesquii Lesson

Description. Similar to Townsend’s big-eared bat, but hairs of the underparts have white tips that contrast sharply with the dark bases; long hairs on foot project noticeably beyond the ends of the toes; middle upper incisors with a secondary cusp; median postpalatal process triangular in shape with a broad base. Dental formula as in P. townsendii. External measurements average: total length, 100 mm; tail, 46 mm; foot, 12 mm; forearm, 43 mm. Weight, 7-13 g.

Distribution in Texas. A bat of the southeastern United States, Rafinesque’s big-eared bat reaches the westernmost portion of its range in the pine forests of East Texas.

Habits. Unlike the closely related P. townsendii, Rafinesque’s big-eared bat occurs in forested regions largely devoid of natural caves. Its natural roosting places are in hollow trees, crevices behind bark, and under dry leaves. It has been observed most frequently in buildings, both occupied and abandoned. Texas specimens have been captured in barns and abandoned wells. P. rafinesquii appears to be a solitary bat although colonies of 2-100 may be encountered in summer. Winter aggregations, usually of both sexes, are more numerous but even then solitary individuals are frequently found. The bats probably do not hibernate in East Texas, but in the northern part of their range they tend to seek out underground retreats and hibernate through the winter.

Like other Plecotus, P. rafinesquii emerges from its daytime roost well after dark to forage. Specific food items have not been recorded but small, night-flying insects, especially moths, are probably important.

The single young is born in late May or early June; they shed their milk dentition by mid-July, and reach adult size and appearance in August or September.

Photo credit: Merlin D. Tuttle, Bat Conservation International.
ORDER LAGOMORPHA:

HARES AND RABBITS

Mammals assigned to this Order superficially resemble rodents, but lagomorphs differ from rodents in several essential features. One of these is the peculiar tandem arrangement of the front (incisor) teeth, with a large tooth in front on each side and a small peglike tooth directly behind it. Also, the number of premolars is 2/2 or 3/2 (2/1 or 0/0 in rodents), so that the total number of teeth is 26 or 28 and never as few as the 16 to 22 found in rodents.

This group of mammals is largely diurnal or crepuscular in habit; the food is almost entirely vegetable matter — grasses, forbs, bark of trees and shrubs, and so forth. Because of their usually large size and food predilections, lagomorphs frequently come into conflict with grazing, agriculture, and forestry interests. No lagomorphs hibernate.

Family Leporidae (hares and rabbits)

Swamp Rabbit, Sylvilagus aquaticus
Desert Cottontail, Sylvilagus audubonii
Eastern Cottontail, Sylvilagus floridanus
Black-tailed Jackrabbit, Lepus californicus

KEY TO THE HARES AND RABBITS OF TEXAS

1. • Length of ear from notch more than 100 mm; general color grayish above, white below; tail with black dorsal stripe: Lepus californicus (black-tailed jackrabbit).
   • Length of ear from notch less than 100 mm: 2

2. • Length of hind foot usually more than 100 mm; total length (tip of snout to tip of tail) in adults near 500 mm; pelage rather harsh for a rabbit: Sylvilagus aquaticus (swamp rabbit).
   • Length of hind foot usually less than 100 mm; total length of adults near 400 mm: 3

3. • Ear 65% to 85% as long as hind foot and usually more than 58 mm in length; hind foot usually less than 90 mm; bullae relative to length of skull large: Sylvilagus audubonii (desert cottontail).
   • Ear 50% to 60% as long as hind foot and usually less than 58 mm in length; hind foot usually near 90 mm; bullae relative to length of skull small: Sylvilagus floridanus (eastern cottontail).
Swamp Rabbit

Order Lagomorpha: Family Leporidae: *Sylvilagus aquaticus* (Bachman)

**Description.** Largest of the "cottontails" within its range; pelage coarse and short for a rabbit; upper parts grayish brown, heavily lined with blackish; rump, underside of tail, and back of hind legs dull ochraceous brown; sides of head and body paler than back, less suffused with blackish; underparts, including underside of tail, white except for buffy underside of neck; front legs and tops of hind feet cinnamon rufous. External measurements average: total length, 534 mm; tail, 69 mm; hind foot, 106 mm; ear, 70 mm. Weight, 1.5-3 kg.

**Distribution in Texas.** Found in eastern one-third of state west to Montague, Wise, and Bexar counties.

**Habits.** The swamp rabbit, as the name suggests, inhabits poorly drained river bottoms and coastal marshes. Well adapted to a semi-aquatic habitat in that its dense fur "waterproofs" its skin, the animal is at home in the water. In fact, it crosses rivers and streams on its own initiative, a habit usually not found in other rabbits in Texas. It is secretive by day and is seldom seen, except when frightened from its bed in some thicket, but its presence in an area is readily disclosed by the piles of fecal pellets deposited on stumps, down logs, or other elevations. Along the coast it is at home in cane thickets, hence the local name "cane cutter," but in inland areas it is restricted to the flood plains of rivers and streams and their associated tangles of shrubs, trees, and vines.

In southeast Texas, one swamp rabbit per 2.8 ha of poorly drained bottomland is typical. The rabbits frequent a definite local range, which they refuse to leave even when pursued by dogs. Their chief protection are thickets of briars or brush, rather than underground burrows. In this area both eastern cottontails (*S. floridanus*) and swamp rabbits occupy the creek and river bottoms in about equal numbers, but in the uplands only cottontails are found.

Little is known of their food habits although succulent vegetation including grasses, forbs, and the new shoots of shrubs are probably important.

The breeding season extends at least from January to September, but the peak is in February and March when green vegetation is available. Possibly two or more litters of two to three young are reared annually. After a gestation period of 39-40 days, the young are born in, or transferred to, surface nests composed of vegetation and lined with rabbit fur, or nests in holes.
in logs and stumps. A nest found at the base of a cypress stump was composed of Spanish moss and rabbit fur; it held six small rabbits. Another found under a long, fallen branch of a tree was lined with fur and held two young rabbits. At birth the young are covered with fur, but the eyes and ears are closed. This condition is not true of other cottontails. The eyes open and the young rabbit is able to walk in 2 or 3 days.

Among their known natural enemies are gray fox, horned owl, and alligator. Doubtless, they are preyed upon by many other species. Other than man, their chief enemy is floods.

*Photo credit: John L. Tveten.*
Eastern Cottontail
Order Lagomorpha: Family Leporidae: *Sylvilagus floridanus* (Allen)

**Description.** A moderately large, rusty-brown cottontail with relatively short ears and large hind feet (ears 50-60% as long as hind feet). Upperparts deep ochraceous buff, heavily lined with blackish, giving a rusty or reddish-brown effect; sides paler and grayer; top of tail like back; rump dingy grayish, not conspicuously different from back; front and sides of legs deep, rich, rusty reddish; underside of neck buff or ochraceous buff, rest of underparts, including tail, white. Differs from *S. audubonii*, with which its range overlaps, in having small, smoothly rounded bullae (rather than large and rough) and relatively and actually shorter ears. External measurements average: total length, 418 mm; tail, 56 mm; hind foot, 92 mm; ear, 52 mm. Weight, 1-2 kg.

**Distribution in Texas.** Occurs throughout eastern three-fourths of the state and in some areas of the Trans-Pecos.

**Habits.** Like other cottontails, this one is a denizen of brushland and marginal areas and seldom ventures far from brushy cover. In central Texas, it commonly frequents brush-dotted pastures, the brushy edges of cultivated fields, and well-drained streamside. Occasionally, it inhabits poorly drained bottoms with the swamp rabbit. In many places it is common along country roads, especially where the sides are grown up to dense vegetation and adjoining areas are heavily grazed or farmed.

These cottontails are active largely in the twilight hours and at night, when they venture to open pastures, meadows, or lawns to forage. They frequently live in the edges of towns and feed in gardens and flower beds. In the daytime they rest in beds in nearby thickets or in underground burrows and small culverts. On the coastal prairies of Texas, a population density of one cottontail to 1.8 ha is not unusual.

The food is variable with the season. They feed on a variety of grasses and forbs but when such vegetation is scarce, they eat the twigs and bark of shrubs and small trees. These rabbits are not sociable and are seldom seen feeding together.

Eastern cottontails are prolific breeders. In southern Texas the breeding season is year-long, although the frequency of breeding does fluctuate throughout the year. Breeding activity is stimulated by environmental factors, such as temperature and rainfall, which affect the growth
of vegetation. As many as four or five litters of one to eight young (average, four) may be reared yearly. The gestation period is 28-29 days. The young are blind and helpless at birth, but grow rapidly; when 4-5 months old they are distinguished from adults only with difficulty. Young females born early in the year may mature sexually and produce young in their first summer but ordinarily, they do not breed until their second summer.

These cottontails are known to be preyed upon by hawks, barn owls, opossums, coyotes, foxes, and weasels. Doubtless, many others can be added to the list.

**Remarks.** Previously, cottontails from mountainous areas of the Trans-Pecos, including the Guadalupe and Chisos Mountains, were regarded as a distinct species (*Sylvilagus robustus*). Based on only nominal cranial differences with *S. floridanus*, these rabbits are now considered merely a subspecies of the eastern cottontail, *S. f. robustus*.

*Photo credit: John L. Tveten.*
ORDER RODENTIA:

RODENTS

The name Rodentia is derived from the Latin verb *rodere* (to gnaw), in allusion to the gnawing habits of the group. Among North American mammals, rodents are unique in that the incisors are reduced in number to one on each side above and below, in the absence of canines, and in the presence of never more than two premolars in each jaw above and one below. The dental formula varies from: I 1/1, C 0/0, Pm 0/0, M 3/3 X 2 = 16 to I 1/1, C 0/0, Pm 2/1, M 3/3 X 2 = 22. Most animals assigned to the order are small in size; some, for example the beaver, may exceed 25 kg in weight. Rodents comprise more than one-third of the known kinds of mammals, and individually they are the most abundant mammal in many sections of the world. Sixty-four species of native rodents occupy Texas, making this the most diverse group of mammals in our state.

In habits, members of this order are diverse. Most of them are nocturnal or crepuscular; ground squirrels and tree squirrels are strictly diurnal; others may be active either by day or by night. Considerable adaptive radiation occurs in the group. Some species (pocket gopher) are fossorial; others are aquatic (beaver), arboreal (tree squirrel), volant (flying squirrel), or terrestrial (cotton rat). Most rodents feed on vegetation, but a few species, notably the grasshopper mouse, feed extensively upon animal matter. Most rodents are active throughout the year, but others, notably ground squirrels, may hibernate for several months.

Family Sciuridae (squirrels and allies)

- Gray-footed Chipmunk, *Tamias canipes*
- Texas Antelope Squirrel, *Ammospermophilus interpres*
- Mexican Ground Squirrel, *Spermophilus mexicanus*
- Spotted Ground Squirrel, *Spermophilus spilosoma*
- Thirteen-lined Ground Squirrel, *Spermophilus tridecemlineatus*
- Rock Squirrel, *Spermophilus variegatus*
- Black-tailed Prairie Dog, *Cynomys ludovicianus*
- Eastern Gray Squirrel, *Sciurus carolinensis*
- Eastern Fox Squirrel, *Sciurus niger*
- Eastern Flying Squirrel, *Glaucium vulgans*

Family Geomyidae (pocket gophers)

- Botta’s Pocket Gopher, *Thomomys bottae*
- Desert Pocket Gopher, *Geomys arenarius*
- Attwater’s Pocket Gopher, *Geomys attwateri*
- Baird’s Pocket Gopher, *Geomys breviceps*
- Plains Pocket Gopher, *Geomys bursarius*
- Jones’ Pocket Gopher, *Geomys knoxjonesi*
- Texas Pocket Gopher, *Geomys personatus*
Llano Pocket Gopher, *Geomys texensis*
Yellow-faced Pocket Gopher, *Cratogeomys castanops*

Family Heteromyidae (pocket mice and kangaroo rats)

Plains Pocket Mouse, *Perognathus flavescens*
Silky Pocket Mouse, *Perognathus flavus*
Merriam's Pocket Mouse, *Perognathus merriami*
Hispid Pocket Mouse, *Chaetodipus hispidus*
Rock Pocket Mouse, *Chaetodipus intermedius*
Nelson's Pocket Mouse, *Chaetodipus nelsoni*
Desert Pocket Mouse, *Chaetodipus penicillatus*
Gulf Coast Kangaroo Rat, *Dipodomys compactus*
Texas Kangaroo Rat, *Dipodomys elator*
Merriam's Kangaroo Rat, *Dipodomys merriami*
Ord's Kangaroo Rat, *Dipodomys ordii*
Banner-tailed Kangaroo Rat, *Dipodomys spectabilis*
Mexican Spiny Pocket Mouse, *Liomys irroratus*

Family Castoridae (beavers)

**American Beaver**, *Castor canadensis*

Family Muridae (mice and rats)

Coues' Rice Rat, *Oryzomys couesi*
Marsh Rice Rat, *Oryzomys palustris*
Fulvous Harvest Mouse, *Reithrodontomys fulvescens*
Eastern Harvest Mouse, *Reithrodontomys humulis*
Western Harvest Mouse, *Reithrodontomys megalotis*
Plains Harvest Mouse, *Reithrodontomys montanus*
Texas Mouse, *Peromyscus attwateri*
Brush Mouse, *Peromyscus boylii*
Cactus Mouse, *Peromyscus eremicus*
Cotton Mouse, *Peromyscus gossypinus*
White-footed Mouse, *Peromyscus leucopus*
Deer Mouse, *Peromyscus maniculatus*
Northern Rock Mouse, *Peromyscus nasutus*
White-ankled Mouse, *Peromyscus pectoralis*
Piñon Mouse, *Peromyscus truei*
Golden Mouse, *Ochrotomys nutalli*
Northern Pygmy Mouse, *Baiomys taylori*
Meaans' Grasshopper Mouse, *Onychomys arenicola*
Northern Grasshopper Mouse, *Onychomys leucogaster*
Tawny-bellied Cotton Rat, *Sigmodon fulviventer*
Hispid Cotton Rat, *Sigmodon hispidus*
Yellow-nosed Cotton Rat, *Sigmodon oehrognathus*
White-throated Woodrat, *Neotoma albigula*
Eastern Woodrat, *Neotoma floridana*
Mexican Woodrat, *Neotoma mexicana*
Southern Plains Woodrat, *Neotoma micropus*
Norway Rat, *Rattus norvegicus*
Roof Rat, *Rattus rattus*
House Mouse, *Mus musculus*
Mexican Vole, *Microtus mexicanus*
Prairie Vole, *Microtus ochrogaster*
Woodland Vole, *Microtus pinetorum*
Common Muskrat, *Ondatra zibethicus*

Family Erethizontidae (New World porcupines)

**Porcupine, Erethizon dorsatum**

Family Myocastoridae (myocastorids)

**Nutria, Myocastor coypus**

---

**KEY TO THE RODENTS OF TEXAS**

1. • Presence of external, furred cheek pouches: 2
   • Absence of external, furred cheek pouches: 15

2. • Front feet much larger than hind feet; ear (pinna) short and inconspicuous; tail about half the length of head and body (pocket gophers): 3
   • Front feet much smaller than hind feet; ear (pinna) conspicuous; tail as long as (or longer than) head and body (pocket mice and kangaroo rats): 5

3. • Upper incisors not grooved on outer face; claws of front feet relatively small and slender: *Thomomys bottae* (Botta’s pocket gopher).
   • Upper incisors distinctly grooved on outer surface; claws of front feet large and long (longest ones about 15 mm): 4

4. • Upper incisors with one deep groove; feet blackish: *Cratogeomys castanops* (yellow-faced pocket gopher).
   • Upper incisor with two distinct grooves; feet whitish (species of the genus *Geomys*):

Seven species of the genus *Geomys* occur in Texas. These are cryptic species, identifiable primarily on the basis of geographic distribution and characters of the karyotype and genes. Only specialists working with prepared study specimens can identify them using morphological features.

(1) *Geomys arenarius* (desert pocket gopher) occurs in El Paso and Hudspeth counties in far western Texas.

(2) *Geomys attwateri* (Attwater’s pocket gopher) occurs in the south-central part of eastern Texas.
(3) *Geomys breviceps* (Baird’s pocket gopher) occurs in eastern and northeastern Texas.

(4) *Geomys bursarius* (plains pocket gopher) occurs in northwestern and north-central Texas.

(5) *Geomys knoxjonesi* (Jones’ pocket gopher) occurs on the southwestern plains of Texas.

(6) *Geomys personatus* (Texas pocket gopher) occurs in the southern part of Texas.

(7) *Geomys texensis* (Llano pocket gopher) occurs in the Llano Basin region of the Hill Country in central Texas and in an isolated area on the northern border of the South Texas Plains.

5. Hind legs more than twice as long as front legs; tail long and bushy at end; head broad, 25 mm or more in width (kangaroo rats): 6

6. Hind legs less than twice as long as front legs; head about 15 mm in width (pocket mice): 10

7. Large size, total length of adults 300 mm or more; tip of tail with conspicuous white "banner": 7

8. Smaller, total length of adults usually less than 250 mm; tip of tail usually dusky, not white: 8

9. Hind foot (from tip of longest claw to heel) 50 mm or more in length; length of tail about 200 mm: *Dipodomys spectabilis* (banner-tailed kangaroo rat).

10. Hind foot less than 50 mm; tail normally less than 200 mm: *Dipodomys elator* (Texas kangaroo rat).

11. Hind foot with five toes (one is very small and difficult to detect): 9

12. Hind foot with only four toes: *Dipodomys merriami* (Merriam’s kangaroo rat).

13. Pelage long and silky, brownish; mastoid bullae greatly inflated, giving skull a triangular appearance; interparietal narrow and triangular in shape: *Dipodomys ordii* (Ord’s kangaroo rat).

14. Pelage short and coarse, with orangish cast; mastoid bullae less inflated; interparietal broad and rectangular to roundish in shape: *Dipodomys compactus* (Gulf Coast kangaroo rat).

15. Size small, total length 100 to 130 mm; weight 6 to 8 grams; pelage silky and soft: 11

16. Size larger, total length 150 mm or more; pelage harsh, often bristly, never silky: 12

17. Length of tail usually 60 mm or more; total length usually 120 mm or more; length of skull usually more than 21 mm; postauricular patch inconspicuous: *Perognathus flavescens* (plains pocket mouse).

18. Length of tail usually less than 60 mm; total length usually less than 120 mm; length of skull usually less than 21 mm; postauricular patch conspicuous. Silky pocket mice:

Two species of silky pocket mice occur in Texas, but only specialists working with prepared study specimens can identify them.
(1) *Perognathus flavus* (silky pocket mouse) occurs in the Panhandle and Trans-Pecos portions of Texas.

(2) *Perognathus merriami* (Merriam’s pocket mouse) occurs in the Great Plains, central, and southern regions of Texas.

12. • Upper incisors plain, not grooved, on outer face; pelage spiny to touch: *Liomys irroratus* (Mexican spiny pocket mouse).
   • Upper incisors distinctly grooved on outer face: 13

13. • Length of tail less than length of head and body (tail laid forward over back does not reach snout); weight 30 to 47 grams: *Chaetodipus hispidus* (hispid pocket mouse).
   • Length of tail greater than length of head and body (tip of tail extends beyond snout when laid forward): 14

14. • Rump with conspicuous black-tipped "spines"; tail sparsely haired on basal half; soles of hind feet blackish; upperparts grizzled blackish: *Chaetodipus nelsoni* (Nelson’s pocket mouse).
   • Rump without conspicuous, black-tipped "spines."

This category contains two species that only a specialist working with comparative material can identify with certainty.

1. (1) *Chaetodipus penicillatus* (desert pocket mouse) occurs in sandy soils mainly in Trans-Pecos Texas.

2. (2) *Chaetodipus intermedius* (rock pocket mouse) occurs mainly in rocky situations in the Trans-Pecos section of the state.

15. • Tail paddle-shaped, naked, scaly; hind feet webbed; size large: *Castor canadensis* (American beaver).
   • Tail not paddle-shaped: 16

16. • Pelage with intermixed sharp quills; large, 4 to 12 kg: *Erethizon dorsatum* (porcupine).
   • Pelage without quills: 17

17. • Lower jaw with four cheek teeth on each side: 18
   • Lower jaw with only three cheek teeth on each side: 28

18. • Hind feet fully webbed; adults weigh up to 12 kg; tail long, naked, and nearly circular in cross section: *Myocastor coypus* (nutria).
   • Hind feet not fully webbed: 19

19. • "Flying" membrane between front leg and hind leg on each side; color wood brown above, white below: *Glaucous volans* (eastern flying squirrel).
   • Legs normal, no "flying" membrane: 20

20. • Upperparts striped or distinctly spotted or both: 21
    • Upperparts not striped or distinctly spotted: 25

21. • Upperparts striped: 22
    • Upperparts spotted: 24

22. • One white stripe on each side; underside of tail grayish white (held over back while
animal is running); upperparts grizzled grayish: *Ammospermophilus interpres* (Texas antelope squirrel).
- Three or more white or light stripes on upperparts: 23

23.  
- Six continuous, whitish stripes alternating with seven rows of whitish spots; ground color brown: *Spermophilus tridecemlineatus* (thirteen-lined ground squirrel).
- Four whitish stripes alternating with five dark brown stripes; sides of face striped: *Tamias canipes* (gray-footed chipmunk).

24.  
- Spots in 10 or more distinct rows; tail narrowly bushy and about three times as long as hind foot: *Spermophilus mexicanus* (Mexican ground squirrel).
- Spots scattered, never in distinct rows; tail about twice as long as hind foot: *Spermophilus spilosoma* (spotted ground squirrel).

25.  
- General color yellowish brown; tail very short (1.5 times length of hind foot) and black-tipped: *Cynomys ludovicianus* (black-tailed prairie dog).
- General color gray, brown, or blackish; tail long and bushy: 26

26.  
- Belly reddish or rusty in color; upperparts grayish; hind foot 70 mm or more: *Sciurus niger* (eastern fox squirrel).
- Belly whitish or grayish; not reddish; hind foot 70 mm or less: 27

27.  
- Belly white; upperparts gray, unspotted: *Sciurus carolinensis* (eastern gray squirrel).
- Belly grayish, back grayish with faint light spots, or shoulders and head black and rump grayish or brownish: *Spermophilus variatus* (rock squirrel).

28.  
- Tail flattened laterally, sparsely haired and scaly; hind toes fringed with stiff hairs; length of adults about 45 cm: *Ondatra zibethicus* (common muskrat).
- Tail round, sparingly haired or bushy: 29

29.  
- Enamel pattern of molar teeth with transverse or oblique folds or triangles: 30
- Enamel pattern of molar teeth with two or three rows of cusps (unworn condition) or roughly circular with slight lateral indentations (worn condition): 37

30.  
- Mouse size, total length usually less than 150 mm; tail less than 50 mm; ears nearly hidden in the fur: 31
- Rat size, total length of adults 225 mm or more; tail 100 mm or more; ears conspicuous or partly hidden in the dense fur: 33

31.  
- Tail less than 25 mm in length; hind foot usually less than 18 mm; color glossy, reddish brown: *Microtus pinetorum* (woodland vole).
- Tail more than 25 mm in length; hind foot usually more than 18 mm; color brownish gray or blackish: 32

32.  
- Enamel pattern of third upper molar with no more than two closed triangles, often with no closed triangles, hence with three loops; never more than two inner re-entrant angles: *Microtus ochrogaster* (prairie vole).
- Enamel pattern of third upper molar with three closed triangles or, if with only two closed triangles, then with three inner re-entrant angles: *Microtus mexicanus* (Mexican vole).

33.  
- Ears conspicuous; tail in adults usually 150 mm or longer; eyes large, black, and bulging in life; fur rather soft; whiskers long, usually more than 50 mm (woodrats): 34
- Ears partly hidden in dense pelage; tail 100-125 mm long; pelage rather harsh; whiskers 25 to 35 mm long (cotton rats): 35

34.  
- First upper molar tooth with a deep antero-internal fold extending half-way across the crown: *Neotoma mexicana* (Mexican woodrat).
• First upper molar tooth without a deep antero-internal fold extending half-way across the crown:

This category includes three species that are difficult to identify without close examination of the skull and the baculum.

(1) *Neotoma micropus* (southern plains woodrat) occurs in the brushlands of the western and southern portions of the state. Over most of its range, this woodrat is characterized by a steel gray dorsum as compared to the brownish pelage of the other two species.

(2) *Neotoma albigula* (white-throated woodrat) is found in the western half of Texas.

(3) *Neotoma floridana* (eastern woodrat) is found in the eastern half of Texas.

35. • Underparts buffy to ochraceous; tail entirely black; top surface of feet buffy: *Sigmodon fulviventer* (tawny-bellied cotton rat).
   • Underparts whitish and not buffy or ochraceous; tail bicolor, dark above and light below; top surface of feet whitish: 36

36. • Snout and eye rings yellowish or orangish and conspicuously different than color of backs and sides; hind foot of adults usually less than 30 mm; total length usually less than 260 mm: *Sigmodon ochrognathus* (yellow-nosed cotton rat).
   • Snout and eye rings not conspicuous and same color as sides and back; hind foot usually more than 30 mm; total length usually more than 260 mm: *Sigmodon hispidus* (hispid cotton rat).

37. • Rat size, total length 230 mm or more: 38
   • Mouse size, total length usually less than 200 mm: 40

38. • Cusps on upper molars in two rows; hind foot narrow and slender (rice rats):

There are two species of rice rats in Texas that only a specialist can identify with certainty.

(1) *Oryzomys palustris* (marsh rice rat), a grayish brown form characteristic of marshy areas along the coast from Brownsville northward into deep East Texas.

(2) *Oryzomys couesi* (Coues' rice rat), a tawny form that occurs in marshy areas in extreme South Texas (Hidalgo and Cameron counties).

39. • Cusps on upper molars in three rows (introduced rats): 39
   • Tail slender and as long as or longer than head and body (tail reaches to or beyond nose when laid forward); color brownish or black; weight to 225 g: *Rattus rattus* (roof rat).
   • Tail chunkier and shorter than head and body; color brownish; weight to 450 g:
**Rattus norvegicus** (Norway rat).

40. • Outer face of each upper incisor with deep groove (harvest mice): 41
   • Outer face of upper incisors not grooved: 44

41. • Tail much longer than head and body (projects beyond nose when laid forward along back); last lower molar with dentine in the form of an "S": *Reithrodontomys fulvescens* (fulvous harvest mouse).
   • Tail shorter than or about as long as head and body; last lower molar with dentine in the form of a "C": 42

42. • Color rich brown to blackish brown; a distinct labial shelf or ridge, often with distinct cusplets on first and second lower molars: *Reithrodontomys humulis* (eastern harvest mouse).
   • Color mainly grayish brown or light buff; no distinct labial shelf or ridge on first and second molars: 43

43. • Tail shorter than head and body. Breadth of braincase not exceeding 9.6 mm: *Reithrodontomys montanus* (plains harvest mouse).
   • Tail length about equal to, or slightly longer than, head and body. Breadth of braincase of adults usually over 9.5 mm: *Reithrodontomys megalotis* (western harvest mouse).

44. • Upper incisors with distinct notch at tip when viewed from the side; distinctly musky odor: *Mus musculus* (house mouse).
   • Upper incisors lacking distinct notch at tip: 45

45. • Total length of adults 100 mm or less; tail short, 35 mm, about three times length of hind foot; color blackish or sooty: *Baiomys taylori* (northern pygmy mouse).
   • Total length of adults 125 mm or more; color not blackish or sooty: 46

46. • Tail less than 60% of head and body; coronoid process of mandible extends high above level of condyloid process; soles of feet furred (grasshopper mice): 47
   • Tail more than 60% of head and body; coronoid process of mandible does not ascend above tip of condyloid process; soles of feet only slightly furred (deer mice and relatives): 48

47. • Tail less than half length of head and body; crown length of maxillary toothrow 4.0 mm or more: *Onychomys leucogaster* (northern grasshopper mouse).
   • Tail more than half length of head and body; crown length of maxillary toothrow 3.9 mm or less: *Onychomys arenicola* (Mearns’ grasshopper mouse).

48. • General color golden yellow: *Ochrotomys nuttalli* (golden mouse).
   • General color brown, buff, or gray (white-footed mice): 49

49. • Tail much shorter than head and body: 50
   • Tail as long as or longer than head and body: 52

50. • Hind foot (of adults) greater than 23 mm: *Peromyscus gossypinus* (cotton mouse).
   • Hind foot (of adults) less than 23 mm: 51

51. • Tail with narrow and distinct dorsal stripe; total length of adults usually less than 170 mm; length of tail usually less than 75 mm; greatest length of skull usually less than 26 mm: *Peromyscus maniculatus* (deer mouse).
   • Tail with broad dorsal stripe and not sharply bicolored; total length of adults usually more than 170 mm; length of tail usually more than 75 mm; greatest length of skull usually more than 26 mm: *Peromyscus leucopus* (white-footed mouse).

52. • Nasals decidedly exceeded by premaxillae; two principal outer angles of first and second upper molars simple, without (or at most with rudimentary) accessory cusps
or enamel lophs; sole of hind foot naked to end of ankle; no pectoral mammae; inguinal mammae, 2-2: Peromyscus eremicus (cactus mouse).

- Nasals slightly or not at all exceeded by premaxillae; two principal outer angles of first and second upper molars with well-developed accessory tubercles or enamel lophs; sole of hind foot hairy on proximal fourth to ankle; pectoral mammae, 1-1, inguinal mammae, 2-2: 53

53. • Ear longer than hind foot; tail about as long as head and body (except in P. t. comanche in which it is longer); bullae unusually inflated: Peromyscus truei (piñon mouse).

- Ear equal to or shorter than hind foot; tail usually longer than head and body; bullae moderately or less inflated: 54

54. • Hind foot length of adults more than 24 mm: Peromyscus attwateri (Texas mouse).

- Hind foot length of adults less than 24 mm: 55

55. • Tarsal joints of ankles white like upper side of hind foot; baculum with long cartilaginous spine at its terminal end: Peromyscus pectoralis (white-ankled mouse).

- Dusky color of hind leg extending to end more or less over tarsal joint, baculum with a short cartilaginous spine at its terminal end: 56

56. • Dorsal coloration grayish black, and often like immature pelage; top of head and flanks of adults predominantly grayish; first two lower molars usually with one or more accessory lophids or stylids: Peromyscus nasutus (northern rock mouse).

- Dorsal coloration with considerable yellow or buff; top of head same color as back; flanks of adults predominantly bright yellowish brown; first of two lower molars usually without any accessory lophids or stylids: Peromyscus boylii (brush mouse).
**Eastern Fox Squirrel**

Order Rodentia : Family Sciuridae : *Sciurus niger* Linnaeus

**Description.** A large tree squirrel with rusty or reddish underparts and brownish or grayish upperparts; tail usually less than half of total length, and cinnamon, mixed with black, in color; feet cinnamon. External measurements average: total length, 522 mm; tail, 245 mm; hind foot, 72 mm. Weight, 600-1,300 g.

**Distribution in Texas.** Occurs in suitable habitats in eastern two-thirds of state. Introduced some places outside of native range.

**Habits.** Fox squirrels are adaptable to a wide variety of forest habitats, but in most areas open upland forests of mixed trees support the heaviest populations. The best habitat is mature oak-hickory woodland broken into small, irregularly shaped tracts of 2-8 ha and connected by strips of woodland which serve as squirrel highways. Intermixture of pine, elm, beech, pecan, maple, and other food-producing trees adds to the attractiveness of the habitat. Along the western parts of their range, fox squirrels are restricted more or less to river valleys which support pecans, walnuts, oaks, and other "required" trees.

Where hollow trees are available they are preferred as den sites and nurseries; if these are unavailable, the squirrels build outside "leaf" nests. These are composed of twigs and leaves, usually cut from the tree in which the nest is placed, and fashioned into roughly globular structures 30-50 cm in diameter surrounding an inner cavity 15-20 cm in diameter.

A fox squirrel occupies an area of at least 4 ha in extent in any one season, but during an entire year 16 or more ha may be utilized. Ranges of different fox squirrels overlap, and the animals are somewhat communal in their use of nests and probably also of winter food stores. A population of one squirrel to 1 ha is about the average carrying capacity of good, unimproved squirrel habitats.

Acorns are the natural mainstay of fox squirrels, although they are most important in fall and winter. Spring and summer foods consist of leftover mast, insects, green shoots, fruits, and seeds of such trees as elm and maple. Nuts are eaten from the time they start to develop and are buried in the fall in individual caches at the surface of the ground for winter use. The squirrels can relocate them by smell. Buds of many trees and fruits of osage orange add to the winter diet.

Mating occurs principally in two periods — January and February and again in May and June.
The former period is most important. Old females usually breed twice a year and yearlings but once. The average female produces only four offspring each year. The gestation period is probably about 6 or 7 weeks, as in the gray squirrel. At birth the young are blind, nearly naked, and helpless. They develop rather slowly; their eyes open in the fifth week. They begin to climb about over the nest tree at the age of 7 or 8 weeks and to venture onto the ground at about 10 weeks. At the age of 3 months they begin to lead a more or less independent existence. Sexual maturity is reached at the age of 10-11 months.

Fox squirrels are important small game animals throughout most of their range, hence they are of decided economic value. Their fondness for green corn, however, often brings them into conflict with farming interests, as does their pilfering in nut orchards.
Eastern Gray Squirrel

Order Rodentia : Family Sciuridae : *Sciurus carolinensis* (Gmelin)

**Description.** A medium-sized squirrel with upperparts dark yellowish rusty, especially on head and back; legs, arms, sides of neck, and sides of rump with gray-tipped or white-tipped hairs, giving a gray tone to these parts; hairs of tail dull yellow at base, then blackish, and tipped with white; underparts white; ears with conspicuous white spot at base in winter. External measurements average: total length, 460 mm; tail, 210 mm; hind foot, 61 mm. Weight of adults, 321-590 g.

**Distribution in Texas.** Native distribution includes eastern one-third of state. Introduced at locations to the west of its native range.

**Habits.** In Texas, gray squirrels live mainly in dense hammocks of live oak and water oak and in the deep swamps of cypress, black gum, and magnolia that border the streams. Phil Goodrum found that they were most abundant in hammocks where the principal vegetation was white oak and water oak mixed with magnolia, linden, sweet gum, and holly. Poorly drained bottom lands with their pin, evergreen and overcup oaks, elms, bitter pecan, black gum, cypress, and ash support much smaller populations. In well-drained bottom lands with post and red oaks, hackberries, gum elastic, and pecan, the populations are still smaller, and upland forests usually are devoid of gray squirrels.

They den in hollow trees when available, but they also utilize outside leaf nests, especially in spring and summer. These serve usually as refuge, resting and feeding stations and occasionally as nurseries. Placed in trees, they are constructed of twigs, leaves, and so forth on the outside and lined with shredded bark, plant fibers, and grasses. Usually there are two openings.

Gray squirrels feed on a variety of foods, chiefly plant in origin. Goodrum lists buds and mast of oak and pecan trees, grapes, fungi, red haw buds, sedges, grasses, mulberry, larval and adult insects, and amphibians. Their mainstay, however, is mast (acorns, etc.). They begin eating acorns in the Spring and continue throughout the year if they are available. When mast crops fail in one area, the squirrels usually move en masse to other areas where food is more abundant. This accounts in large measure for the "migrations" of squirrels that are frequently reported. Normally they feed twice a day — early morning and late afternoon — and are less active at midday.
These squirrels breed throughout the year, but there are two rather distinct peaks — July, August, and September and again in December, January, and February. Mating is more or less promiscuous; several males usually attempt to mate with each receptive female. After a gestation period of 40-45 days, the two to four naked, blind, and helpless young are born. They remain in the nest for about 6 weeks by which time their eyes are open and their teeth have developed so they can eat solid foods. By that time they weigh about 200 g. They remain in family groups for a month or so after they begin foraging for themselves. When 6 months old they are nearly adult in size and have left the home territory. They mature sexually in their first year and produce young of their own when about 12 months old.

These squirrels are highly prized as game. In most parts of their range they are decreasing in numbers because of overhunting and the removal of favored habitat by drainage or lumbering operations. Consequently, sound management of their habitat is becoming an increasingly important responsibility. Their future will depend upon the acreage remaining in hardwood forests, the length of timber rotations, the species composition of hardwood stands, and the abundance of mast supplies and dens. They do some damage in pecan orchards, but such depredations are local in nature and can usually be minimized by placing tin shields around the trunks which prevent the squirrels from climbing trees.

*Photo courtesy of Texas Parks and Wildlife.*
Nutria*  
Order Rodentia: Family Myocastoridae: *Myocastor coypus* (Molina)  

**Description.** A large rodent, nearly as large as a beaver but with long, rounded, scaly, ratlike tail; hind feet webbed; incisors orange-colored; female with mammae along each side of back, not on belly; upperparts reddish brown; the underfur dark slaty; tip of muzzle and chin white. External measurements of adults average: total length, 800-900 mm; tail, 350-400 mm; hind foot, 130-140 mm. Total length may reach 1.4 m. Weight, normally 8-10 kg.

**Distribution in Texas.** Known from aquatic habitats in eastern two-thirds of state.

**Habits.** Throughout much of their natural range in South America, nutria prefer a semiaquatic existence in swamps, marshes, and along the shores of rivers and lakes. In southern Chile and Tierra del Fuego they are found mainly in the channels and bays separating the various islands off the coast. Here, their habitat seems to be mostly in the estuaries of glacier-fed streams, and colonies of nutria are often seen swimming among the floating ice blocks in the vicinity of glaciers. Apparently, the nutria is equally at home in salt and fresh water.

They are docile creatures, much like the beaver in this respect, and can be handled easily in captivity. They are almost entirely nocturnal, consequently their presence in an area usually is revealed only by their trails, feces, and lengths of cut vegetation that have been left in their trails. They are not extensive burrowers. Burrows that have been examined were approximately 20 cm in diameter and extended into the bank for a distance of over 1 m. Often they were open at both ends, with the entrance toward the river usually above water level. Some of the burrows are under roots of trees that are exposed along the banks of the river or stream. Their nests are made of reeds and sedges built up in large piles somewhat after the fashion of a swan’s nest. These are built on land among the marsh vegetation and close to the water's edge.

Their natural food consists almost entirely of aquatic and semiaquatic vegetation, but when these animals live along the coast they also feed upon shellfish. Cattails, reeds, and sedges appear to be especially prized items of food. When established near gardens, they take cabbage readily; they are also fond of carrots and sweet potatoes.

These animals appear to breed throughout the year. Each adult female produces two or three litters a year. The gestation period is from 127 to 132 days. The number of young per litter ranges from two to 11 and averages about five. At birth the young are fully furred, and their

http://www.nsrl.ttu.edu/tmotl/myoccyyp.htm  
1/17/2007
eyes are open; they are able to move about and feed upon green vegetation within a few hours. At that time they weigh approximately 200 g. They mature rapidly, increasing at the rate of about 400 g per month during the first year, and reach sexual maturity at the age of 4 or 5 months. Females sometimes give birth to their first litter when they themselves are 8 or 9 months old. The maximum length of life for nutria kept in captivity is 12 years, but the life span in the wild probably is considerably less.

These animals are important fur producers in their native range. They are reared extensively on fur farms in South America and most of their pelts are sold on the European market. On the American market, nutria pelts have at times been of some value, but currently there is no market for nutria pelts. Because of their known competition with muskrats, which are well-established and valuable fur-producing animals in this country, it appears that muskrats may be driven out and replaced by the much less desirable nutria.

They have been widely introduced in Texas as a "cure-all" for ponds choked with vegetation. They do reduce many kinds of aquatic plants, but they will not eat "moss" (algae) and many of the submerged plants. At times they do the job too well. The trouble is that once nutrias get established in a lake, their high reproductive capacity soon results in overpopulation. There are so many nutrias that the available food supply will not satisfy them, and then trouble begins. The animals move into places where they are not wanted or where they destroy vegetation that is valuable for such wildlife as waterfowl and muskrats. A case in point is Eagle Lake in Colorado County. There, a stocking of nutrias increased to the point where the animals seriously damaged the waterfowl values of the lake. Hundreds of dollars were spent in attempts to eradicate the pests.

Currently, nutria populations in Texas are moderately high and on the increase. Unless the market for nutria improves, a serious and costly overpopulation problem is likely in the very near future.

* nonnative species

Photo courtesy of Texas Parks and Wildlife.
American Beaver

Order Rodentia: Family Castoridae: *Castor canadensis* Kuhl

**Description.** A large, robust, aquatic rodent with a broad, horizontally flattened, scaly tail; hind feet webbed; upperparts in fresh fall pelage dark, rich, chestnut brown which fades by spring; underparts paler, often with silvery sheen. Sexes colored alike. External measurements average: total length, 1,160 mm; tail, 400 mm; hind foot, 178 mm. Weight, averages 18 kg; rarely as much as 27 kg. The dental formula is I 1/1, C 0/0, Pm 1/1, M 3/3 X 2 = 20.

**Distribution in Texas.** Found over most of the state where suitable aquatic habitat prevails; absent from the Llano Estacado and some adjacent areas and from much of the Trans-Pecos.

**Habits.** Beavers are essentially aquatic and require water in the form of a pond, stream, lake, or river for their well-being. Because of their skills in regulating water level and stream flow with dams, beavers are able to convert an otherwise unfavorable area into one that is habitable. But they must be ever alert as water engineers because their ponds tend to fill up with sediment washed off the slopes above and in time become meadows, forcing the beavers to move to new sites. Large rivers and lakes offer suitable habitat in places where natural food and den or house sites are available, but the largest populations are on small bodies of water.

In cold regions, beavers live in houses constructed of sticks and mud and enter and leave them by means of underwater tunnels or "plunge holes"; in Texas they may burrow into cut banks of streams or lakes. Burrows examined in the Rio Grande in the Big Bend section of Texas were large enough to admit a man and were 10 m or more in length. Burrows as long as 50 m have been reported. Burrows, or houses, are used for loafing, sleeping, and rearing the young.

The average beaver colony consists of six or seven animals, usually including parents and their young of two age classes; rarely is it as large as 12.

Beavers feed on a variety of vegetation, but the inner bark of willows and cottonwood seems to be their mainstay. In summer a number of herbaceous aquatic plants and sedges are eaten. In central Texas, where willows are absent, beavers in winter utilize as first choice such trees as button willow, juniper, and pecan and rely heavily on Bermuda grass, beard grass, ragweed, and yellow water lily in summer. Thus, the plants eaten and their order of preference depend in large measure on availability.
Breeding begins in January or February, and the young are normally born in May or June after a gestation period of about 107 days. Beavers are usually monogamous, and normally only one litter of three to four young is produced each year, but some females produce a second litter in August or September.

At birth the kits are fully furred, the eyes are open, and the incisor teeth are visible; they weigh about 450 g. The tail is broad and flat, as in adults. They grow rather slowly and attain a weight of about 10 kg the first year. They mature sexually the second year. Rarely, yearling females may breed and produce young. The young often stay with the family group through the second year.

Because of the high commercial value of their pelts, beavers figured importantly in the early exploration and settlement of western North America. Thousands of their pelts were harvested annually, and it was not many years before beavers were either exterminated entirely or reduced to very low populations over a considerable part of their former range. By 1910 their populations were so low everywhere in the United States that strict regulation of the harvest or complete protection became imperative. In the 1930s live trapping and restocking of depleted areas became a widespread practice which, when coupled with adequate protection, has made it possible for the animals to make a spectacular comeback in many sections. Their value as soil and water conservationists is well-known and, in most sections of the country, appreciated. They can be destructive to crops, trees, and irrigation systems, however, in which case they can be live-trapped and removed from the area.

*Photo credit: John L. Tveten.*
Prairie Vole

Order Rodentia: Family Muridae: *Microtus ochrogaster* (Wagner)

**Description.** A dark (brownish or blackish) mouse with tail less than twice as long as hind foot, ears almost hidden in long, lax fur, and only five plantar tubercles; underparts tinged with buff. External measurements average: total length, 146 mm; tail, 34 mm; hind foot, 20 mm. Weight, 30-50 g.

**Distribution in Texas.** Known in Texas only from Hardin County in southeastern Texas, and Hansford and Lipscomb counties in the extreme northern Panhandle.

**Habits.** Prairie voles for the most part inhabit tall-grass prairies. They live in colonies, utilizing underground burrows and surface runways under lodged vegetation for concealment and protection. Their burrows are said to be shallow but complex in their ramifications and to contain large storage chambers. In farming regions they frequently take up winter quarters in shocks of corn and other small grains which offer both food and protection. Their nests are rather large structures, averaging about 20 by 10 by 10 cm in length, width, and height and may be placed either above ground or in underground chambers about 12 cm below the surface. Small hillocks of earth and pieces of grass at the entrances of burrows often indicate the presence of underground nests.

Their food is almost entirely vegetable matter including green parts of plants, seeds, bulbs, and bark, much of which they store for winter use. They also seem to relish flesh and feed on their own kind caught and killed by traps.

Their breeding habits are not well-known. They probably breed throughout the year. Gravid females have been captured in the winter months of November, January, and February. The main season, however, is in spring and summer. Apparently each breeding female produces several litters a year, the size of which varies from two to six and averages about four. At birth the young are blind, nearly naked, and helpless. They mature rather rapidly and are capable of reproducing in their first year.

**Remarks.** Previously, this vole was known in Texas on the basis of a single specimen captured at Sour Lake (Hardin County) in 1902. No additional specimens have since been encountered at this locality; however, eight specimens recently were recorded by the late J. Knox Jones, Jr., and his students at Texas Tech University from two counties (Hansford and Lipscomb) in the northern Panhandle. It is probable that this species is extirpated from southeastern Texas but a small, relic population still survives in the northern Texas Panhandle.
Golden Mouse

Order Rodentia : Family Muridae : *Ochrotomys nuttalli* (Harlan)

**Description.** A medium-sized, golden-coloured (rich ochraceous tawny), white-footed mouse with soft, thick pelage; larger than *Reithrodontomys fulvus.* and without grooves on upper incisors; feet white; underparts pale cinnamon buff; tail brownish, darker above than below. External measurements average: total length, 176 mm; tail, 78 mm; hind foot, 19 mm. Weight, 15-25 g.

**Distribution in Texas.**
Woodlands of extreme eastern Texas.

**Habits.** These small, arboreal mice are adapted to, and occur chiefly in, forested areas. Tangles of trees, vines, and brush seem to be a preferred habitat. Specimens have been trapped on dark, wooded slopes where the mice lived in nests in tangles of grapevines; others were taken in an old pasture overgrown with blackberry, wild grape and a few small trees. Near Bowie, a pair of mice was taken in a hollow, fallen tree in river bottom lands, while near Lufkin, one specimen was trapped in a pile of brush in hammock territory near the edge of the Angelina River bottom.

Their nests are constructed of grasses, Spanish moss, or leaves; lined with shredded plant fibers, or occasionally feathers; and vary in size from the small brood nest about the size of a baseball to the large "communal" nests as big as 20 by 30 cm that may house a half-dozen or more mice. One such nest housed eight mice, all males. Usually the nests are placed in trees or bushes from a few centimeters to 3 m above the ground; occasionally they are on the ground under some protective cover such as a log, a stump, a pile of brush, or they may be in cavities in standing trees.

Invertebrates make up about 50% of their diet. They also eat a variety of seeds including sumac, wild cherry, dogwood, greenbrier, poison ivy, and blackberry.

The breeding season begins in September and extends through winter and spring, with little reproductive activity during summer. The peak breeding season is in winter. Adult females may produce up to three litters annually. The young, ranging in number from two to five (average, three), are born following a gestation period of 25-30 days.

Newborn golden mice weigh about 2.7 g and are reddish with relatively smooth skin. The eyes and ears are closed at birth, but open between 11 and 14 days of age. Weaning is completed at
3 weeks and adult size is attained between the eighth and tenth weeks. The young mice are sexually mature 1-2 months after birth.

*Photo credit: John L. Tveten, courtesy of Texas A&M University Press.*
Cotton Mouse

Order Rodentia: Family Muridae: *Peromyscus gossypinus* (Le Conte)

**Description.** A medium-sized, heavy bodied, white-footed mouse; tail much shorter than head and body, between three and four times the length of hind foot and not sharply bicolor, but darker above than below; ears small (16-18 mm from notch); upperparts mummy brown, the mid-dorsal area suffused with black; sides bright russet; underparts creamy white; feet white, but tarsal joint of heel dark like leg. External measurements average: total length, 180 mm; tail, 78 mm; hind foot, 23 mm. Weight, 34-51 g.

This mouse is most easily confused with the white-footed mouse (*Peromyscus leucopus*), from which it can be distinguished by larger size (weight usually over 30 g in adults as opposed to 15-25 g in *leucopus*) and longer skull (27 mm or more in *gossypinus* and less than that in *leucopus*).

**Distribution in Texas.** Found in woodlands in eastern one-fourth of state.

**Habits.** Cotton mice are typically woodland dwellers and occur along water courses where stumps, down logs, and tangles of brush and vines offer suitable retreats; frequently they occur in woodland areas bordering open fields. They have been trapped in eastern Texas in canebrakes, under logs, and around and in old, tumbledown buildings in wooded areas. That they are adept at climbing and may live off the ground in hollows in trees as indicated by the capture of individuals in live traps set on platforms in trees.

Their other habits are not well-known. Nothing specific is known of their natural foods, although cotton mice are omnivorous. Over one-half of their diet may be made up of animal matter and food availability probably determines the dietary composition. Captive mice seemed to relish rolled oats, wheat, corn, and bread. Green foods were eaten sparingly.

Breeding may occur throughout the year although there is a decline in reproductive activity during the summer months. In Texas, most breeding commences in late August, reaches a peak in November, December, and January and subsides by early May. The gestation period is about 23 days in non-nursing females and about 30 days in females which are nursing a previous litter. Adult females may produce four or more litters a year. The litter size ranges from one to seven and averages three or four. The young are naked and blind at birth. Their ears open in 5 or 6 days at which age their incisor teeth erupt. Their eyes open in about 13 days and shortly after that they begin to eat solid foods. They are completely weaned at an age of 20-25 days. They become sexually mature at about 60-70 days of age.

The name cotton mouse was applied to the species by Le Conte, who found that the mice often used cotton for nest construction. Ordinarily, however, they do little or no damage to cotton or foodstuffs.
The Mammals of Texas - Online Edition

Eastern Harvest Mouse

Order Rodentia: Family Muridae: Reithrodontomys humulis (Audubon and Bachman)

Description. A diminutive harvest mouse like *R. montanus*, but upperparts deep brown or gray, heavily mixed with black, especially on the mid-dorsal area; ears blackish all over rather than dark at the base and light at the tip; tail about as long as head and body, the dark dorsal and light ventral stripes about equal in width. External measurements average: total length, 126 mm; tail, 61 mm; hind foot, 16 mm. Weight, 10-15 g.

Distribution in Texas. Known in the eastern part of the state, west to Fort Bend, McLennan, and Hunt counties.

Habits. The eastern harvest mouse is found mainly in habitats dominated by grasses and other herbaceous plants characteristic of early vegetational succession, including places such as abandoned fields, weed-filled ditches, and briar thickets.

Eastern harvest mice are essentially nocturnal, although at times they may be active during the daylight hours, particularly during cold weather. During periods of cold weather, these mice huddle together in the nest at night to reduce heat loss from their bodies, and they feed in the daytime when it is warmer.

*R. humulis* constructs nests of shredded grass and plant fibers that are placed on the ground in tangled herbage or above the ground in a clump of grass. The nest, which is about the size of a baseball, generally has a single entrance.

Although breeding may occur throughout the year, most births take place between late spring and late fall. Litter sizes range from one to eight (average, three to four), and the gestation period is 21-22 days. At birth the young weigh approximately 1.2 g. The eyes do not open until 7-10 days, and weaning takes place between the second and fourth weeks. The young become sexually mature and are capable of breeding at about 11-12 weeks of age.

The food habits of *R. humulis* are not well known. They appear to feed almost wholly on seeds and grain, but are known to eat grasshoppers and crickets while in captivity.

Photo credit: John L. Tweten.

http://www.nsrl.ttu.edu/tmot1/reithumu.htm
Marsh Rice Rat
Order Rodentia: Family Muridae: *Oryzomys palustris* (Harlan)

**Description.** Ratlike, with long, nearly naked, scaly tail; ears short and hairy; upperparts grizzled grayish brown, heavily lined with black, especially in winter pelage; underparts whitish. External measurements average: total length, 245 mm; tail, 116 mm; hind foot, 29 mm. Weight, 40-68 g, averaging 51 g.

**Distribution in Texas.** Found in eastern Texas west to Brazos County and south to Cameron County.

**Habits.** These rats typically inhabit marshy areas but they may be found in almost any situation where grasses and sedges offer an adequate food supply and protective cover. They are semiaquatic and do not hesitate to swim or dive to escape capture. Near Copano Bay their runways are so situated in the salt grasses and sedges that the rats have to travel in shallow water most of the time. In southeastern Texas, the rats are common on the dikes and levees thrown up in the coastal marshes. In inland areas they prefer marshes and moist meadows; occasionally they live in forested areas.

Their surface runways resemble those made by cotton rats. They are 5-8 cm in width and lead from the shallow burrows or surface nests to the feeding areas. The globular nest is composed of grasses, sedges, or weeds and frequently is placed under debris above high water in the emergent vegetation. They occasionally take over and remodel for their own use the nests of blackbirds.

The marsh rice rat is omnivorous, with about equal amounts of plant and animal matter making up the diet, although the types of food eaten varies with season and availability. Plant foods include green vegetation, fungus, and the seeds of sedges, marsh grasses, and rice. Animal foods include insects, fiddler crabs, snails, fishes, and the carcasses of small rodents and birds. It is because of their fondness for cultivated rice that they were named rice rats. In most places these rats do no damage, but in rice fields they may become economically important by consuming large quantities of rice.

They are prolific. The breeding season is nearly yearlong, during which time breeding females may bear several litters. A single female may bear five to six litters per year, although suboptimal conditions may restrict reproductive output. Litter size ranges from two to seven (average, four) but may be affected by population density as crowded conditions appear to restrict the number of young produced.

The gestation period is about 25 days. A captive female produced six litters, totaling 20
young, in 1 year — an average of 3.3 young per litter. At birth the young are blind, helpless, nearly naked, and weigh about 3 g each. They grow rather rapidly. Their eyes open on the fifth or sixth day; they are weaned on the 11th day; and sexual maturity is reached between 40 and 45 days of age. These rats appear to grow continually throughout their lifetime.

*Photo credit: John L. Tveten, courtesy of Texas A&M University Press.*
Baird's Pocket Gopher

Order Rodentia : Family Geomyidae : Geomys breviceps Baird

**Description.** Nearly identical in appearance to *G. bursarius* and *G. attwateri*. Morphologically, this species may be distinguished from *G. bursarius* by cranial characters described in the account for *G. attwateri*, but is not readily distinguishable from *G. attwateri* without genetic testing.

The most important feature for identifying this gopher is its karyotype, which has a diploid number of 74 and a fundamental number of 72. *G. breviceps* has four more biarmed elements in the autosomal complement than does *G. attwateri*. Compared to *G. bursarius*, *G. breviceps* has two more chromosomes.

*G. breviceps* is smaller than both *G. attwateri* and *G. bursarius*. External measurements average: total length, 208 mm; tail, 61 mm; hind foot, 26 mm. Dental formula as in *G. bursarius*.

**Distribution in Texas.** This pocket gopher is found in the eastern portion of Texas. The westward limits of its range in the state are from Falls County north to Fannin County, and southeastward along the Brazos River to Brazoria County.

**Habits.** The habits of *G. breviceps* are essentially the same as those described for *G. bursarius*.

These pocket gophers are polygamous, but breeding is restricted to immediate neighbors. The annual reproductive cycle in eastern Texas shows seven consecutive months of breeding activity, from February until August. A peak in production occurs in June and July, and a lesser peak in April; no young are produced from September through January. Litter size is from one to six, with an average of two or three. Females may produce two broods annually. The gestation period is 4-5 weeks and lactation lasts 5-6 weeks, after which the young leave the parental burrow. Young females may reach sexual maturity and produce a litter before the end of the breeding season.

Cellulose-digesting bacteria are known from the caecum and large intestine of *G. breviceps*, which may allow winter feeding on stored, underground rhizomes. Also, these pocket gophers re-ingest fecal pellets, which apparently increases the efficiency of food utilization.
Attwater's Pocket Gopher

Order Rodentia : Family Geomyidae : Geomys attwateri Merriam

Description. This pocket gopher closely resembles the Plains pocket gopher (Geomys bursarius) and Baird's pocket gopher (G. breviceps). Morphologically, the three are nearly identical and extremely difficult to distinguish in the field. G. attwateri is intermediate in size between G. breviceps (larger) and G. bursarius (smaller). A cranial feature used successfully in separating these species is the length of the jugal bone on the zygomatic arch compared with the width of the rostrum ventral to the infraorbital openings. In G. bursarius, the dorsal exposure of the jugal is longer than the width of the rostrum, whereas in G. attwateri and G. breviceps the dorsal exposure of the jugal is shorter than the width of the rostrum.

The best distinguishing feature is the karyotype, which in G. attwateri has a diploid number of 70 and a fundamental number of either 72 or 74. External measurements average: total length, 216 mm; tail, 62 mm; hind foot, 26 mm. Dental formula as in G. bursarius.

Distribution in Texas. From the Brazos River in eastern Texas south to southern Texas near the San Antonio River and along the coast from Matagorda to San Patricio counties.

Habits. The general habits of G. attwateri are similar to G. bursarius and G. breviceps. Attwater's pocket gopher is also an opportunistic herbivore, consuming a wide range of perennial and annual plant species. On the Welder Wildlife Refuge in South Texas, these gophers consume 41 of the 51 plant species available to them.

In contrast to the burrow systems of the plains pocket gopher, burrows of Attwater's pocket gopher tend to be more circuitous in nature. Their burrows are nonlinear and have few lateral or blind branches. This may be in response to a localized, or "clumped," distribution of resources, adaptations to low population densities, or their social structure.

G. attwateri is active at all hours of the day. Peaks in daily activity are not known.

Attwater's pocket gopher breeds from October through June with peaks in December-January and April-May. Little, if any, breeding occurs during the summer months of July, August, and September. Females produce an average of two or three young per litter and at least two litters per year.

Remarks. A small zone of contact between G. breviceps and G. attwateri occurs just west of the Brazos River in Burleson County. Of 42 gophers collected in this area, 31% had an apparent karyotype intermediate between the two species, indicating that hybridization may occur in the wild. In general, the range of G. attwateri is limited on the north by the Brazos River, although small zones of contact with G. breviceps (the range of which is limited on the south by the Brazos River) may occur where the Brazos River has periodically changed course in the past.
Eastern Flying Squirrel

Order Rodentia : Family Sciuridae : *Glaucomys volans* (Linnaeus)

**Description.** A small squirrel with flattened, bushy tail; "flying" membrane connecting front and hind legs; eyes large; upperparts nearly uniform drab or pinkish cinnamon; underparts creamy white; sides often tinged with buff; toes usually strongly marked with white in winter pelage. External measurements average: total length, 225 mm; tail, 100 mm; hind feet, 29 mm. Weight, 41-67 g.

**Distribution in Texas.** Known from wooded areas in eastern one-third of state.

**Habits.** These small, nocturnal squirrels inhabit forested areas where suitable trees are present to afford den sites. In the western parts of their range, suitable habitat is restricted largely to areas along rivers and streams. In other parts of their range, they show preference for hammocks where Spanish moss is abundant. In suitable habitat they may be more abundant than most other squirrels. They are sociable and tend to live together in groups.

Holes in stumps are preferred den sites, but the squirrels will utilize almost any cavity that is dry and large enough. Woodpecker nests are ideal, particularly those of the larger species. When such sites are not available, the squirrels construct outside nests. A clump of Spanish moss is ideal.

They feed on a variety of items, but nuts and acorns are their mainstay. They also eat insect larvae, beetles, young and eggs of birds, persimmon, and cultivated corn. The frequency with which they are caught in traps set for fur animals and baited with meat indicates a decided fondness for flesh. Food is cached in holes in trees or other places for winter use.

There are two breeding seasons, the principal one in late February and March, the other in July. However, it is not known if an individual female participates in both the spring and fall breeding periods. Captive females mate only once annually. Males are in breeding condition from late January to early September. Mating is probably promiscuous because several males will chase a female in heat. The female alone assumes responsibility for rearing the young. The gestation period is about 40 days. At birth the two or three young are blind, nearly naked, and helpless and weigh about 3 g. The membrane between the wrist and ankle is well developed. The eyes open at 26-29 days, and a week later the young begin eating solid foods. At 6 weeks of age they are old enough to fend for themselves. They reach sexual maturity when about a year old.
Flying squirrels do not actually fly, but travel by gliding from one tree to another. This is accomplished by stretching the legs to extend a membrane connecting the front and hind legs. Glides are usually only about 6-9 m in length, but may extend up to 30 m.

*Photo credit: E. P. Walker.*
ORDER CARNIVORA:

CARNIVORES

To this group belong some of our most common and best-known wild mammals — dogs, cats, bears, weasels, skunks, raccoons, and so forth.

The carnivores are nearly worldwide in distribution and occur in the native wild state on all the continents. They are absent, except for introduced domesticated kinds, from all the oceanic islands and are represented in Australia only by the dingo, a wild dog.

The habits of the group are diverse. Coyotes and wolves are terrestrial and adapted for running; martens, fishers, and cats are expert at climbing trees; the badger is adept at digging in the ground; otters are expert swimmers and spend much of their time in the water. Most forms subsist on flesh either as carrion or that freshly killed. Bears, raccoons, ringtails, coyotes, and foxes, however, feed on a variety of foods, including insects, fruits, nuts, grain, and other plant materials, as well as flesh.

Texas has a varied carnivore fauna, including 27 native and one introduced species in five families. However, at least six of these species are now extinct in the state and several others are in danger of the same fate.

Family Canidae (canids)

Coyote, *Canis latrans*
Gray Wolf, *Canis lupus*
Red Wolf, *Canis rufus*
Swift or Kit Fox, *Vulpes velox*
Red Fox, *Vulpes vulpes*
Common Gray Fox, *Urocyon cinereoargenteus*

Family Ursidae (bears)

Black Bear, *Ursus americanus*
Grizzly or Brown Bear, *Ursus arctos*

Family Procyonidae (procyonids)

Ringtail, *Bassariscus astutus*
Common Raccoon, *Procyon lotor*
White-nosed Coati, *Nasua narica*

Family Mustelidae (mustelids)
Long-tailed Weasel, *Mustela frenata*
Black-footed Ferret, *Mustela nigripes*
Mink, *Mustela vison*
American Badger, *Taxidea taxus*
Western Spotted Skunk, *Spilogale gracilis*
Eastern Spotted Skunk, *Spilogale putorius*
Hooded Skunk, *Mephitis macroura*
Striped Skunk, *Mephitis mephitis*
Eastern Hog-nosed Skunk, *Conepatus leuconotus*
Common Hog-nosed Skunk, *Conepatus mesoleucus*
River Otter, *Lutra canadensis*

Family Felidae (cats)

*Mountain Lion, Felis concolor*
*Ocelot, Felis pardalis*
*Margay, Felis wiedii*
*Jaguarundi, Felis yagouaroundi*
*Jaguar, Panthera onca*
*Bobcat, Lynx rufus*

---

**KEY TO THE CARNIVORES OF TEXAS**

1. • Catlike; total number of teeth 30 or less; claws retractile: 2
   • Not catlike; total number of teeth 34 to 42; claws usually not retractile: 7
2. • Tail 10 to 15 cm, shorter than hind foot; total number of teeth 28; upperparts reddish or grayish brown streaked with black: *Lynx rufus* (bobcat).
   • Tail 30 to 100 cm, much longer than hind foot; total number of teeth, 30: 3
3. • Upperparts concolor in adults, not spotted: 4
   • Upperparts spotted with black rosettes with light centers at all ages: 5
4. • Total length of adults up to 3 m; tail about 1 m; weight usually more than 45 kg; color tawny: *Felis concolor* (mountain lion).
   • Total length of adults up to 1 m; tail about 45 cm; weight up to 7 kg; upperparts reddish or grayish: *Felis yagouaroundi* (jaguarundi).
5. • Total length of adults 2 m or more; weight more than 45 kg: *Panthera onca* (jaguar).
   • Total length usually less than 1.2 m; weight usually less than 18 kg: 6
6. • Length of hind feet more than 120 mm; length of head and body alone about 75 cm; weight 7 to 16 kg: *Felis pardalis* (ocelot).
   • Length of hind foot less than 120 mm; length of head and body about 50 to 55 cm; weight 2 to 3 kg: *Felis wiedii* (margay).
7. • Doglike; total number of teeth, 42: 8
   • Not doglike; total number of teeth less than 42 (except in bears): 13
8. • Hind foot usually less than 170 mm; weight less than 9 kg (foxes): 9
   • Hind foot usually more than 170 mm; weight more than 9 kg (coyotes, wolves): 11
9. • Tip of tail white; upperparts yellowish or reddish; feet and lower part of legs black;
hind foot near 160 mm: *Vulpes vulpes* (red fox).
- Tip of tail black; hind foot usually less than 150 mm: 10

10. General color of body grizzled grayish; legs reddish brown; tail with black stripe on upperside and black tip; hind foot usually more than 140 mm: *Urocyon cinereoargenteus* (common gray fox).
- General color of body grayish-tan; hind foot usually less than 140 mm: *Vulpes velox* (swift or kit fox).

11. Hind foot less than 200 mm; nose pad less than 25 mm in width; weight usually less than 18 kg: *Canis latrans* (coyote).
- Hind foot more than 200 mm; nose pad more than 25 mm in width; weight usually more than 18 kg: 12

12. Hind foot more than 250 mm; general color grayish: *Canis lupus* (gray wolf).
- Hind foot less than 250 mm; general color tawny or reddish mixed with black: *Canis rufus* (red wolf).

13. Tail considerably shorter than hind foot; total number of teeth, 42; weight of adults usually more than 100 kg; color black or brown (bears): 14
- Not as above: 15

14. Claws of front feet 7 to 12 cm long; face distinctly "dished in"; ruff or mane present between shoulders; last upper molar nearly twice as large as the one in front of it: *Ursus arctos* (grizzly or brown bear).
- Claws on front feet seldom as long as 75 mm; face slightly arched or nearly straight in profile; no ruff or mane; last upper molar about 1.5 times as large as the one in front of it: *Ursus americanus* (black bear).

15. Total number of teeth, 40; tail usually with indications of alternating dark and light rings: 16
- Total number of teeth, 32 to 36; tail lacking dark and light rings: 18

16. Tail as long as, or longer than head and body with 14 to 16 alternating black and white rings and a black tip; hind foot less than 80 mm; weight 1 to 2 kg: *Bassariscus astutus* (ringtail).
- Tail shorter than head and body and with six to seven alternating dark and light rings or rings inconspicuous; hind foot of adults 85 mm or more: 17

17. Snout extending conspicuously beyond mouth and highly flexible; tail about five times as long as hind foot; alternating rings obscured in adults: *Nasua narica* (white-nosed coati).
- Snout not extending conspicuously beyond mouth; tail two to three times as long as hind foot, rings conspicuous at all ages: *Procyon lotor* (common raccoon).

18. Upperparts black with longitudinal white stripe or stripes (skunks): 19
- Upperparts not black and white striped: 24

19. Total number of teeth, 32; back with single, broad white stripe from head to tail; nose pad large and flexible (hog-nosed skunks): 20
- Total number of teeth, 34; back normally with two or more white stripes; nose pad normal: 21

20. Total length of adults 700 mm or more; hind foot, 75 mm or more: *Conepatus leuconotus* (eastern hog-nosed skunk).
- Total length of adults usually less than 600 mm; length of hind foot usually less than 70 mm: *Conepatus mesoleucus* (common hog-nosed skunk).

21. Six distinct broken or continuous white stripes on anterior part of body; white spot in center of forehead; hind foot seldom more than 50 mm: 22
Not as above: 23

22. Black and white stripes on back nearly equal in width; white spot on forehead large, covering more than half of the area between the eyes; white stripes beginning between the ears or just behind them: Spilogale gracilis (western spotted skunk).
   Black stripes on back wider than the white ones; white spot on forehead small, seldom more than 15 mm in diameter; white stripes on back begin about 25 mm behind the ears: Spilogale putorius (eastern spotted skunk).

23. Dorsal white stripe bifurcate; sides black: Mephitis mephitis (striped skunk).
   Dorsal stripe white or black but never bifurcate; sides usually with narrow white stripe beginning at ear: Mephitis macroura (hooded skunk).

24. Total number of teeth, 36; feet webbed; tail long, heavy, tapering; ears short; color chocolate brown; total length 1 m or more: Lutra canadensis (river otter).
   Total number of teeth, 34; feet not webbed; total length less than 1 m: 25

25. Tail about as long as hind foot; claws on front feet about 25 mm in length and much longer than those on hind foot; body thick-set, heavy; fur lax and long: Taxidea taxus (American badger).
   Tail noticeably longer than hind foot; body long and slender; fur relatively short: 26

26. Color chocolate brown to black; midline of belly white: Mustela vison (mink).
   Color yellowish brown; head usually with black and white markings; tip of tail black and contrasting markedly with rest of tail: 27

27. Feet brown or tan; hind foot 50 mm or less; weight 500 g or less: Mustela frenata (long-tailed weasel).
   Feet black; hind foot more than 50 mm; weight 500 to 1,500 g: Mustela nigripes (black-footed ferret).
Coyote

Order Carnivora: Family Canidae: *Canis latrans* Say

**Description.** A medium-sized, slender, doglike carnivore, similar in appearance to the red wolf* but usually smaller, more slender, with smaller feet, narrower muzzle, and relatively longer tail; colors usually paler, less rufous, rarely blackish; differs from gray wolves in much smaller size, smaller feet and skull; upperparts grizzled buffy and grayish overlaid with black; muzzle, ears and outsides of legs yellowish buff; tail with black tip, and with upperpart colored like back. Dental formula: I 3/3, C 1/1, Pm 4/4, M usually 2/2, occasionally 3/3, 3/2, or 2/3 X 2 = 40, 42, or 44. External measurements average: total length, 1,219 mm; tail, 394 mm; hind foot, 179 mm. Weight, 14-20 kg.

**Distribution in Texas.** Statewide.

**Habits.** Although often called "prairie wolf," the extensive range of the coyote includes from sea level to well over 3,000 m and habitats ranging from desert scrub through grassland into the timbered sections of the West. Around the turn of the century, coyotes were not known in eastern Texas, where red wolves were common. Land use in this area, including intensive lumbering and agriculture, as well as intensive predator control, eradicated the wolves and now coyotes have expanded their range to also include that part of the state.

The basic social unit is the family group, comprised of a mated pair and their offspring. Nonfamily coyotes include bachelor males, nonreproductive females, and near-mature young. They may live alone or form loose associations of two to six animals. One animal in such "packs" usually is dominant, but the interaction among pack members is only temporary.

Coyotes may be active throughout the day, but they tend to be more active during the early morning and around sunset. Their movements include travel within a territory or home range, dispersal from the den, and long migrations. The home range size of coyotes varies geographically, seasonally, and individually within populations.

The food habits of coyotes are varied. They are opportunists and make use of anything that can be eaten — garbage, carrion, fresh meat in the form of both wild and domestic animals, insects, frogs, snakes, fruits, melons, and so forth. Although coyotes prey on poultry and the smaller livestock, their natural foods consist largely of rabbits, rodents, and carrion. Charles Sperry analyzed 8,339 stomachs of coyotes from the western United States with the following...
results (expressed in percentages): rabbits, 33; carrion, 25; rodents, 18; domestic livestock (chiefly sheep and goats), 13.5; deer, 3.5; birds, 3; insects, 1; other animal matter (skunks, weasels, shrews, moles, snakes, and lizards), 1; vegetable matter, 2.

Nursery dens are usually located in brush covered slopes, steep banks, thickets, hollow logs, or rock ledges. One den was in a hollow cottonwood tree with the entrance 5 m above the ground. Access to this unusual den was gained by means of a large limb that sloped to the ground. They are also known to den in crevices and shallow caves in rocky bluffs. Rarely is no den provided for the young.

The breeding season begins in January, reaches its peak in late February or early March, and terminates by the middle of May. Coyote mates maintain a close social bond throughout the year, although when the female is in late pregnancy the male often hunts alone and brings food to his mate. One litter a year is the rule. Normal litter size is two to 12, averaging about six. The gestation period is approximately 63 days. At birth, the young are blind and helpless. The eyes open at about 9 days of age and by October or November the young are difficult to distinguish from their parents.

Few coyotes live more than 6-8 years in the wild. Losses are due mainly to predation, parasites and disease, and man. Mortality is particularly high for pups, who are vulnerable to hawks, owls, eagles, mountain lions, and even other coyotes. Hunting and trapping account for many adult deaths. In terms of economic importance, the coyote is the second most important fur-bearing animal in the state, exceeded only by the raccoon.

* see the Red Wolf species entry for a detailed comparison of the two animals.

Photo credit: John L. Tveten.
Common Gray Fox

Order Carnivora : Family Canidae : *Urocyon cinereoargenteus* (Schreber)

**Description.** A medium-sized fox with grayish upperparts, reddish brown legs, tawny sides, and whitish throat, cheeks and mid-line of belly; sides of muzzle and lower jaw with distinct blackish patch; tail with distinct blackish stripe on upperside and black tip (no white on end of tail as in the red fox); tail roughly triangular, not round, in cross section; skull with distinct lyrate temporal ridges, which meet only at hind part of skull. Dental formula as in the red fox.

External measurements average: total length, 970 mm; tail, 347 mm; hind foot, 143 mm. Weight, ordinarily 3-5 kg, occasionally as much as 9 kg.

**Distribution in Texas.** Statewide.

**Habits.** The gray fox is essentially an inhabitant of wooded areas, particularly mixed hardwood forests. It is common throughout the wooded sections east of the shortgrass plains and in the pinyon-juniper community above the low lying deserts.

This fox is adept at climbing trees, particularly if they are leaning or have branches within 3 m of the ground, and it is not unusual for it to use this escape device when pursued by hounds. Contrary to common belief, gray foxes are not strictly animals of the night, but they are much more active then. They have been observed on many occasions in the daytime under conditions that suggested they were foraging. When so encountered, they often move to one side behind a protecting screen of vegetation and wait for the intruder to pass.

Gray foxes usually den in crevices in the rocks, in underground burrows, under rocks, in hollow logs, or in hollow trees. In eastern Texas, one was found denning about 10 m above the ground in a large hollow oak. In central Texas, a den was found in a hollow live oak with the entrance about 1 m above the ground. Two unusual den sites which have been documented include a pile of wood and a field of sorghum into which a fox had "tunnelled."

The gray fox is omnivorous; the food varies with season and availability. Based upon the stomach contents of 42 foxes from Texas, the winter food consisted chiefly of small mammals (cottontails, cotton rats, pocket gophers, pocket mice), 56%; followed by insects, largely grasshoppers, 23%; and birds (ducks, quail, sparrows, blackbirds, towhees), 21%. In the spring the diet was but slightly changed — small mammals, 68%; insects, 25%; small birds, 17%. In late summer and fall, persimmons and acorns led with 30%; insects, 26%; small mammals, 16%; birds, 14%; crayfish, 14%. In these 42 stomachs, chicken and quail occurred once each,

http://www.nsrl.ttu.edu/tmot1/uroccine.htm
and mourning doves twice. Consequently, as judged from these analyses, the usual food habits of the gray fox do not conflict much with man's economy.

In Texas, the breeding season begins in December and continues on into March. Most females captured in March and April are gravid. The three to six pups are born in April or May after a gestation period of about 53 days. At first they are blind and helpless, but they grow rapidly and soon leave the home nest, possibly because of the heavy infestation of fleas characteristic of such nests. Then they seek shelter in rock piles, under rocks, in piles of brush, or in other sites that offer concealment and protection.

Of some interest is the possible relationship between gray foxes and coyotes. In sections of Texas where coyotes formerly were numerous, the gray fox was scarce; now, after elimination of the coyote, the gray fox has become abundant. Perhaps the coyote tends to hold this fox in check under conditions where they both occupy the same area.

Gray foxes are thought to live six to 10 years in the wild. Major factors causing mortality include predation, parasites, diseases, and man. The gray fox is among the most important of Texas' fur-bearing animals.

Photo courtesy of U.S. Fish and Wildlife Service.
Red Fox*  
Order Carnivora: Family Canidae: *Vulpes vulpes* (Linnaeus)

Gray fox but conspicuously different in color and in cranial characters. Considerably larger and more reddish than the *swift fox*. Tail a thick "bush," circular in cross section, and white-tipped; face rusty fulvous, grizzled with white; upperparts bright golden yellow, darkest along middle of back; chin, throat and mid-line of belly white; forefeet and legs to elbow black; black of hind feet extends as a narrow band along outer side of leg to thigh; backs of ears black. Several color phases — cross, black, silver, Sampson, and the normal red. Young duller in color than adults. Dental formula: I 3/3, C 1/1, Pm 4/4, M 2/3 X 2 = 42. External measurements average: total length, 972 mm; tail, 371 mm; hind foot, 163 mm; females average slightly smaller than males. Weight, 3-5 kg.

**Distribution in Texas.** Introduced in eastern and central parts of state. Now ranges across central Texas from eastern part of the state to central Trans-Pecos region.

**Habits.** Red foxes are not native to Texas, having been introduced for purposes of sport around 1895. Today, red foxes occur throughout central and eastern Texas, but they do not seem to be common anywhere. Their favored habitat is mixed woodland uplands interspersed with farms and pastures. Although usually active at night, the red fox moves about considerably in daylight hours and occasionally may be observed then, especially if the observer is alert and still. The den is usually an underground burrow, a crevice in a rocky outcrop, or a cavity under boulders. Occasionally, the burrow of some other animal, such as the badger, is taken over and remodeled to suit the new occupants.

Red foxes are opportunistic feeders and will take any acceptable food in proportion to its availability. The major food items are small rodents, rabbits, wild fruits and berries, and insects. Small mammals evidently constitute staple foods during the greater part of the year. Other kinds of prey fluctuate according to season, weather conditions, abundance, and vulnerability of prey populations, and with the experience of the fox. Young animals learning to hunt have to take what they can get.

Female red foxes have a single estrous each year and reputedly remain mated for life. Males and females pair off and mate from late December to January or February. Females have a very short period of heat that lasts only 2-4 days. The young, which may number anywhere from one to 10 (average, four to six), are born in March or April following a gestation period of about 53 days.
The female establishes the den site for the young in late winter, but both parents live together while raising the young. Foxes either dig their own dens or utilize those of other burrowing animals. Sometimes two litters may occupy one den.

The young at birth are dark brown or black in color, but the tip of the tail is white. They are blind and helpless; the eyes open at the age of 8 or 9 days. They seldom venture out of the den until they are a month old, and the den may also be their refuge for the next 2 months or longer. The parents are solicitous of the pups, bringing them food and guarding the den. The family remains together until autumn, by which time the young have attained almost adult proportions.

Few foxes live beyond the age of 3 or 4 years, particularly in areas where they are hunted and trapped heavily. Man and domestic dogs are their major predators, although pups may be lost to great horned owls and other predators. Red foxes are susceptible to a variety of diseases, including rabies, distemper, and infectious canine hepatitis.

* nonnative species

*Photo credit: John L. Tveten.*
Mink

Order Carnivora: Family Mustelidae: *Mustela vison* Schreber

**Description.** A weasel-like carnivore about the size of a house cat and semi-aquatic in habit; general color dark chocolate brown, darkest on back, and nearly black on feet and end of tail; underparts paler than back, with considerable white on midline from chin to vent; neck long, head hardly larger around than neck; tail long and moderately bushy; eyes and ears small; legs short; pelage soft and dense, overlaid with longer, blackish guard hairs. Dental formula as in the weasel. External measurements of an adult male: total length, 560 mm; tail, 190 mm; hind foot, 67 mm; of a female, 540-180-60 mm. Weight (males), 680-1,300 g; (females), 450-700 g.

**Distribution in Texas.** Known from eastern one-half of state westward to northern Panhandle in habitats near permanent water.

**Habits.** Mink are closely associated with the waterways and lakes of North America, but the smaller streams are preferred to the large, broad rivers. Along the coast they frequent the brackish marshes and, on occasion, the littoral area adjacent to the ocean. They are most common along streams partly choked by windfalls and other debris which create numerous water holes and at the same time offer concealment for the mink. Lake and marsh-dwelling mink are usually larger than those that live along streams.

- Mink are active throughout the year. They are tireless wanderers and may travel several kilometers in their search for food.

- The den is usually a retreat under the roots of a tree near the water, in a hole in the bank of a stream, in a pile of debris choking a stream, or in the houses of muskrats, which they kill or otherwise evict from their dens.

- Their food consists of a wide variety of animals which they usually capture and kill. The fact that they are attracted to traps by carcasses of birds and other animals suggests that they also feed on carrion. Fish, frogs, clams, freshwater mussels, snakes, rats and mice, ground squirrels, muskrats, and birds constitute their main diet.

- Mink are polygamous. The mating season is in January, February, and March and the four to eight young are born after a gestation period of from 39 to 76 days. At birth the young are blind, helpless, and covered with a coat of fine, short, silvery-white hair. They weigh about 6 g. When they are about 2 weeks old, the whitish hair is replaced by a dull, fluffy, reddish brown coat which, late in the year, is replaced by the adult pelage. Their eyes open at about 37
days of age and they leave the nest for the first time when about 7 weeks old. They are weaned when 8 or 9 weeks of age, at which time they weigh about 350 g. When about 5 months old, they are as large as adults.

The mink is one of the principal fur-bearing animals in the eastern United States and is one of the few animals that can be reared economically on fur farms. This is not the case in Texas, however, where mink ranked only thirteenth in numbers of individuals harvested and ninth in economic value to trappers during the 1988-89 trapping season, as determined in a survey conducted by the Texas Parks and Wildlife Department.

*Photo credit: Donald F. Hoffmeister, courtesy of Museum of Natural History, University of Illinois.*
Common Raccoon

Order Carnivora : Family Procyonidae : *Procyon lotor* (Linnaeus)

**Description.** A robust, medium-sized carnivore with distinctive, blackish facial mask outlined with white, and with alternating black and buff (or whitish) rings on the bushy tail; tip of tail black; general color of upperparts grayish, suffused with orange, and heavily sprinkled with blackish buff; top of head mixed gray and brownish black, giving a grizzled effect; throat patch brownish black; rest of underparts brownish, thinly overlaid with light orange buff; limbs similar to underparts, but becoming whitish on feet except for dusky marking near heels; the complete hind foot touches the ground when the animal walks; five toes on each foot, claws non-retractile; soles naked; pelage coarse, long, and full. Young like adults, but fur "woolly." Molar teeth "flat"-crowned and adapted for crushing, not for cutting as in dogs and cats. Dental formula: I 3/3, C 1/1, Pm 4/4, M 2/2 X 2 = 40. External measurements of adult male: total length, 880 mm; tail, 265 mm; hind foot, 125 mm; a female 834-243-123 mm. Weight, 4-13 kg.

**Distribution in Texas.** Statewide.

**Habits.** Raccoons are primarily inhabitants of broadleaf woodlands, although they are rather common in the mixed-pine forests of southeastern Texas. They seldom occur far from water, which seems to have more influence on their distribution than does any particular type of vegetation. Still, they are one of the most abundant carnivores in the semi-desert areas of West Texas.

They are strictly nocturnal and seldom are seen except when hunted with dogs or caught in traps. Their fondness for water is well-known and, except in seasons when fruits, nuts, and corn are maturing, they do most of their foraging near or in bodies of water. They often make well-worn trails at the water's edge where they have been searching for food.

The den is usually a large hollow tree or hollow log in which the animal spends the daylight hours sleeping and in which it also rears its young. In the western part of the range, dens usually are in crevices and crannies in rocky bluffs, but hollow trees are used when available. Several unusual nesting sites have been reported in the literature. In eastern Texas, a female and her three newborn young were found in a nail keg that had been fashioned as a nest site for wood ducks and wired 5 m up in a tree standing in water some 6 m from shore. A young raccoon was seen using a crow's nest some 6 m up in a willow tree as a daytime bed. Near Parker, Colorado, a raccoon and her naked and blind young occupied a large magpie nest located about 4 m above the ground in a scrub oak.
In the colder parts of their range, raccoons are said to "hibernate" during periods of inclement weather. This appears to be mere "holing up and sleeping," and not true hibernation. Raccoons do not exhibit the marked physiological changes — reduced temperature, reduced rate of respiration and heart beat, insensitivity to pain — that characterize true hibernation.

The crushing type of molars indicates that raccoons are not specialized feeders. Stomach and fecal analyses bear out this assumption. In eastern Texas, acorns and crayfish constitute more than half their yearly diet and both are consumed in considerable quantities at all seasons. Grapes and persimmons are utilized when available and other fruits in smaller amounts. Insects and other invertebrates form an important part of the diet. Fish, birds, and snakes are taken occasionally. In summer and early autumn raccoons develop a fondness for adult and larval wasps and their stored foods. In winter they concentrate in the river bottoms and subsist largely on acorns and crayfish.

The breeding season begins in February and continues through August. The single litter of one to seven (average three or four) young usually is born in April or May after a gestation period varying from 60 to 73 days (average, 63 days). Raccoons are promiscuous in their sexual relations.

At birth, young raccoons are well-furred and have dark skins, no rings on the tail, and the eyes and ears are closed. The eyes open between the 18th and 23rd day. The mother alone tends her youngsters, and when they have grown large enough to leave the den site they follow her about, seeking shelter when necessary in tangles of roots or vines, in crevices, or under rocks. The family group remains intact long after the young ones have been weaned. The young do not reach adult size until their second year but females, at least, reach sexual maturity when 9 or 10 months old; males appear to mature sexually when about 2 years old.

*Photo credit: John L. Tveten.*
Stripped Skunk

Order Carnivora : Family Mustelidae : Mephitis mephitis (Schreber)

Description. A medium-sized, stout-bodied skunk with two white stripes on sides of back that join each other in the neck region and extend onto the head anteriorly and onto each side of the tail posteriorly (note varying patterns in photo at right); tip of tail black; two large scent glands, one on each side of the anus, produce the characteristic skunk musk; ears short, rounded; eyes small; five toes on each foot, front ones armed with long claws; hind feet with heel almost in contact with ground; tail long and bushy; pelage long, coarse and oily. Dental formula as in the spotted skunk. Sexes colored alike, but males usually larger than females. External measurements average: (males), total length, 680 mm; tail, 250 mm; hind foot, 90 mm; (females), 610-225-65 mm. Weight, 1.4-6.6 kg, depending on age and amount of fat.

Distribution in Texas. Statewide.

Habits. Striped skunks are inhabitants of wooded or brushy areas and their associated farmlands. Rocky defiles and outcrops are favored refuge sites, but when these are absent the skunks seek out the burrows of armadillos, foxes, and other animals. In central Texas, favored refuge sites are under large boulders.

These skunks are largely nocturnal and seldom venture forth until late in the day; they retire to their hideouts early in the morning. One of us (Davis) has seen striped skunks abroad in midday only twice, and in each instance a female was trailing her family of third-grown youngsters in single file across a meadow to a patch of woodland beyond.

In late fall they become exceedingly fat. In Texas, they are abroad throughout the year and seemingly more active in winter than in the heat of summer. They are social creatures; often several individuals occupy a well-situated winter den. J.D. Bankston of Mason, Texas informed us that he removed as many as seven striped skunks from one winter den and that one of his neighbors found 10 in one den in December. These may have constituted family groups.

Striped skunks are not choosy in their food habits. In Texas, their seasonal food, as judged from the analyses of 79 viscera, is as follows (expressed in percentages): Fall — insects, 76; arachnids, 24. Winter — insects, 52.3; arachnids, 5.3; reptiles, 1.6; small mammals, 18.3; vegetation, 22; birds and millipedes making up the balance. Spring — insects, 96; reptiles, 1.6; small mammals, 2; vegetation and small birds making up the balance. Summer — insects, 88; arachnids, 4; reptiles, 1.5; small birds, 3.5; centipedes, small mammals, and vegetation making up the balance.
Breeding begins in February or March. After a gestation period of about 63 days, the three to seven (average, five) young are born. In Texas, most of the young appear in the first half of May. There is some evidence that two litters may be born to certain females, but one litter seems to be the general rule. The nursery is a cavity under a rock, a burrow, or a thicket of cactus or other protective vegetation. Usually the mother builds a nest of dried grasses and weed stems for the blind, helpless young. The young remain in the nest until their eyes are open and they are strong enough to follow their mother.

Striped skunks have few natural enemies. Owl, hawks, coyotes, bobcats, foxes, and dogs may occasionally take one, but most predators are repulsed by the odor of their musk. Striped skunks are highly susceptible to being struck by vehicles, and road-killed animals are commonly seen along highways throughout Texas. Individuals seldom live more than two years in the wild.

When disturbed or startled, skunks utter a peculiar purring sound and often growl when attacked by man. They typically express their anger by rising upon their hind feet, lurching forward, stamping both front feet, and at the same time clicking their teeth. The expelling of musk generally follows this behavior.

Their fur is the most valuable of all the skunks. They are easily reared on fur farms, but the relatively low value of their pelts does not make such a practice economically worthwhile.

*Photo credit: D. W. Lay.*
Eastern Spotted Skunk

Order Carnivora : Family Mustelidae : Spilogale putorius (Linnaeus)

**Description.** A small, relatively slender skunk with small white spot on forehead and another in front of each ear, the latter often confluent with dorsolateral white stripe; six distinct white stripes on anterior part of body, the ventrolateral pair beginning on back of foreleg, the lateral pair at back of ears, the narrow dorsolateral pair on back of head; posterior part of body with two interrupted white bands; one white spot on each side of rump and two more at base of tail; tail black except for a small terminal tuft of white; rest of body black; ears short and low on side of head; five toes on each foot, the front claws more than twice as long as hind claws, sharp and recurved. Dental formula: 1 3/3, C 1/1, Pm 3/3, M 1/2 X 2 = 34. External measurements average: (males), total length, 515 mm; tail, 210 mm; hind foot, 49 mm; (females), 473-170-43 mm. Males weigh about 680 g; females, about 450 g.

**Distribution.** Occurs in eastern one-half of state east of the Balcones Escarpment, westward through north-central Texas, to the Panhandle as far south as Garza County.

**Habits.** Spotted skunks are much more active and alert than any of the other skunks. They occur largely in wooded areas and tall-grass prairies, preferring rocky canyons and outcrops when such sites are available. They are less common in the short-grass plains. In areas where common, they have a tendency to live around farmyards and often den under or in buildings.

Their den sites are varied. In rocky areas they prefer cracks and crevices in the rocks or a burrow under a large rock. Since they are expert climbers, they occasionally den in hollow trees or in the attics of buildings. In settled communities they frequently live under buildings, in underground tile drains and in underground burrows. They are almost entirely nocturnal and seldom are seen in the daytime.

Their food habits are largely beneficial to the agriculturist although they can do considerable damage to poultry if they develop a taste for such food. Their seasonal natural foods consist of: winter — cottontails and corn; spring — native field mice and insects; summer — predominantly insects, with smaller amounts of small mammals, fruits, birds, and birds' eggs; fall — predominantly insects, with small amounts of mice, fruits, and birds. They are excellent rat-catchers and can soon rid a barn of these pests.

Mating occurs in March and April. Some females possibly mate again in July and August and produce a second litter. The gestation period is estimated to be 50-65 days, and no known period of delayed implantation exists. The number of young in a litter may range from two to
nine, but the usual litter consists of four or five young.

At birth the young are blind, helpless, and weigh about 9 g each; the body is covered with fine hair. The black and white markings are distinct. Their eyes open at the age of 30-32 days; they can walk and play when 36 days old; emit musk when 46 days old; and are weaned when about 54 days old. When 3 months old they are almost as large as adults. Sexual maturity is reached at the age of 9-10 months in both sexes.

Their enemies, other than man, include dogs, coyotes, foxes, cats, bobcats, and owls. Their defensive behavior consists of a rapid series of handstands, which serve as a warning device to aggressors. If approached too closely, they drop to all fours in a horseshoe-shaped stance, lift their tail, and direct their anus and head toward the potential aggressor. The foul-smelling musk can be accurately discharged for a distance of 4-5 m.

*Photo credit: John L. Tveten.*
River Otter

Order Carnivora: Family Mustelidae: Lutra canadensis (Schreber)

Description. A large, dark brown "weasel" with long, slender body; long, thick, tapering tail; webbed feet; head broad and flat; neck very short; body streamlined; legs short, adapted for life in the water; five toes on each foot, soles more or less hairy; pelage short and dense; upperparts rich, glossy, dark brown, grayish on lips and cheeks; underparts paler; tinged with grayish. Dental formula: I 3/3, C 1/1, Pm 4/3, M 1/2 X 2 = 36. External measurements average: total length, 1,168 mm; tail, 457 mm; hind foot, 124 mm. Weight, 6-7 kg, occasionally as much as 10 kg.

Distribution in Texas. Presently known only from eastern one-fourth of state in major watersheds; probably extirpated from the Panhandle, north-central, and southern Texas.

Habits. River otters are largely aquatic and frequent lakes and the larger streams. In the Gulf Coast region, marshes, bayous, and brackish inlets afford suitable range. They are expert swimmers and divers and can remain underwater for several minutes if necessary. They are not bound to water, however, and when occasion demands they do not hesitate to travel overland from one body of water to another. Their movements on land appear awkward. The long body is arched and supported by four short legs and reminds one somewhat of a "measuring" worm.

The slides and apparent playfulness of otters are well-known. The slide, situated on some steep clayey bank, seems to be used chiefly for "recreational" purposes. The otters play "follow the leader" in tobogging, with front legs folded back, from the top of the slide into the water below.

Otters are notorious wanderers in their chosen habitat and an animal may range over several kilometers of a waterway. For this reason they are never abundant in any locality. They are ordinarily shy, unobtrusive creatures that are seldom seen even though they are active throughout the year.

The den varies with the locality and availability of sites. Most otters locate their dens in excavations close to water under tree roots, rock piles, logs, or thickets. The hollow bases of cypress trees and tupelo gums are especially popular. Occasionally, they will take over beaver lodges or muskrat dens for their own use after killing the occupants. A typical den consists of a hole leading into a bank, with the entrance below water level. Otters may occupy two dens, one as a temporary resting den and the other as a permanent nesting den.
Otters are not specific in their food habits. Their main diet consists of fish, crustaceans, mollusks, amphibians, reptiles, invertebrates, birds, and mammals. One of their choicest morsels is crayfish, and where they are abundant, an otter will consume a tremendous number annually. The fish they eat are primarily rough fish.

Virtually nothing is known about their reproduction in Texas. They probably breed in fall, but males do not generally mate until they are four years of age, and females rarely breed before two years. Males typically engage in fierce combat during the mating season, and they are believed to be solitary except when accompanying estrous females. Estrous lasts 40-45 days, and the female is receptive to the male at about six-day intervals. Mating usually occurs in the water. Delayed implantation results in the gestation period extending to as much as 270 days. Litter size varies from one to five, with two about average. Females may mate again as soon as 20 days following birth, which means that otters may remain continuously pregnant once they reach sexual maturity.

Newborns are about 275 mm in total length and weigh about 130 g. They are fully furred, but the eyes are closed and none of the teeth are erupted. Their eyes open at 22-35 days, and they are weaned at 18 weeks. The adult waterproof pelage appears after about 3 months.

*Photo credit: John L. Tveten.*
Bobcat

Order Carnivora: Family Felidae: *Lynx rufus* (Schreber)

**Description.** A medium-sized, short-tailed, reddish brown or grayish cat about the size of a chow dog; upperparts reddish brown, streaked with black; underparts whitish, spotted with black; back of ears black-rimmed, with white in center; ears usually slightly tufted; hair on sides of head long, producing a ruff; pelage elsewhere rather short; tail usually shorter than hind foot; the tip black above and white below, with three or four blackish bars above just in front of tip; legs relatively long; feet large, with five toes in front, four behind. Dental formula: I 3/3, C 1/1, Pm 2/2, M 1/1 X 2 = 28. External measurements average: (males); total length, 870 mm; tail, 146 mm; hind foot, 171 mm; females, 772-144-158 mm. Weight of adults, 5-9 kg, occasionally as much as 16 kg in old animals.

**Distribution in Texas.** Statewide.

**Habits.** Bobcats occupy a variety of habitats, but they have a decided preference for rocky canyons or outcrops when such are available. In rockless areas they resort to thickets for protection and den sites. They are associated more commonly with pinyon pines, junipers, oak, or chaparral in Texas but they also occur in small numbers in open pine forests. These cats are highly adaptable and in most places have been able to cope with the inroads of human settlement.

Shy and retiring, they are active largely at night although they frequently leave cover and begin hunting long before sundown. In hilly country, their presence can often be detected by their habit of dropping their feces on large rocks on promontories or ridges. Also, like the mountain lion, the males make scrapes — small piles of leaves, sticks, and so forth on which they urinate — along their travel routes, but these scrapes are smaller. They den in crevices in canyon walls, in boulder piles, or in thickets. The dens can be readily recognized by the strong odor emanating from them. Expert at climbing trees, bobcats seek refuge in them when available.

Their food consists mainly of small mammals and birds. The stomachs of 118 bobcats contained the following (expressed in percentages): mammals, 65.8 (44.5 of which were harmful species, 20.5 beneficial, 1.1 neutral); birds (bait), 3.1; fish (bait), 0.6; unidentified
foods, 3.1; miscellaneous material (not food), 27.1. Among the mammals, wood rats, ground squirrels, mice, and rabbits supply the bulk of the diet. Although deer occasionally are killed and eaten, most of the deer meat found in bobcat stomachs has been carrion. They also prey upon domestic sheep, goats, and poultry but the damage done is rarely great.

The breeding season begins usually in February, and after a gestation period of about 60 days the two to seven young are born. Average litter size is three. The young are well-furred and spotted at birth; their eyes open in about 9 days. The kittens are weaned when about 2 months old. They remain with their mother until early fall, at which time they begin to fend for themselves. Females do not breed during their first year, but they may mate between their first and second years and breed annually afterwards until 8-9 years of age.

*Photo courtesy of Texas Parks and Wildlife.*
ORDER ARTIODACTYLA:

EVEN-TOED UNGULATES

This Order is characterized by either two or four (usually) hoofed toes on each foot, with the exception of the peccary which has four toes on each forefoot, but only three on the hind. The American forms of the order are readily divisible into two groups on the basis of structure of the teeth, presence or absence of horns, and structure of the stomach and feet. The pig group has crushing cheek teeth, upper incisors, a simple stomach, no horns, four hoofed toes, and includes the peccaries. The cow group has rasping cheek teeth, no upper incisors, two or four hoofed toes on each foot, complex stomach, and horns or antlers in most species. It includes the deer, elk and allies; cows and allies; and the pronghorn.

Seven species of artiodactyls are native to Texas although three of these — the mountain sheep, bison, and American elk have been extirpated. Recent reintroductions of these big game animals account for their current presence in the state. In addition, 123 species of ungulates not native to Texas have been imported into the state since 1930. For the most part, these "exotic" animals have been confined on private ranches; however, seven species have escaped, reproduced, and now exist in parts of Texas as free-ranging, feral populations that comprise a part of the local fauna. As the possibility of sighting, or for finding the remains of, these unusual animals mounts yearly in Texas, accounts for the most common exotics have been included in this revision. Accounts of exotics are adapted from the book, Taxotics, by Elizabeth Cary Mungall and William J. Sheffield, Texas A&M University Press, College Station, Texas.

Family Suidae (pigs)

Feral Pig, Sus scrofa

Family Dicotylidae (peccaries)

Collared Peccary, Tayassu tajacu

Family Cervidae (cervids)

Axis Deer, Cervus axis
Fallow Deer, Cervus dama
Wapiti or Elk, Cervus elaphus
Sika Deer, Cervus nippon
Mule Deer, Odocoileus hemionus
White-tailed Deer, Odocoileus virginianus

Family Antilocapridae (pronghorn)

Pronghorn, Antilocapra americana
Family Bovidae (bovids)

- Nilgai, *Boselaphus tragocamelus*
- Bison, *Bos bison*
- Mountain Sheep, *Ovis canadensis*
- Barbary Sheep, *Ammotragus lervia*
- Blackbuck, *Antilope cervicapra*

---

**KEY TO THE EVEN-TOED UNGULATES OF TEXAS**

1. Medium size; body form stocky and barrel-like; head long and pointed with very short neck; legs short; snout with terminal nasal disc (piglike); upper incisors present: 2
- Large size; body form slender or cowlike; head with well developed neck; legs long; snout never piglike; upper incisors absent: 3

2. Sparsely covered with coarse bristly hair; some individuals with a scantily haired dorsal mane; tail approximately 300 mm in length; each foot with four toes (the middle two are flattened and have hooves, whereas the lateral toes are higher up on the limb and do not normally touch the ground); adult weight up to 350 kg: *Sus scrofa* (feral pig).
- Pelage thick and bristly; well developed dorsal mane of long, stiff hairs extending along back from crown to rump; tail length 15-55 mm; front feet with four toes, hind feet with three toes; adult weight 14-30 kg: *Tayassu tajacu* (collared peccary).

3. Two toes on each foot; males with prominent, forked horns; horn sheaths shed annually; females usually with smaller horns that do not shed annually: *Antilocapra americana* (pronghorn).
- Four toes on each foot; horns or antlers present: 4

4. Males (rarely females) with branching antlers that are shed annually. Family Cervidae: 5
- Males and females (except in nilgai) with backward curving, unbranched horns no part of which is shed: 10

5. Adults with reddish, brown, or dark brown pelage generally heavily speckled with white spots: 6
- Adults with unspotted pelage (juveniles often spotted): 8

6. Antlers flattened, palmate, and with numerous points: *Cervus dama* (fallow deer).
- Antlers not palmate: 7

7. Antlers 75-100 cm in length along outer curve; normally with only three tines; brow tines project outward to form a nearly 90° angle with main beam: *Cervus axis* (axis deer).
- Antlers 25-48 cm in length; normally with 3 or 4 tines branching from main beam: *Cervus nippon* (sika deer).

8. Large size (cow size); conspicuous white or cream colored rump patch; upper canine teeth normally present: *Cervus elaphus* (wapiti or elk).
- Medium size; white rump patch reduced; upper canine teeth absent: 9

9. Antlers usually equally branched (dichotomous) and normally with five or more tines per side, including brow tine; metatarsal gland on hind leg narrow and
elongate, 75-125 mm long, and situated above mid point of shank; tail narrow at base: *Odocoileus hemionus* (mule deer).

- Antlers with all tines branching off the main beam in a nearly vertical position; metatarsal gland on hind leg nearly circular and about 25 mm or less in diameter; tail broad at base, when alarmed held erect to show conspicuous white "flag." *Odocoileus virginianus* (white-tailed deer).

10. Large size; body form stocky and compact ("cowlike"); conspicuous hump dorsally over shoulder: *Bos bison* (bison).

- Medium size; body form slender and "deerlike"; dorsal hump absent: 11

11. Horns short and smooth; or tall, marked with strong transverse wrinkles, and twisted in a "corkscrew" pattern; but in all cases rise straight above head in a V-shaped pattern: 12

- Horns massive (in males), curve out and back from head and then inward to form a "curl" at side of head; females with smaller horns that do not curl, but horns in both sexes marked with strong transverse wrinkles: 13

12. Large size; height at shoulder greater than height at rump, giving a backward sloping appearance to profile; males with short, straight horns seldom exceeding 18 cm in length; coloration uniform light brown to iron gray: *Boselaphus tragocamelus* (nilgai).

- Medium size; height at shoulder equal to height at rump, no backward slope to profile; males with long, twisted horns up to 79 cm in length; coloration tan to black dorsally with striking white eye rings, chin, chest, belly, and inner legs: *Antilope cervicapra* (blackbuck).

13. Conspicuous ventral mane of long hairs hanging from throat and chest; coloration light rufous-brown; whitish rump patch small and inconspicuous: *Ammotragus lervia* (Barbary sheep).

- Ventral mane absent; coloration light brown to gray; white rump patch large and prominent: *Ovis canadensis* (mountain sheep).
Feral Pig

Order Artiodactyla: Family Suidae: *Sus scrofa* Linnaeus

**Description.** Feral pigs in Texas are descended from introductions of European wild hogs for sporting purposes, and from escaped domestic swine that have established feral populations. European wild hogs have several distinguishing characteristics that set them apart from domestic or feral hogs. Among these are brown to blackish brown color, with grizzled guard hairs, a mane of hair (8-16 cm long) running dorsally from the neck to the rump, a straight heavily tufted tail, and ears covered with hair. Characteristics of feral hogs are varied, depending upon the breed of the ancestral stock. European wild hogs and feral hogs interbreed readily, with traits of European wild hogs apparently being dominant.

**Distribution in Texas.** Feral pigs have established sizeable, free-ranging populations in various places on the Rio Grande and Coastal Plains, as well as the wooded country of eastern Texas.

**Habits.** Good feral hog habitat in timbered areas consists of diverse forests with some openings. The presence of a good litter layer to support soil invertebrates and/or the presence of ground vegetation affording green forage, roots, and tubers is desirable. Hogs are also fond of marsh and grass-sedge flats in coastal areas, particularly if wild grapes are common. During hot summer months, "wallows," or depressions dug in the mud by feral hogs, are much in evidence near marshes or standing water, such as along roadside ditches.

On the Texas coast, feral pigs eat a variety of items, including fruits, roots, mushrooms, and invertebrates, depending on the season. The major foods in spring are herbage, roots, invertebrates, and vertebrates. Fruit, invertebrates, and herbage are most common in fall and winter diets. Herbage eaten by feral pigs includes water hyssop, pennywort, frog fruit, spadefoot, onion, and various grasses while important roots used for food include bulrush, cattail, flatsedges, and spikesedges. Fruits and seeds such as grapes, acorns, and cultivated sorghum are important, and animal matter ingested by feral pigs includes earthworms, marsh fly larvae, leopard frogs, snakes, and rodents.

Feral pigs can have detectable influences on wildlife and plant communities as well as domestic crops and livestock. Extensive disturbance of vegetation and soil occurs as a result of their rooting habits. The disturbed area may cause a shift in plant succession on the immediate site. Feral pigs also compete, to some degree, with several species of wildlife for certain foods, particularly mast.

Feral pigs generally breed year round; litters range from one to seven, averaging two per sow. An average of one to three suckling pigs usually accompanies brood sows. The heat period is only about 48 hours in duration and the average gestation period is 115 days.
White-tailed Deer

Order Artiodactyla : Family Cervidae : *Odocoileus virginianus* (Boddart)

**Description.** A relatively small deer with relatively short ears; all major points of the antlers come off the main beam; tail relatively long, broad basally, and white underneath; metatarsal gland small and circular; females usually antlerless; upperparts reddish brown in summer, bright grayish fawn sprinkled with black in winter; face and tail usually lack blackish markings; underparts white. Dental formula as in the mule deer. External measurements average: (males) total length, 1,800 mm; tail, 300 mm; hind foot, 450 mm; females slightly smaller. Weight of males, 30-70 kg.

**Distribution in Texas.** Suitable brushy or wooded country throughout the state.

**Habits.** White-tailed deer occur almost entirely in the hardwood areas within their general range except for the southeastern section of Texas where the principal vegetation is a mixture of pines and hardwoods or nearly pure stands of pines. In the Chisos Mountains of Texas they occur in the mountains, whereas the mule deer occupies the lower foothills and broken deserts; in most other places this habitat relationship is reversed. For example, in the Guadalupe Mountains the whitetail occurs almost entirely in the foothills; the mule deer, in the higher mountains.

White-tailed deer have a relatively small home range and cruising radius. Normally, when food conditions are adequate, the deer tend to stay in one locality for long periods. For example, in the Edwards Plateau region, where deer were bailed in an experimental study, many of the marked deer remained on an area of 259 ha for at least 3 years. A few of them were found as far away as 8 km.

Deer are most active just before sunset and again shortly after sunrise. It has been found in experimental trials that they are most easily observed in the hour just before dark. During the middle part of the day they are generally bedded down in some thicket or on some promontory where they are more or less protected. Under cover of darkness it is not uncommon for them to feed well into the night, but there is usually a period of resting and cud chewing during the middle part of the night. In regions heavily populated with deer their trails and beds, the latter usually scraped out under the protection of overhanging boughs or at the bases of trees, are readily seen and give some clue to the density of the population.
As with most other mammals, the feeding habits of whitetails vary from place to place and from season to season. E. L. Atwood listed more than 500 different plants utilized by whitetails in the United States. Availability determines in large measure what the animals will eat but if adequate food is available, the deer are dainty eaters and exercise considerable choice in the items taken. In the Chisos Mountains of Trans-Pecos Texas, whitetails feed extensively on mountain mahogany and other low shrubs. In the Edwards Plateau region the deer graze twice as much as they browse. There, 67% of their total feeding time was spent in grazing on forbs and grasses, 26% in eating fruits and mast, and only 7% in browsing. In South Texas, however, browse species make up the bulk of the diet.

The 10 most favored foods as observed in the Edwards Plateau of Texas are grasses and weeds, Mexican persimmon, live oak acorns, live oak leaves, mesquite beans, oats or other grain, Spanish oak acorns, spike rush, Foresteria or elbow bush, and turkey pear. On the basis of food consumed, seven deer will eat about as much as one medium-sized cow.

White-tailed deer are polygamous. The rut begins in early fall and continues through early winter. The onset of breeding varies considerably from one section of the country to another. In coastal Texas, for example, it is not uncommon for breeding to begin as early as September. In the Edwards Plateau, not more than 300 km distant, the peak of the breeding season is in November, whereas in the southern "brush country" section of Texas the peak is in late November and December.

The fawns, usually one or two in number, are dropped after a gestation period of approximately 7 months and hidden by the female for 10 days to 2 weeks. She goes several times daily to nurse them but as soon as they are strong enough to follow her about they do so. The spots are retained until the fawns molt in early fall by which time they are usually weaned. Normally, sexual maturity is not reached in females until the second year but occasionally, when food conditions are excellent, female fawns mate the first fall and produce offspring the following spring when they themselves are only 1 year old. This appears to be unusual throughout most of their range, however.

There is a relationship between testicular activity and the growth and shedding of antlers. The antlers begin their annual growth when the testes and accessory organs are inactive, harden and lose their velvet when these glands are enlarging, and are shed when they begin to decline. Castration following loss of the velvet results in shedding within 30 days. New growth, which occurs at the normal time, is abnormal in shape and the velvet is not lost. Growth ceases at the usual time and part of the growth, being somewhat fragile, may be lost by accident. Renewed growth activity follows in the spring. Eventually, an aggravated burr is produced. These events have been interpreted as indicating that antler growth is under the influence of a non-testicular hormone, possibly from the anterior pituitary, and antler hardening and subsequent loss of the antler is due to the action of a testicular hormone.

One can estimate the age of whitetails by examination of the teeth. At 9 months of age the fawn will be acquiring the middle pair of permanent incisors while the remainder of the incisors as well as the premolars will be milk teeth. At this age one molar on either side of each jaw is well developed while the second is barely breaking through the gum. At the age of 1½ years all milk incisors have been replaced by permanent teeth. At least two molars are fully developed while the third may be in any condition from barely emerging from the mandible to fully emerged. At the age of 2 years the full set of permanent teeth is acquired. Beyond 2 years age determination is somewhat uncertain but can be roughly estimated by the
wearing of the teeth. Wear of the teeth is gradual until at 5 years the ridges of enamel are no longer sharp, but rise slightly and gradually above the dentine. At still later ages the crowns of the premolars and molars rise only a short distance above the gums, and the grinding surfaces are worn practically smooth.

Contrary to popular opinion, it is almost impossible to determine accurately the age of deer by the number of points on the antlers. For example, the shed antlers collected from one buck in Texas over a period of 5 years had each year either four or five points on each side. There is some correlation between age and diameter of the beam of the antler, however. The older bucks tend to have heavier antlers, but antler development is also so closely associated with nutrition that it is hazardous to make generalizations concerning age and diameter of the beam. Also, a certain amount of geographic variation is seen in antler development.

White-tailed deer are the most important big game animals in Texas. In the face of an expanding human population this species has done remarkably well. It is estimated that our 1991 white-tailed deer population numbered more than 3.1 million in spite of heavy hunting pressure and approximately 474,000 were harvested by hunters in that year.

On some ranges there is considerable competition for forage between white-tailed deer and domestic livestock. This is particularly true between deer and domestic goats. Competition between deer and cattle is not so severe. Where abundant in farming areas, deer often become pests and destroy such crops as peas, peanuts, wheat, oats, and other small grains.
Bison

Order Artiodactyla : Family Bovidae : Bos bison (Linnaeus)

**Description.** A large, cowlike mammal with distinct hump in the shoulder region; head, neck, shoulders, and forelegs with long, shaggy hair; hind part of body with short hair; head heavy with short, curved, black horns; tail short and ending in tuft of hair; color brownish black anteriorly, brownish posteriorly. Dental formula: I 0/3, C 0/1, Pm 3/3, M 3/3 X 2 = 32. External measurements approach: (males) total length, 3,400 mm; tail, 610 mm; hind foot, 610 mm; height at shoulders, 1,800 mm; females somewhat smaller. Weight of bulls, 700-1,000 kg; females, 300-400 kg.

**Distribution in Texas.** Formerly widespread in the western two-thirds of Texas; now extirpated or confined in captivity. It is no longer considered a game animal in Texas.

**Habits.** In early days the bison was found in great numbers over a vast range in North America. With the westward expansion of the white settlers, it became an object of exploitation on a tremendous scale that resulted in its total disappearance from the East and its almost complete extermination over much of its western range. By 1825 it had become practically extinct east of the Mississippi River. The building of the transcontinental railways after 1830 hastened the slaughter of the vast herds west of the river. In the 1870s hundreds of thousands were recklessly killed for their hides and tongues. In 1877-78 the last great slaughter of the "southern herd" took place south of the main transcontinental railroads. In the north their numbers likewise rapidly decreased.

When protection of the buffalo was under consideration by the Texas Legislature, General Phil Sheridan opposed it, pointing out that the sooner the buffalo was eliminated the sooner the Indian would be starved into submission. Sure enough, before 1880 both the buffalo and the Indian had all but passed away.

The big slaughter took place about 1877-78 when there were reported to be 1,500 hunting outfits working out of Fort Griffin (Shackelford County) alone. More than 100,000 hides were taken in the months of December and January of that winter. From 1881 to about 1891 there were shipments of buffalo bones from Texas totaling $3 million in value.

In the late 1880s it was realized that the bison was approaching extinction. By then, there were left in the United States only a few privately owned herds and a herd in Yellowstone National Park. It was not until May of 1894 that an effective law for the preservation of the bison was
passed by the United States Congress, and subsequently, the various herds were built up in the United States and Canada. By 1933 the total population of bison in North America was estimated at 21,000, of which the greater part (17,000) were in Canada on the Buffalo National Park near Wainwright, Alberta.

The bison of the western United States is normally a dweller of open prairies. The subspecies B. b. athabascae of Canada and the Old World relative (Bos bonasus), however, are forest animals. This, together with the fact that our plains bison lacks the keen eyesight of most plains dwellers but has a keen sense of smell, suggests that at some remote time in the past the plains bison, too, lived in woodland areas.

Bison are gregarious creatures that live together in herds, except for the old bulls which, especially in spring and early summer, lead a more or less solitary existence. During the period of rut in July and August, and again in winter, the old bulls tend to be more tolerant of the herd. Normally, bison are unobtrusive but when angered or when called upon to protect their calves they are vicious and dangerous. As with domestic cattle, old bulls are surly and may attack with slight provocation, as will cows with calves.

The daily activity of bison is much like that of domestic cattle. The chief feeding periods are early morning and late afternoon, with midday given over to cud-chewing, siesta, and wallowing. Normally, nighttime is a period of rest. Formerly, the plains bison migrated seasonally, going south as far as Florida and Texas in winter, and northward again in summer. Their normal gait is a plodding walk, which may break into a swinging trot or, when frightened or angered, a stiff-legged gallop.

Plains bison are predominantly grazers, feeding chiefly on grasses and secondarily on forbs. Browse species contribute slightly to their menu. Because of this, competition between bison and domestic cattle for range forage is so great that we cannot afford, for economic reasons, the return of the bison to anything like its former numbers.

The period of rut is July and August. The animals are promiscuous in mating habits but usually only the large, mature bulls do the breeding. Young and undersized bulls are driven from the herd to linger on the outskirts and await with anticipation the opportunity to participate whenever the herd bull is off guard. As with range cattle, a scale of social dominance is established with each bull next highest dominating those below him.

The period of gestation is 8½ - 9 months — the calves arriving in April, May, or early June. One calf at a time is the rule; twins are rare. The young one normally is weaned in late fall, but occasionally it continues to nurse until the arrival of the next calf. Sometimes cows breed only in alternate years. Sexual maturity is reached in the third year. According to Cahalane, cows have remained productive for 40 years indicating a life span of at least 45 years.

At present, the plains bison has little economic importance. There is some demand for its flesh as food for man, but the temperament of the beast will not permit its wide replacement of cattle.

Photo courtesy of the U.S. Fish and Wildlife Service.
ORDER SIRENIA:

MANATEE AND ALLIES

The Sirenia are large, plump, torpedo-shaped mammals adapted to an aquatic habitat; they live in the bays and coastal waters in tropical regions of the world. Front limbs developed into paddles; hind limbs absent externally; tail expanded into a rounded, horizontal fluke; muzzle truncate; skin naked except for stiff bristles on the muzzle; nostrils separate and valvular; eyes and mouth small; bones dense and heavy; two mammary glands, pectoral in position; testes abdominal.

Family Trichechidae (manatees)

West Indian Manatee, *Trichechus manatus*
West Indian Manatee

Order Sirenia: Family Trichechidae: *Trichechus manatus* Linnaeus

**Description.** A large, grayish, nearly hairless, aquatic mammal without hind limbs; tail broadened into a horizontal, rounded paddle; front limbs paddlelike. Dental formula: I 2/2 (nonfunctional), C 0/0, Pm 0/0, M 6/6 (variable and continuously being replaced) X 2 = 32. Total length of adults, up to 3.5 m; weight, up to 1,000 kg.

**Distribution in Texas.** West Indian manatees are found in rivers, estuaries, and coastal areas of the tropical and subtropical New World from the southeastern United States coast along Central America and the West Indies to the northern coastline of South America. Manatees are extremely rare in Texas although near the turn of the century they apparently were not uncommon in the Laguna Madre. Texas records also include specimens from Cow Bayou, near Sabine Lake, Copano Bay, the Bolivar Peninsula, and the mouth of the Rio Grande.

**Habits.** These animals occur chiefly in the larger rivers and brackish water bays. They are able to live in salt waters of the sea, however, and travel from one island to another or from place to place along the coast. They are extremely sensitive to cold and may be killed by a sudden drop in the temperature of the water to as low as 8°C. This intolerance doubtless limits their northward distribution in North America. Their irregular occurrence along the Texas coast suggests that they do considerable wandering — specimens from Texas probably represent migrants from coastal Mexico.

Sluggish and easily captured, West Indian manatees were once extensively exploited as a food source. Although now protected as an endangered mammal, manatees still face occasional losses from poaching and from collisions with speedboats. Additionally, habitat loss to land development and channelization continues to pose problems for them. Conversely, in Florida the construction of power plants and industrial parks has apparently been beneficial in creating new warm water habitat that may be preferred by manatees in winter.

Manatees are opportunistic, aquatic herbivores that feed exclusively on aquatic vegetation, although captive animals have eaten lawn grass, dandelions, palmetto, and garden vegetables. Wild manatees seem to prefer submersed vegetation, followed by floating and emergent species. Manatees consume 30-50 kg of food per day. In saline waters, they feed on seagrasses.

Manatees occur in loosely knit groups, but are not gregarious by nature. Breeding and calving occurs year round with the gestation period lasting 12-13 months. Newborn manatees are about a meter long at birth and weigh 18-27 kg. One young is born.
Remarks. Stephanie Fernandez and Sherman Jones reported the recent (February, 1986) stranding of a manatee on the Texas coast. A local fisherman found the carcass of a male manatee, in an advanced state of decomposition, rolling in the surf about 1.5 km west of Caplen, Bolivar Peninsula. Parts of the anterior portion of the skull, the flipper bones, and sternum were exposed. The total length of the manatee was 274 cm. Along the right side of the abdomen were 10 golfball-sized holes, which penetrated, but did not pass through, the blubber. Seven holes formed a V-shaped figure, with the other three forming a straight line immediately beneath it. The cause of these holes was undetermined. A recent rope mark was also visible around the tail stock.

This was the first manatee stranding recorded by the Texas Marine Mammal Stranding Network since its inception in 1980.

Illustration credit: Pieter A. Folkens.
ORDER CETACEA:

WHALES, PORPOISES, AND DOLPHINS

Small to extremely large, hairless, fish-shaped mammals that are adapted strictly to an aquatic habitat; front limbs modified as flippers or fins, hind limbs absent, except for vestigial internal remnants; eyes and ears small, the latter valvular and lacking external parts; skull telescoped so that nostrils open on top of head through a single or double blowhole; no vocal apparatus, the so-called roar being produced by expelled air; soft palate and epiglottis so modified that nasal cavities connect directly with lungs and not with mouth; tail lengthened and dural elements expanded into broad, flattened flukes; mammary glands situated on either side of vaginal opening, the single teat lodged in a slitlike recess; penis and testes contained within the body integument; skin glands, except for conjunctival and mammary, lacking; teeth present or absent.

This group contains the largest of all known mammals, living or extinct. The blue whale sometimes reaches a length of 33 m and may weigh up to 135 metric tons. As a group whales are slow breeders — one young every 2 years is generally the rule. The teat in a 15-m whale is no larger than a man's thumb, and the mouth of the young calf is so constructed that it cannot suck. Perhaps the milk is forced into the mouth of the baby by contraction of muscles over the udder or by the "butting" of the young one. In a freshly killed, lactating female palpation of the udder may force out jets of cream-colored milk.

Cetaceans have no voice but many produce distinct sounds used in mating rituals, communication, and echolocation. Such sounds are specific in character and many are audible for distances of a kilometer or more. Bats and cetaceans are the only mammals known to echolocate; they use sound emissions and echoes to form mental images of their surroundings.

Many of the whales have retained teeth in both jaws. Some have retained them in the lower jaw only, whereas others have lost them completely and have developed instead peculiar structures termed baleen or whalebone. These are elongated, flattened, leaflike modifications of the ridges in the roof of the mouth. Two series of plates, one on each side, hang from the roof of the mouth and the long, fibrous, hairlike structures on the inner edge of one plate overlap with those of its neighbor in such a way that an efficient sieve is produced. All whales with such structures feed on small organisms strained from the water. Toothed whales feed on larger animal life: fish, seals, or even other whales.

The spout is characteristic of many species. It is produced by expelling moisture-laden air from the lungs into the air. As the air escapes it cools, condenses, and becomes visible if the temperature of the outside air permits and then quickly dissipates. When not in use, the blowholes are closed by external flaps that prevent water from entering the lungs. All whales must come to the surface to breathe; if they are forced to remain submerged, they drown.

Many whales and porpoises live near the coast, frequenting shallow water, but a large number of them are pelagic and roam the open seas. Many of the latter perform regular migrations. In
winter they inhabit temperate or tropical waters where they mate and give birth to their young a year later; in summer they move to the Arctic or Antarctic seas among the ice floes. Most of the food in the ocean is produced where cold and warm streams meet and it is there that whales flock in great numbers.

Twenty-nine species of cetaceans have been documented within the Gulf of Mexico. This assemblage includes approximately 40% of the genera and 35% of the cetacean species in the world. Twenty-six of the 29 Gulf species have either stranded on Texas beaches or been observed at sea in the waters of the western Gulf.

The terms whale, dolphin, and porpoise need explanation. As here used, the term whale is all-inclusive and may be applied to any cetacean. The term dolphin applies to those small whales that have a distinct snout or beak and numerous conical teeth that are roughly circular in cross-section. The term porpoise applies to those small, blunt-nosed whales that have flat, spade-shaped teeth. Based on these definitions, all the small, beaked whales in Texas waters with numerous conical teeth are dolphins. No porpoises are known to occur in Texas waters.

One of the more interesting biological aspects about marine mammals, especially cetaceans, is their propensity to strand — to ground or beach themselves out of water and be unable to return under their own power. Generally, there are two types of strandings — those of a single individual, which are by far the most prevalent, and multiple or mass (two or more animals) strandings, excluding parent/offspring combinations. The study of marine mammal strandings is a subject of considerable interest to scientists and the general public, and stranding studies have proven to be an undeniably good source of information, perhaps the only information, about aquatic mammals that exists.

A Texas Marine Mammal Stranding Network was organized in 1980, as a means of discovering, gathering, and reporting information of marine mammals stranded along the Texas coast. It also assists live stranded animals, administering first aid and transporting them to facilities where they can be treated. The network consists of scientists, students, federal and state agencies, marine veterinarians, and other interested individuals.

From October, 1980, through May, 1987, the Texas Marine Mammal Stranding Network documented a total of 501 cetacean strandings. Of these, 87% were represented by bottlenose dolphins, the most common inshore species. Live strandings accounted for only 7% of all strandings, and a majority of these occurred near Port Aransas where deeper waters are closer to shore. There was only one known instance of a mass stranding, that of a group of pygmy killer whales.

Although there has been much speculation and theorizing, scientists do not completely understand why cetaceans beach themselves. Oftentimes when live strandings are observed, attempts to return the animals to sea fail. Many, upon release, simply turn and head for shore once more. Undoubtedly, many factors may account for this "suicidal" form of behavior. Among the possible causes suggested for strandings are: parasites, disease, and illness; choking on ingested objects; wounds from gunshots and boat and ship encounters; difficulties in the birth process; starvation; bad or rough weather; seaquakes, tremors, and underwater explosions; pollution; net entanglements associated with commercial fishing; fouled sonar systems; and panic caused by the pursuit of other animals (predators). Social facilitation or as it is more commonly known, the "follow the leader" theory, is widely given as a reason for mass strandings. Social facilitation involves a cohesive group behavior whereby a dominant
individual suddenly beaches itself causing the whole group to follow suite and do likewise.

Family Balaenidae (right whales)

Northern Right Whale, *Eubalaena glacialis*

Family Balaenopteridae (rorquals or baleen whales)

Minke Whale, *Balaenoptera acutorostrata*  
Bryde’s Whale, *Balaenoptera edeni*  
Blue Whale, *Balaenoptera musculus*  
Fin Whale, *Balaenoptera physalus*  
Humpback Whale, *Megaptera novaeangliae*

Family Physaceridae (sperm whales)

Sperm Whale, *Physeter macrocephalus*  
Pygmy Sperm Whale, *Kogia breviceps*  
Dwarf Sperm Whale, *Kogia simus*

Family Ziphiidae (beaked whales)

Blainville’s Beaked Whale, *Mesoplodon densirostris*  
Gervais’ Beaked Whale, *Mesoplodon europaeus*  
Cuvier’s Beaked Whale, *Ziphius cavirostris*

Family Delphinidae (toothed whales and dolphins)

Killer Whale, *Orcinus orca*  
False Killer Whale, *Pseudorca crassidens*  
Pygmy Killer Whale, *Feresa attenuata*  
Short-finned Pilot Whale, *Globicephala macrorhynchus*  
Melon-headed Whale, *Peponocephala electra*  
Rough-toothed Dolphin, *Steno bredanensis*  
Common Dolphin, *Delphinus delphis*  
Risso’s Dolphin, *Grampus griseus*  
Bottlenose Dolphin, *Tursiops truncatus*  
Pantropical Spotted Dolphin, *Stenella attenuata*  
Clymene Dolphin, *Stenella clymene*  
Striped Dolphin, *Stenella coeruleoalba*  
Atlantic Spotted Dolphin, *Stenella frontalis*  
Spinner Dolphin, *Stenella longirostris*

KEY TO THE WHALES AND DOLPHINS OF THE TEXAS COAST
1. • No teeth present; baleen plates in upper jaw; twin blowholes; skull symmetrical; no mandibular symphysis (baleen whales): 2
• Teeth present (although sometimes not erupted); no baleen plates; single blowhole; skull slightly to moderately asymmetrical; mandibular symphysis present (toothed whales): 8

2. • Dorsal fin and ventral throat grooves present; no growths on top of head; upper jaw relatively flat when viewed from the side and broad from the top: 3
• No dorsal fin or ventral throat grooves; crusty growths (callosites) present on head; upper jaw arched when viewed from the side and relatively narrow from the top: *Eubalaena glacialis* (northern right whale).

3. • Throat grooves end well before navel: 4
• Throat grooves extend to or beyond navel: 5

4. • 50-70 ventral grooves, longest ending between flippers; 231-285 white or yellowish-white baleen plates per side, less than 21 cm long; conspicuous white bands on flippers; maximum body length 9 m: *Balaenoptera acutorostrata* (Minke whale).
• 32-60 ventral grooves, longest ending well short of navel; 219-402 pairs of black baleen plates, less than 80 cm long; flippers totally dark; maximum body length 16 m: *Balaenoptera borealis* (Sei whale).

5. • Flippers more than 25% of body length, heavily scalloped on the leading edge, and marked on the underside with a variable pattern of white: *Megaptera novaeangliae* (humpback whale).
• Flippers less than 25% of body length, smooth on the leading edge, and without a distinct pattern of white on the underside: 6

6. • Head with only one prominent ridge from blowhole to snout; 55-100 ventral grooves; maximum body length more than 20 m: 7
• Head with series of three parallel ridges from blowhole to snout; 40-50 ventral grooves; maximum body length less than 15 m: *Balaenoptera edeni* (Byrde’s whale).

7. • Head broad and almost U-shaped from above; dorsal fin very small (< 33 cm) and set in the last one-third of back; 270-295 black baleen plates per side; coloration of head symmetrical; body mottled gray; maximum body length 26 m: *Balaenoptera musculus* (blue whale).
• Head V-shaped and pointed at tip as viewed from above; dorsal fin up to 61 cm tall and set more than one-third forward from fluke notch; 260-480 white to gray baleen plates per side; head coloration asymmetrical (left side gray, much of right side white); back dark, with light streaks; maximum body length 24 m: *Balaenoptera physalus* (fin whale).

8. • Upper jaw extending well past lower jaw; lower jaw very narrow: 9
• Upper jaw not extending much or at all past lower jaw; lower and upper jaw about the same width: 11

9. • Body length 4-18 m; head squarish and large, up to one-third of body length; blowhole at left side of front of head; low roundish dorsal hump present, followed by a series of bumps; 18-25 teeth in each side of lower jaw, fitting into sockets in upper jaw: *Physeter macrocephalus* (sperm whale).
• Body length less than 4 m; head much less than one-third of body length; blowhole set back from front of head; prominent dorsal fin present; 8-16 teeth in each side of lower jaw: 10
10. • Throat creases generally absent; dorsal fin small and located in last one-third of body; distance from tip of snout to blowhole greater than 10.3% of total length; 12-16 (rarely 10-11) teeth in each half of lower jaw: *Kogia breviceps* (pygmy sperm whale).
• Two small creases present on throat; dorsal fin generally tall and located near midpoint of back; distance from tip of snout to blowhole less than 10.2% of total length; 8-11 (rarely up to 13) teeth in each side of lower jaw: *Kogia simus* (dwarf sperm whale).

11. • Two conspicuous grooves on throat; notch between flukes absent or indistinct; enlarged teeth numbering no more than two pairs in lower jaw (beaked whales): 12
• No conspicuous grooves present on throat; prominent median notch in flukes; teeth present in both upper and lower jaws (dolphins and toothed whales): 14

12. • One or two pairs of teeth at or near tip of lower jaw, erupted only in some adults; beak indistinct; head small relative to body size; body to at least 7 m long: *Ziphius cavirostris* (Cuvier’s beaked whale).
• One pair of teeth well behind tip of lower jaw, erupted only in adult males; moderate beak, not sharply demarcated from forehead; body to 4.5 m long: 13

13. • Tooth positioned approximately 7.5-10 cm from tip of mandible (one-third the length of mandible): *Mesoplodon europaeus* (Gervais’ beaked whale).
• Tooth positioned at midpoint of mandible on bony prominences near corners of mouth: *Mesoplodon densirostris* (Blainville’s beaked whale).

14. • Beak not sharply delineated from head by a distinct crease: 15
• Beak sharply delineated from head by a distinct crease: 21

15. • Head blunt, with no prominent beak: 16
• Head long and conical but beak runs smoothly into forehead, with no crease; body dark gray to black above and white below with narrow cape on back: *Steno bredanensis* (rough-toothed dolphin).

16. • Head divided medially by a heavy vertical crease; coloration gray with heavy scarring in the form of numerous scratches; no teeth in upper jaw (1-2 rarely present), 0-7 teeth present in each side of lower jaw: *Grapimus griseus* (Risso’s dolphin).
• Head not divided by a vertical, median crease; body coloration predominantly black with some white markings; teeth (7 or more pairs) in both upper and lower jaws: 17

17. • Striking black and white coloration, with white postocular patches, white lower jaw, and light gray saddle behind dorsal fin; dorsal fin tall and erect (up to 0.9 m in females and 1.8 m in males); flippers large and paddle-shaped; 10-12 large oval teeth (2.5 cm in diameter) in each tooth row; body to at least 9 m long: *Orcinus orca* (killer whale).
• Coloration predominantly black with little, if any, gray or white markings; dorsal fin less than 0.5 m in height; flippers long and pointed to slightly rounded at tips; body never more than 7 m long and often considerably less: 18

18. • Low, broad-based dorsal fin located on forward third of back; head bulbous; body black, with light anchor-shaped patch on belly and often light gray saddle-shaped flippers, one-fifth to one-sixth of body length; 7-9 pairs of teeth in front half of each tooth row; body to about 7 m long: *Globicephala macrorhynchus* (short-finned pilot whale).
• Dorsal fin located near midpoint of back; body never more than 5.5 m long: 19

19. • Flippers with distinct hump on leading edge giving S-shaped appearance; body
predominantly black; 7-12 large teeth in each half of both jaws; body to at least 5.5 m long: *Pseudorca crassidens* (false killer whale).

- Flippers lack hump on leading edge and not S-shaped; body predominantly black but with some white markings on belly and chin or lips; 8-25 teeth in each half of the jaws; body considerably less than 5 m long: 20

20. • Fewer than 15 teeth in each half of both jaws; flippers rounded at tip; body mostly black with white belly patch which may extend onto sides in area of anus; head rounded from above; body to almost 3 m long: *Feresa attenuata* (pygmy killer whale).

- More than 15 teeth per side of each jaw; flippers sharply pointed at tip; body black to brownish black on back, light gray on sides, light gray to white on belly, lips often white; head triangular from above; body to at least 2.7 m long: *Pepinocephala electra* (melon-headed whale).

21. • Body coloration dark gray on back, lighter gray on sides, with white to pink belly; no stripes or spots; beak relatively short and thick; 20 to 26 teeth present in each side of upper jaw and 18 to 24 teeth present in each side of lower jaw: *Tursiops truncatus* (bottlenose dolphin).

- Body coloration includes numerous spots, mottling, or stripes; beak relatively long and slender; up to 200 total teeth present in mouth: 22

22. • Body coloration heavily mottled with light or dark spots: 23

- Body coloration without spots but traversed by one or more longitudinal stripes: 24

23. • Coloration characterized by "spinal blaze" sweeping up and back below the dorsal fin; peduncle not divided into upper dark and lower light halves; no black stripes connecting eyes and flippers with jaws; background of dark ventral spots is white; total number of vertebrae, 67-72: *Stenella frontalis* (Atlantic spotted dolphin).

- Coloration not characterized by a "spinal blaze"; peduncle divided into upper dark and lower light halves; dark stripe from flippers to lower jaw; background of dark ventral spots is gray; total number of vertebrae, 74-84: *Stenella attenuata* (pantropical spotted dolphin).

24. • Light gray, tan, or yellow stripes crisscross on sides; palate with deep grooves bordering upper teeth: *Delphinus delphis* (common dolphin).

- Stripes do not crisscross; palatal groove shallow or absent: 25

25. • Black stripes extending from eye to anus, eye to flippers, and from above flippers toward belly; 43 to 50 teeth present in each side of both jaws: *Stenella coeruleoalba* (striped dolphin).

- Black side stripes absent: 26

26. • Dark-colored rostrum with gray or white "moustache" area; chin white to cream-colored; tip of upper jaw to apex of melon less than 12 cm; seldom more than 46 teeth in each side of the jaw: *Stenella longirostris* (Clymene dolphin).

- Dark rostrum without "moustache"; tip of upper jaw to apex of melon more than 12 cm; chin gray to black; usually more than 46 teeth in each side of the jaw: *Stenella longirostris* (spinner dolphin).

\[3\] The Sei whale is not included in the species accounts because there are no confirmed records of this species from the Texas coast. However, it is possible that this species could occur in the region and has therefore been included in this key.
Bottlenose Dolphin

Order Cetacea : Family Delphinidae : *Tursiops truncatus* (Montague)

**Description.** A rather stout, short-beaked (seldom more than 75 mm long) dolphin with sloping forehead and projecting lower jaw; dorsal fin high, falcate, and situated about midway from snout to flukes; pectoral fin broad at base, obtusely rounded at tip; uppersparts plumbeous gray, more or less tinged with purplish, becoming black soon after death; sides pale gray, belly white; teeth 23/23, large, nearly round in cross section in adults, and conical; height above jawbone, 12-17 mm, diameter, 5-9 mm. Total length of adults may reach 3.5 m. A sub-adult male measured: total length, 2.9 m; length of mouth, 319 mm; tip of snout to dorsal fin, 1,275 mm; length of pectoral fin, 395 mm; vertical height of dorsal fin, 229 mm; breadth of flukes, 612 mm.

**Distribution in Texas.** Bottlenose dolphins are distributed worldwide in tropical and temperate waters. In the western North Atlantic, these dolphins occur as far north as Nova Scotia but are most common in coastal waters from New England to Florida, the Gulf of Mexico, the Caribbean, and south to Venezuela. This is the most common cetacean of the Gulf of Mexico and along the Texas coast.

**Habits.** Bottlenose dolphins may be seen in groups numbering up to several hundred but smaller social units of two to 15 are more common. Group size is affected by habitat structure and tends to increase with water depth. Group members interact closely and are highly cooperative in feeding, protective, and nursery activities. These dolphins make numerous sounds and are probably both good echolocators and highly communicative.

Bottlenose dolphins eat a wide variety of food items depending on what is available and abundant at a given time. In Texas waters they eat fishes including tarpon, sailfish, sharks, speckled trout, pike, rays, mullet, and catfish. They are also known to eat anchovies, menhaden, minnows, shrimp, and eel. They eat about 18-36 kg of fish each day. Commonly observed feeding behaviors include foraging around shrimp boats, either working or not, to feed on fish attracted to the boats. The dolphins also eat "bycatch" dumped from working trawlers. Groups of these dolphins have been observed cooperating in prey capture, with several dolphins herding fish into tight schools that are more easily exploited. Bottlenoses are also known to chase prey into very shallow water and may lunge onto mud banks and shoals in pursuit of panicked fish.

Of 15 females captured in Texas waters, six that were pregnant were taken between December 17 and March 19. On the first date the fetus was 78 cm long and weighed 5 kg; on the last date fetuses were almost as large as some of the small calves. Nursing females were all taken between April 20 and September 11. These data suggest that breeding occurs in the summer.
and that the young are born the following March to May. At birth the calf is more than a third as long as its mother. The longest fetus recorded was 1.1 m in a female 2.8 m long; the smallest calf also was 1.1 m in length. Females give birth to a single calf and only give birth every 2-3 years. Males mature at 10-13 years of age and females at 5-12 years, when about 2.4 m in length. That the family group may remain intact for nearly a year is suggested by the capture on February 24 of a pregnant female and a young male approximately 1.5 m in length. These two animals were traveling together and were presumably mother and son.

Bottlenose dolphins are the most widespread and common cetacean of the coastal Gulf of Mexico and are commonly seen in bays, estuaries, and ship channels. Two distinct forms may occur in the Gulf. These are inshore animals that inhabit shallow lagoons, bays, and inlets and oceanic, or offshore, populations that remain in deeper, offshore waters. Interaction between the two populations is thought to be minimal. Populations of these dolphins in the southern and central portions of the Texas coast appear to increase dramatically in fall and winter. Either offshore dolphins move into nearshore waters during these seasons, or dolphins from adjacent bay systems move into these coastal sections. There is some evidence of a winter decline in dolphin numbers off Galveston.

The bottlenose dolphin is the only cetacean for which census techniques have yielded useful population estimates in the Gulf of Mexico. Nevertheless, these estimates do not include offshore dolphins, which are difficult to census, and therefore underestimate the total Gulf population. A cumulative summation of aerial surveys estimates 35,000-45,000 bottlenose dolphins in the Gulf of Mexico.

All cetaceans, including bottlenose dolphins, are protected from hunting by strict laws, but are affected by other human-caused activities. In the Gulf these include petroleum resource development, heavy boating traffic, and the pollution of Gulf waters, but the cumulative effects of these factors on dolphins are difficult to determine. Bottlenoses have been observed swimming through heavy oil spills and superficially show no ill effects. Bottlenoses may be able to adapt to man's activities but probably are readily affected by pollution and would make a good "indicator species" signalling the overuse and excessive pollution of Gulf waters.

Illustration credit: Pieter A. Folkens.


**BIRDS.** No other state in the United States has such a remarkable variety of birds as Texas. By 1991 the number of species recorded from the state totalled 594, including extinct, extirpated, and introduced species. An additional six species were listed as historical and eleven species were considered to hypothetically occur in Texas. There are several reasons for the great number of species: aside from being the largest state, Texas is also one of the most diversified so far as its surface is concerned; moreover, the state extends north into the Great Plains, east into the humid lowlands of the southeastern United States, south into the almost tropical lower Rio Grande region, and west into the desert country. Thus the state has attracted species from east and west, north and south, from the sandy gulf coastal islands, the wide open plains of the north, the deserts and desert mountains of the west. This situation applies not only to the permanently resident birds, of which Texas has a greater proportion than any other state with the possible exception of California; but it also means that migrants from other areas of the United States visit some part of Texas. Perhaps the greatest variety of birds is to be found along parts of the coast and in the region of the lower Rio Grande.

In the humid, heavily forested river bottoms of East Texas one of the most spectacular as well as most famous of birds, now extirpated from Texas was, the ivory-billed woodpecker. Its retiring habits, even where it was in the more inaccessible swamps, made it difficult to study this bird in its native haunts. Its nest, an excavation in a tall tree, was watchfully guarded by the parent birds. This woodpecker is sometimes confused with another inhabitant of the lowland forests, the pileated woodpecker, which, however, is somewhat smaller and has less white on the wing, lacking also the conspicuous whiteness of bill that has suggested the name ivory-billed woodpecker. The pileated woodpecker is much more numerous, although it is by no means a conspicuous bird, being also more or less shy and at times difficult to approach. It, too, lives in the forest and rears its young in a similar hole in a large tree. The mortise-like holes that it makes in the trees in search of insect food are a good means of identification. When actively employed in digging these holes it makes the chips fly, and sometimes the noise that results resembles not a little that of a distant wood chopper. Some of the humid river bottom lands and forests attract an almost unbelievable population of small birds, and among them one of the most beautiful is the yellow-trimmed hooded warbler, the black mask on the head suggesting the name. This warbler is an inhabitant chiefly of the lower parts of the trees and of the undergrowth, where, particularly in the canebrakes, its song is one of the outstanding bird melodies.

The upland park-like forests do not have so many bird inhabitants as the deciduous areas of the stream valleys. These fragrant pineries, however, attract several interesting birds that are found much less frequently, if at all, in other kinds of country. Among these is the appropriately named pine warbler. It is an inconspicuous olive-green bird which behaves somewhat like an injured creeper and entertains its mate with a monotone song singularly suggestive of that of the chipping sparrow. Another characteristic inhabitant of the pine forests is the brown-headed nuthatch, a cousin of the common white-breasted nuthatch and a smaller, much less conspicuous bird with a voice that sounds like a miniature cracked tin horn. In cultivated lands,
and particularly about human dwellings, one of the most conspicuous of all the birds is the Texas state bird, the northern mockingbird.\(^9\) Its almost unlimited vocal repertoire is notorious, and its imitative ability has, of course, suggested the bird's name. Around the lakes of the interior of Texas are the snowy egret and the great egret, the white pinions of which make them conspicuous features of the landscape. Other herons, particularly the great blue heron, together with the elusive king rail, inhabit the marshes and borders of these bodies of water, while the surface is frequently dotted with various kinds of ducks, particularly in the region of the Great Plains. On the prairies of the interior, as well as on the coast and in other bushy areas, the scissor-tailed flycatcher is conspicuous. This bird, one of the best known of all the land birds of Texas, has gray, black, and white plumage with a dash of red and pink to relieve the monotony, together with long tail feathers, which make it easily distinguishable.

The Llano Estacado of the northwestern part of the state has a relatively sparse bird population. The slate-gray Mississippi kite is one of the most characteristic; its soaring flight makes it an attractive bird. It nests in the trees of the narrow fringe of vegetation along the streams, as well as in the tall bushes of the chaparral. Another bird of the high open areas is the burrowing owl, so called because it makes its nest in a hole in the ground, often adapting to its use an abandoned prairie dog burrow, which has given rise to the story that it inhabits these burrows along with the prairie dog and rattlesnake, a story long since disproved. In the mesquite and other chaparral of the southern and middle parts of Texas, one of the most conspicuous and intriguing birds is the greater roadrunner, or "paisano," as it is known to the Mexicans. Its habit of running on the ground to escape its enemies, and the many stories that are told of its prowess in fighting rattlesnakes, have made it almost a legendary character in folklore. Its speed on foot is really remarkable, although this has been often somewhat exaggerated.

In the marshes of the Gulf coast one finds blackbirds and grackles of various kinds in abundance. Their great flocks sometimes resemble clouds of smoke. Hidden away in the grass, reeds, or grain are the long-billed marsh wren, the wary clapper rail, and the brilliantly colored purple gallinule, along with other water and shore birds. On the coastal beaches, both of the islands and the mainland, one of the outstanding birds is the black skimmer, which has received its name from its habit of flying close to the water and dipping its bill frequently into the surface. It sometimes appears in large flocks that range themselves along the sand or on the mud flats like great platoons of soldiers. Another inhabitant of the shores is the red-billed, black and white plumaged American oystercatcher, a bird which has acquired its name from its habit of feeding on bivalves. Perhaps the most conspicuous bird, as it is the largest along the shore, is the brown pelican, which breeds in sometimes extensive colonies not far back from the waters of the Gulf of Mexico. This bird, apparently clumsy on land, is marvelous on the wing, for not only can it soar indefinitely, but it has the uncanny ability to skim over the water, even when waves are running, so close to the surface that it seems almost impossible for it not to touch the water with its wings, yet it never does. To obtain its food it dives from on high with a great splash into the water and disappears, soon coming up again but facing in the opposite direction. Perhaps the most spectacular of Texas's birds on the wing is the magnificent frigatebird, or, as it is sometimes called, the man-o'-war bird, so named because it is a pirate and obtains a large part of its food by robbing the gulls and other water birds. Its black or black and white plumage makes it a conspicuous figure as it sails for long periods with wings and long forked tail expanded, and with very little or no motion of the wings. On the coastal prairie there lives one of the most attractive game birds of all Texas, Attwater's greater prairie-chicken. Unfortunately, this bird has been greatly reduced in relatively recent years, since over-shooting and lack of proper protection caused it to be practically exterminated from many of its former haunts.
In the semi-tropical valley of the lower Rio Grande there are many birds that are found in practically no other area in the United States, these being tropical species that extend up from northeastern Mexico. Among them no bird is more bizarre than the northern jacana. This bird, with a peculiar comb-like fleshy appendage on top of its head and bright yellow-green wings, is a strange apparition as it flies low over the water, or with its long, slender, unwebbed toes stalks about over the lily pads.

Out on the edge of the arid region in the deep canyons, the remarkable black-capped vireo lives. In addition to its own regular song, it has notes which in many respects remind one of the mockingbird. Like many of the other vireos it inhabits the bushes along the canyons, and, like them, builds a pendant nest in the horizontal fork of a bush. The canyon wren also holds a high place among the songsters of the west. Its remarkable melody, starting high and descending through more than an octave, resounds from the canyon walls until it seems to come from a bird two or three times its size. It lives in the crevices of the rocky walls of the canyons, where it is easily completely hidden from sight. The dry regions of central western Texas harbor such birds as the black phoebe, which places its nest on a little shelf of rock in a canyon or even in an abandoned well. Here, too, lives one of the most remarkable birds of all Texas, the white-throated swift. It is well-named, because it is one of the most rapid fliers in the world. When it really is in haste, it dashes down through the canyons at such speed that the eye finds it difficult to follow. There are also in the desert area other attractive birds, such as the vermilion flycatcher, which draws attention not only because of its brilliant plumage but also because of its intriguing nesting and other habits. Here, too, is the cactus wren, well-named because it is so fond of building its coconut-shaped nest in the most forbidding cacti as well as in other bushy vegetation, leaving only a very small opening at the side for an entrance. The tiny verdin, although barely half the size of the cactus wren, sometimes builds a thorny castle almost as large with the entrance being from below at one end, which effectively keeps out most of its enemies.

So many remarkable birds occur in the picturesque Chisos Mountains that it is difficult to pick out the most important. The gray-breasted jay, which is common throughout this range, is found in no other area in the United States and is a noisy, conspicuous inhabitant of the woodland. Here, also, lives the Colima warbler, a very small bird whose color makes it obscure. It breeds in these mountains but nowhere else in the United States. In the Chisos, as well as in other mountains, there are also many birds that have come down from the more northern Rocky Mountains. Such are the zone-tailed hawk, a marvelous flyer that lives in canyons and the forests of the mountains; the Hutton's vireo; the mountain chickadee, which is similar in appearance to the Carolina chickadee of eastern Texas; and the noisy, mischievous, Steller's jay.

In addition to the great variety of remarkable birds that are to be found in Texas, there are two famous birds that were formerly common in the state, but which now unfortunately, have been exterminated throughout their ranges in the United States. These are the well-known Carolina parakeet, whose taste for food runs to cockleburs, and the still more widely known passenger pigeon. This bird was at one time so abundant at certain seasons of the year in parts of eastern Texas that it broke down the branches of the trees in some of its roosts.

Rappole and Gene H. Blacklock, *Birds of Texas: A Field Guide* (College Station: Texas A&M
University Press, 1994). John L. Tveten, *The Birds of Texas* (Fredericksburg, Texas: Shearer,
1993).

*Harry C. Oberholser*

The following, adapted from the *Chicago Manual of Style*, 15th edition, is the preferred
citation for this article.

*Handbook of Texas Online, s.v. "",* [http://www.tsha.utexas.edu/handbook/online/articles/BB/tbb1.html](http://www.tsha.utexas.edu/handbook/online/articles/BB/tbb1.html)

(accessed January 17, 2007).

(NOTE: "s.v." stands for sub verbo, "under the word.")

The *Handbook of Texas Online* is a joint project of The General Libraries at the University of Texas at Austin
([http://www.lib.utexas.edu](http://www.lib.utexas.edu)) and the Texas State Historical Association ([http://www.tsha.utexas.edu](http://www.tsha.utexas.edu)).

Copyright ©, The Texas State Historical Association, 1997-2002
Last Updated: June 6, 2001
Please send us your comments.