

DEAR TEACHER,

Raptors, or birds of prey, are magnificent predators that can readily be seen in both urban and rural settings. They are ideal species for teaching many biological concepts such as predator-prey relationships, adaptations and the effects of human influences on natural systems.

This packet has been designed to help you teach your students about raptors and their importance in the environment. Multidisciplinary lessons that support the Washington State Essential Academic Learning Requirements and mandate for environmental education are included to assist you in developing your curriculum. The background information enclosed was designed to familiarize you with raptors, issues pertaining to raptor ecology and conservation, and to help you develop student lesson plans. The background information was designed to increase your familiarity with the topic. However, you may choose to distribute some of the materials to older students.

This curriculum will also help you instill in your students an appreciation for raptors as important members of our environment that are worthy of the students' respect and protection. Interested students may even choose to become active bird watchers and/or stewards of wild habitats.

This teacher packet is intended for use with students in grades K-12. A variety of activities has been provided; however, not every activity is appropriate for all ages. Grade level suggestions are provided for each lesson but we encourage you to adapt the activities to meet your needs or the developmental level of your students.

THIS PACKET INCLUDES:

- Teacher background information
- Animal fact sheets
- Multidisciplinary activity and project suggestions
- Student activity sheet masters
- Reference list
- Vocabulary list
- Resource information
- Map of Woodland Park Zoo
- Onetime pre-visit Teacher's Pass
- Fliers from local raptor organizations

Please call the zoo's Teacher Resource Center at (206) 684-4850 if you have any questions or would like additional information.

We hope this packet will make learning about raptors and the environment a stimulating and rewarding experience for you and your students.

Sincerely,



School Programs Naturalist



Teacher Training



Agnes Overbaugh

RAPTORS

WHAT IS A RAPTOR?

Raptors are birds of prey that catch and kill other animals for food using their powerful feet and sharp claws, also called **talons**. The term raptor comes from the Latin word “raptare” which means to grab or seize. Raptor species include eagles, hawks, falcons, owls, kites, harriers, old world vultures, osprey and secretary birds.

Many other birds such as robins, pelicans and swallows are also predatory birds; however, they are not raptors. Why not? It is not their diet that distinguishes them from raptors since many raptors also eat fish, insects or other small prey. These other predators are distinguished from raptors by their hunting technique; they use their beaks to catch their food while raptors use their feet. By killing with their feet, instead of their beaks, raptors avoid having potentially dangerous prey near their valuable and vulnerable eyes. Raptors are more highly adapted to catching live prey than other predatory birds, so much so that the term “birds of prey” has become synonymous with the word raptor.

There are approximately 450 species of birds worldwide which are classified as raptors. Raptors vary greatly in ancestry, size, color, diet and hunting style, but all raptors do share certain distinguishing characteristics. The major distinguishing features shared by raptors are their powerful feet and legs, and their sharp talons which raptors use for capturing their prey. Raptors also have strong hooked beaks for tearing their food into smaller pieces, as well as excellent eyesight and good hearing to help them find their prey.

Raptors can be found on every continent on earth except Antarctica. They are also found in every type of habitat from desert to tropical rain forest, and from the remote arctic tundra to crowded cities.



Kevin Schaefer

RAPTORS AND PEOPLE

Raptors have been an integral part of human culture for thousands of years. Human and raptor relations have been and remain paradoxical. People have at once admired, feared, worshipped and persecuted raptors. Raptors have been randomly killed by ranchers fearing attack on their livestock and at the same time raptors are used as symbols of honor and freedom. Owls have been feared as evil omens and revered as wise philosophers.

Raptors have also been depicted in religions throughout the world. In Greek mythology the eagle was revered as the messenger of Zeus

and the owl was the symbol of Athena, goddess of wisdom. Native Americans called the eagle “Thunderbird” because they believed it controlled thunder and lightning. In ancient Egypt, raptors were at the center of many religious beliefs and several were deities. Horus, the god of the sky, took the form of a falcon-headed man. Raptors even appear in Egyptian hieroglyphics: the figure of an eagle forms the letter A.

Many Native American cultures believed that all living things had a role in the great circle of life and that people were a part of that circle, not separate from it. Because Native Americans depended on the land for their food, shelter and clothing, survival itself might be in jeopardy if a severe winter or summer drought depleted the food supply. Many of their prayers asked for help from spirits or animals, especially eagles. Warriors of some Native American nations hoped to gain some of the strength, power and hunting skill of the eagle by wearing feathers or other parts of the bird. Eagle parts are still used in ceremonial pieces such as fans, pipes, whistles, headdresses and staffs. Eagle feather war bonnets were worn only by the great warriors of some tribes. Most braves only wore a single feather for protection.

Today birds of prey are still important symbols for all Americans. The bald eagle became the national bird of the United States in 1782. It appears on our Great Seal, holding an olive branch in one foot and a bundle of arrows in the other to symbolize the powers of Congress to make both peace and war. Eagles appear on quarters and dollar bills, on postage stamps and on postal trucks. In the Boy Scouts, Eagle Scout is the highest award you can achieve and many amateur and professional sports teams have a raptor as their mascot.

HISTORICAL PERSPECTIVE: THE SPORT OF FALCONRY

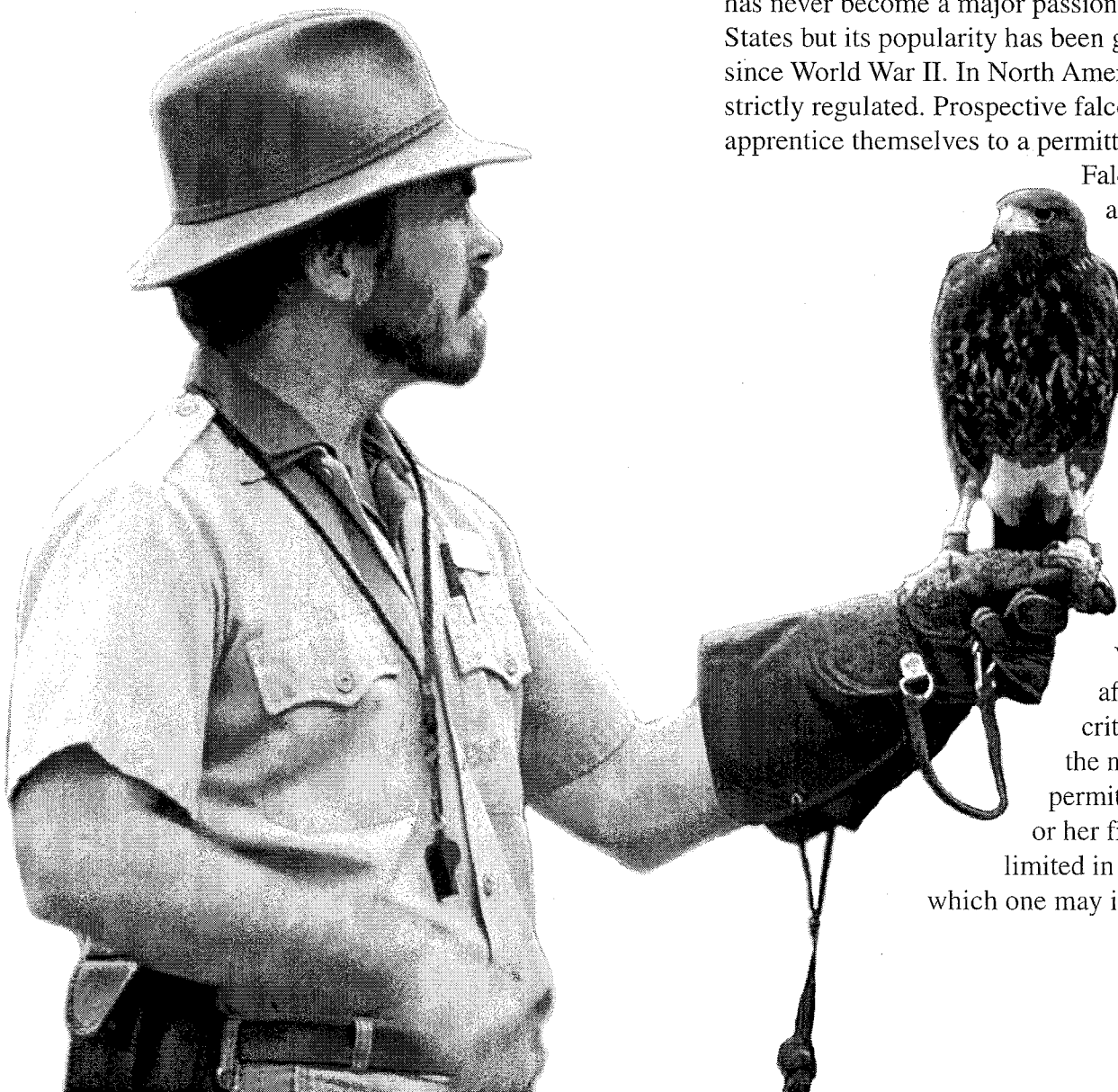
Falconry, the training and use of raptors for hunting, is one of the oldest partnerships between humans and animals and dates back at least 4,000 years. Throughout history, falconry has been

practiced in much of the world. In most countries falconry was largely a sport for the wealthy who had the time and resources to house and train their birds. The type of bird flown by a person often corresponded to a strictly enforced social hierarchy. In Europe, only the highest ranking men were allowed to fly peregrine falcons or gyrfalcons. Noble women might fly a merlin, while a servant or young child could only fly a kestrel. The nobility often made it illegal for commoners to own or fly birds altogether. During medieval times the sport of falconry was pursued with such fervor that no expense was spared in the birds' care or equipment. Some people even brought their birds to church.

After the invention of firearms, falconry's popularity soon dwindled in Europe but remained very popular in Asia and the Middle East. The sport of falconry has never become a major passion in the United States but its popularity has been growing steadily since World War II. In North America, falconry is strictly regulated. Prospective falconers must apprentice themselves to a permitted Master

Falconer and must also pass a state falconry test.

Next they must acquire the necessary equipment and build appropriate housing which is then inspected by the State Department of Fish and Wildlife. Only after all these criteria are met may the novice falconer be permitted to acquire his or her first bird and is still limited in the species with which one may initially work.



Falconry is more than the keeping of raptors as pets. It is a hunting sport that requires a considerable amount of time and expense in order to care for and train the birds properly. For many of the people involved, the sport of falconry becomes a way of life. Because of Europe's earlier passion for falconry a whole language was built up around the sport. Today we unknowingly use many falconry terms or derivatives in our everyday speech. Here are just a few.



Falconry Term	Original Meaning	Modern Usage
haggard	a hawk captured as an adult	looking wild, untamed or unkempt
harrier harried	a group of hawks being pursued by a harrier	one that harasses/harries harassed, overcome with problems
cadger	a falconer, usually an older one, who carried a portable perch or cadge	codger — an older man
gorged	a falcon that has a full crop	to be completely full or stuffed
boozer	a falcon that drinks a lot of water	a person who drinks a lot of alcohol
mew	a raptor enclosure	a place to hide, a small living space
on a lark	setting a merlin after a skylark was considered a great show	doing something for fun or adventure
rouse	to shake the feathers (as birds do when they wake)	to stir up, excite or awaken
tether/tethered	to restrain a raptor with leg straps	to be stuck with something, unable to go farther

EVOLUTIONARY HISTORY

The first reptilian-like bird, Archaeopteryx (archaeo=ancient + pteryx=wing) lived 150 million years ago. Since that time birds have evolved into many forms. Some, like the ostrich, are large and flightless. Others, like the penguins, now do their “flying” only under water. Most, however, have retained a basic avian body shape that makes flight possible. Within this basic body form, birds have evolved to survive on every corner of the earth and to eat an amazing array of plant and animal foods.

The ancestors of today's raptors probably evolved during the early years of bird diversification. Fossil hawks and eagles have been found that date back 35-50 million years. Like most birds, raptors have hollow, thin-walled bones. Because thin bones do

not preserve as well as thicker bones, very little early fossil evidence has been found for most of the major raptor groups. This lack of fossil evidence has made it difficult to reconstruct the evolutionary history of, and the modern relationships between, birds of prey. In short, we do not clearly know how closely related modern raptors are to one another. New DNA hybridization studies are confirming some earlier theories of raptor evolutionary relationships while disproving others. These studies match the DNA of one species to that of another. Presumably if the DNA of two species is closely matched then the two species are closely related to one another. For instance, at one time turkey vultures were believed to be related to hawks, but now scientists believe they are more closely related to storks.

RAPTORS OF THE WORLD

GROUPS OF RAPTORS

There are two main groups of raptors. Most owls are nocturnal and are active primarily at night. Although certain species of owls are diurnal, many scientific sources group all owls under the heading of “nocturnal raptors” while all other raptors are grouped as “diurnal raptors.” Diurnal raptors are active primarily during the day.

Diurnal Raptors - Diurnal raptors are divided into three distinct families representing 292 species worldwide

Ciconiidae (formerly Cathartidae): New World Vultures (not true raptors, see text for explanation.)

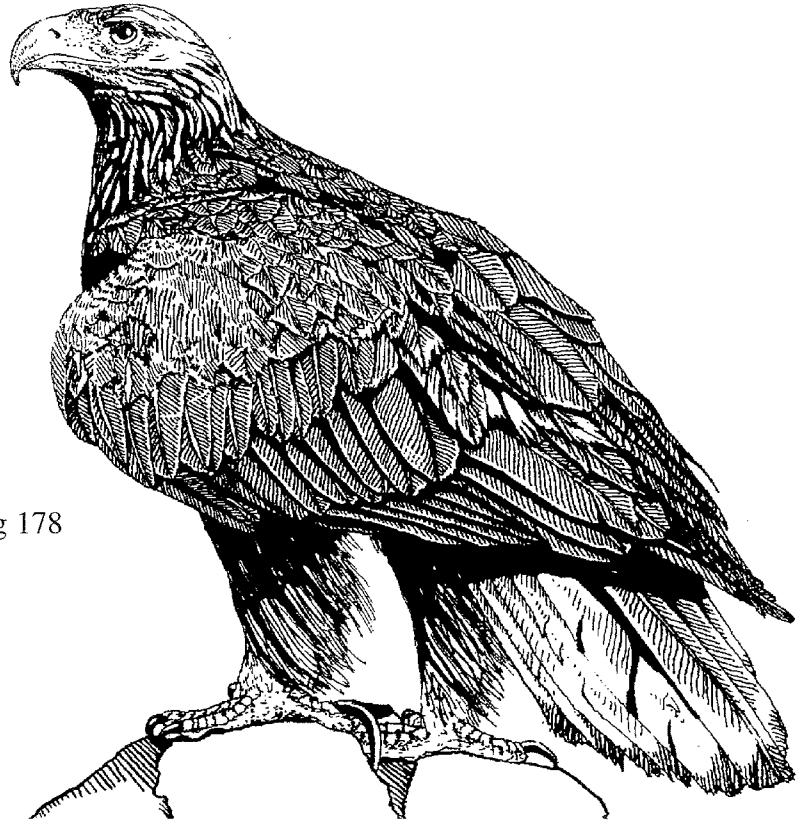
Accipitridae: Old World Vultures, Eagles, Hawks, Kites, Harriers and Osprey

Falconidae: Falcons and Caracaras

Owls - Owls are divided into two families representing 178 species worldwide

Tytonidae: Barn and Bay Owls

Strigidae: Typical Owls



DIURNAL RAPTORS

Family Accipitridae

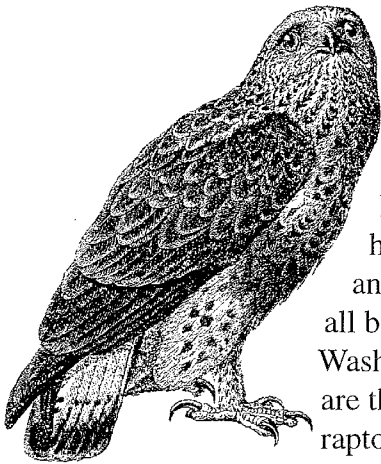
Accipiters

Accipiters, also known as true hawks, are small to large forest-dwelling hawks. Their short, rounded wings and long narrow tails allow them to accelerate quickly and maneuver easily among trees in pursuit of birds and small mammals. Accipiters are agile and aggressive sprinters that often use surprise attacks, but will break off their pursuit if they are unsuccessful after a short chase.

All three North American accipiters species, sharp-shinned hawk, Cooper's hawk and northern goshawk, can be found in Washington. Goshawks are found in mountainous areas while sharp-shins and Cooper's hawks are often seen at backyard bird feeders hunting song birds.

Buteos

Buteos are medium to large hawks or "buzzards." (The word buzzard is often erroneously used when referring to vultures.) The long, broad wings and relatively short, rounded tails of the buteos allow them to fly high and soar for long periods. Buteos are the most varied family of diurnal raptors, even showing great diversity of plumage, diet and habitat preference within a single species. While most live in open country, some are forest-dwellers. Buteos are versatile and opportunistic hunters and take a variety of prey ranging from grasshoppers and lizards, to birds, prairie dogs and jackrabbits.

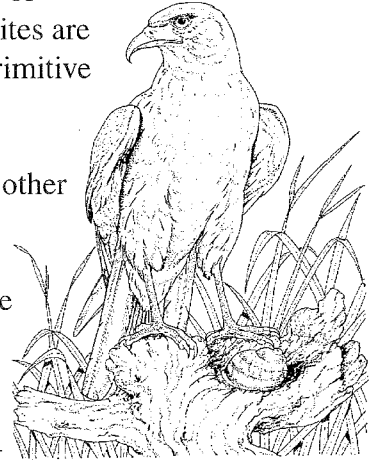


There are 12 buteo species in North America. Of these, four, including rough-legged hawks, Swainson's hawks, ferruginous hawks and red-tailed hawks, can all be found in the state of Washington. Red-tailed hawks are the most commonly seen raptors in North America.

They are often seen perching on posts or soaring in wide circles over freeways and other open areas where they live and hunt.

Kites

Kites are a diverse group of medium-sized raptors. Kites are often considered more primitive than hawks and falcons because their talons are smaller and weaker than other raptors their size. Most kites live in open areas, often by water. They have falcon-like wings and a long tail that may be forked like a swallow's tail. Some kites can hang motionless in the air, not moving their body while hunting and hence, paper kites are named after these graceful birds. Insects, snails, amphibians, small reptiles and small mammals are the mainstay of the kite's diet.

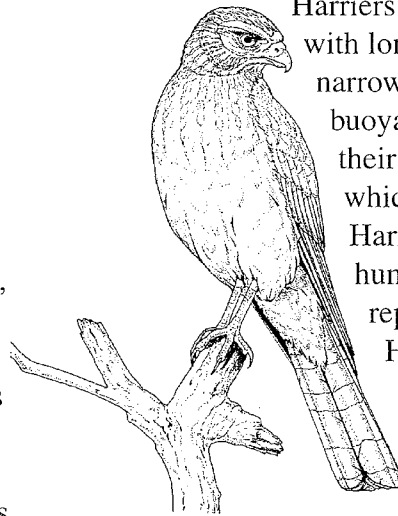


There are five species of kites breeding in North America. The only one found in Washington is the white-tailed kite, which has only recently expanded its range north from California into southwestern Washington.

Harriers

Harriers are medium-sized raptors with long legs and tails, and long, narrow wings. These lean birds are buoyant in flight and often hold their wings in a strong V-shape, which is also called a **dihedral**. Harriers fly low over the ground hunting small birds, mammals, reptiles and amphibians.

Harriers often hunt at dawn and dusk, and have very acute hearing. They also have facial disks similar to those of owls.



Of the 10 species of harriers known worldwide, only one species is represented in North America. This bird, the Northern harrier, sometimes referred to as marsh hawks, can be seen in open fields and marshes in Washington state.

Osprey

Osprey are large raptors with long, bent wings that give them a gull-like silhouette in flight. Osprey live near water and feed almost exclusively on fish. Other raptors may hunt fish but only osprey dive, feet first, into the water in pursuit of prey. Osprey can do this



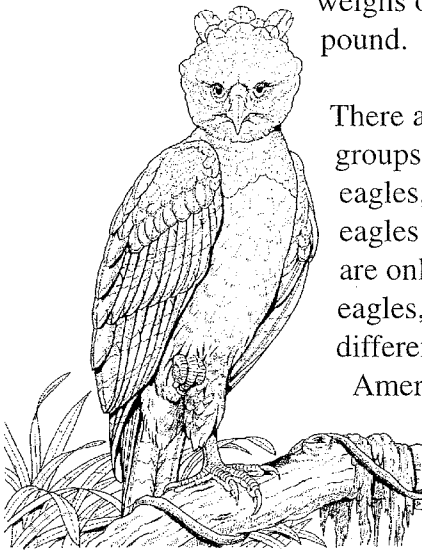
because their wing structure enables them to lift themselves out of the water, even after becoming completely submerged. The ability to turn a toe backward, and special spicules or little spikes on their feet, enable osprey to grasp and carry slippery fish.

There is only one species of osprey and it ranges, either as a migrant or resident bird, over every continent except Antarctica. Osprey are common summer residents on both sides of the mountains in Washington state.

Eagles

When most people think of eagles they think of very large birds. It is a surprise to most people to discover that some eagles are quite small. The little eagle of Australia has just a three foot wingspan and

weighs only a little over a pound.



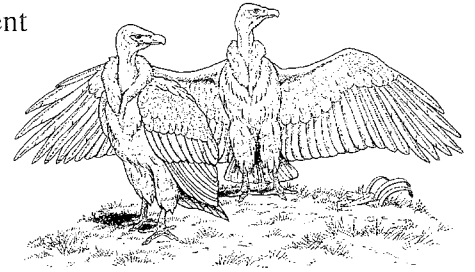
There are four recognized groups of eagles: harpy eagles, snake eagles, booted eagles and sea eagles. There are only two species of eagles, representing two different groups, in North America. Both North

American species are very large raptors with long, broad wings.

The golden eagle is a booted eagle, so called for the feathers on its legs which go all the way down to its feet like boots. Bald eagles are called fish or sea eagles because they eat primarily fish and water birds and are usually found near water.

Old World Vultures

Old World vultures are generally very large birds with a wingspan up to 10 feet. The head and neck are bare and the neck is often very long. Old World vultures are scavengers and feed on carrion, or dead animals, which they find using their excellent eyesight. Vultures often put their head deep into carcasses of large animals while feeding. Due to their feeding style, the scarcely-feathered heads of Old World vultures prevents matting of feathers that otherwise would be difficult to clean. This adaptation helps to prevent infection.



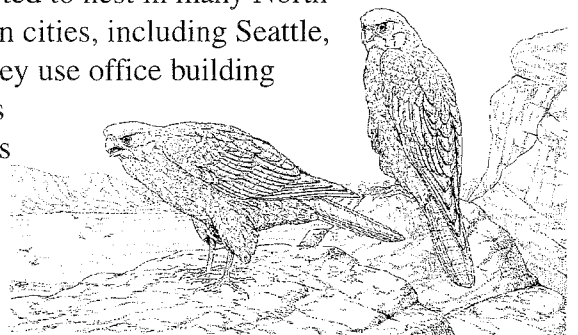
As the name implies, Old World vultures are found only in Europe, Asia and Africa, and live primarily in open habitats such as the Serengeti plains. They are not closely related to the New World vultures of the Americas.

Family Falconidae

Falcons

Falcons are small to medium raptors with long, pointed wings, long tails and squarish heads. Falcons, with their speed, maneuverability and stamina, are adapted for catching other birds in flight. Smaller falcons, such as the robin-sized American kestrel, may also eat large numbers of insects and small rodents.

There are six species of falcons that live or breed in North America. These include the American kestrel, merlin, peregrine falcon, gyrfalcon, prairie falcon and aplomado falcon. All but the aplomado falcon can be seen in Washington state. Peregrine falcons have started to nest in many North American cities, including Seattle, where they use office building ledges as substitutes for cliff ledge nesting sites.



Caracaras

Caracaras are medium to large raptors with long, rounded wings and bare or partially-bare faces.

Caracaras are both hunters and scavengers and eat a wide variety of foods including insects, birds, reptiles, frogs and small mammals.

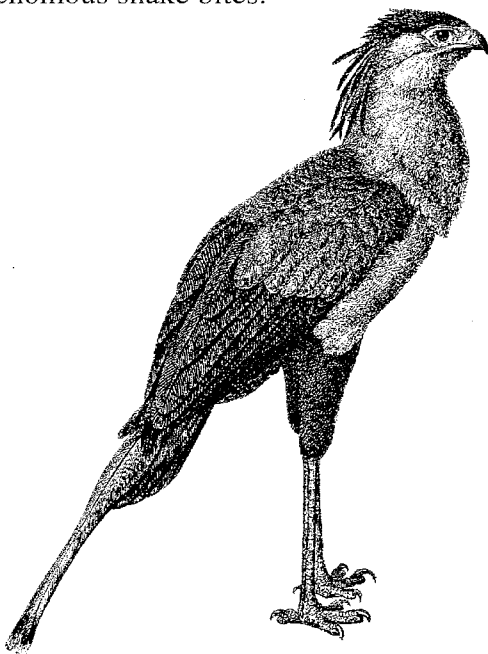


There is only one species, the crested caracara, in North America. These birds are found only in a few pockets in southern Florida, Texas and Arizona, and their range seems to be declining. Caracaras are widespread in the New World tropics.

Family Sagittaridae

Secretary Bird

Only one species belongs to this group and it is found in Africa, south of the Sahara to the Cape. The secretary bird is so named for the plumes of feathers sticking out from its head like a secretary with a feather pen behind his ear. Secretary birds are large raptors with very long legs. They stalk their prey on the African plains and walk up to 20 miles a day in search of food. Secretary birds eat all kinds of small animals, but specialize in killing and eating snakes. Secretary birds use their powerful legs to stomp on snakes and stab them with their back talons. Their legs are covered with tough scales which help protect the secretary bird from venomous snake bites.



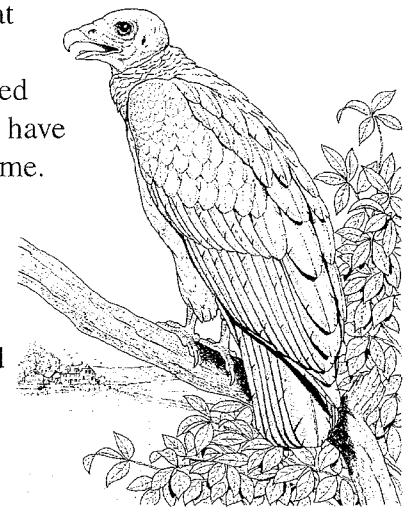
Family Ciconiidae (formerly Cathartidae)

New World Vultures

The misnomer "buzzard" was given to New World vultures by European settlers who thought they were related to European buteos which are called "buzzards." New World vultures are not true raptors since they feed almost exclusively on carrion, and therefore lack the powerful feet characteristic of raptors. However, since New World vultures look very much like raptors and have been associated with them for so long, we have included them in this packet.

New World vultures are large birds with featherless heads, long, broad wings and most have blackish bodies. In the air they are often confused with eagles. New World vultures do not generally hunt their own food; however, they do have sharp beaks for tearing into carcasses as well as bald heads to make cleaning their heads easier. New World vultures spend considerable amounts of time soaring in search of food which they often locate by smell. They are one of the few birds that have a good sense of smell.

It is only recently that DNA hybridization studies have confirmed what many scientists have believed for a long time. New World vultures are actually more closely related to storks than they are to hawks or even Old World vultures. This new discovery has shuffled the raptor family tree and New World vultures are now placed in the stork family.



There are three North American vultures: the turkey vulture, black vulture and California condor. Only the turkey vulture is found in Washington where it is a summer resident. It is interesting to note that the California condor, one of the world's most endangered birds, was found in Washington state as late as the early 1800s.

OWLS

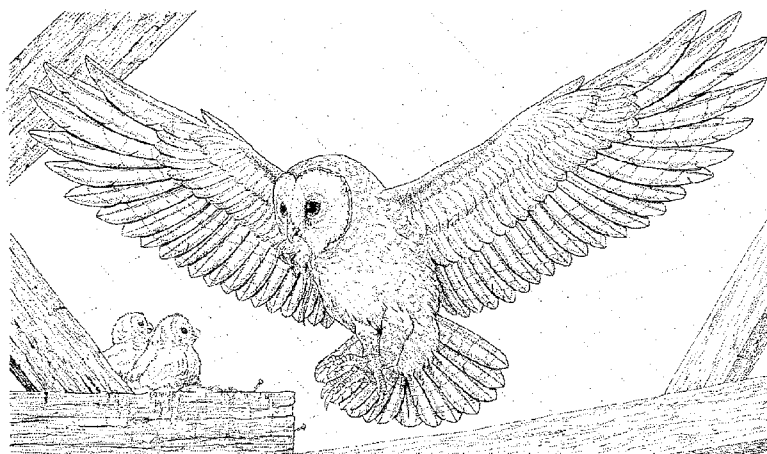
Family Strigidae

Typical Owls

This group contains 161 species of owls which show a great amount of variety in size, color and choice of habitat. Many of the typical owls are forest- or woodland-dwellers with short, broad wings. The distinct facial features and round appearance of owls make them hard to confuse with other raptors, or other birds for that matter. Owls look the way they do to accommodate the adaptations they have for nighttime hunting. The large head houses large, sensitive eyes and ears specially adapted for night hunting. Large eyes allow in more light, allowing the owls to be able to see better at night. The ears of owls are offset, enabling the birds to use triangulation to locate their food. The facial disk, a group of special feathers radiating out from the eyes, funnel sounds to the owl's ears much as our outer ear does for us.

Owl feathers are soft and fluffy which gives the owl a round profile. These specialized feathers also help owls fly silently, enabling them to sneak up on prey and to avoid making noise that would interfere with the owl's sensitive hearing. Some typical owls have ear tufts; these small groups of feathers stand up on the owl's head and look like ears or horns. Ear tufts have nothing to do with hearing but instead are used in communication and possibly camouflage.

There are 15 species of typical owls in Washington state. These include: great horned, flammulated, great gray, burrowing, boreal, snowy, barred, spotted, northern hawk-owl, northern saw-whet, western screech, northern pygmy, short-eared, long-eared and boreal owls.

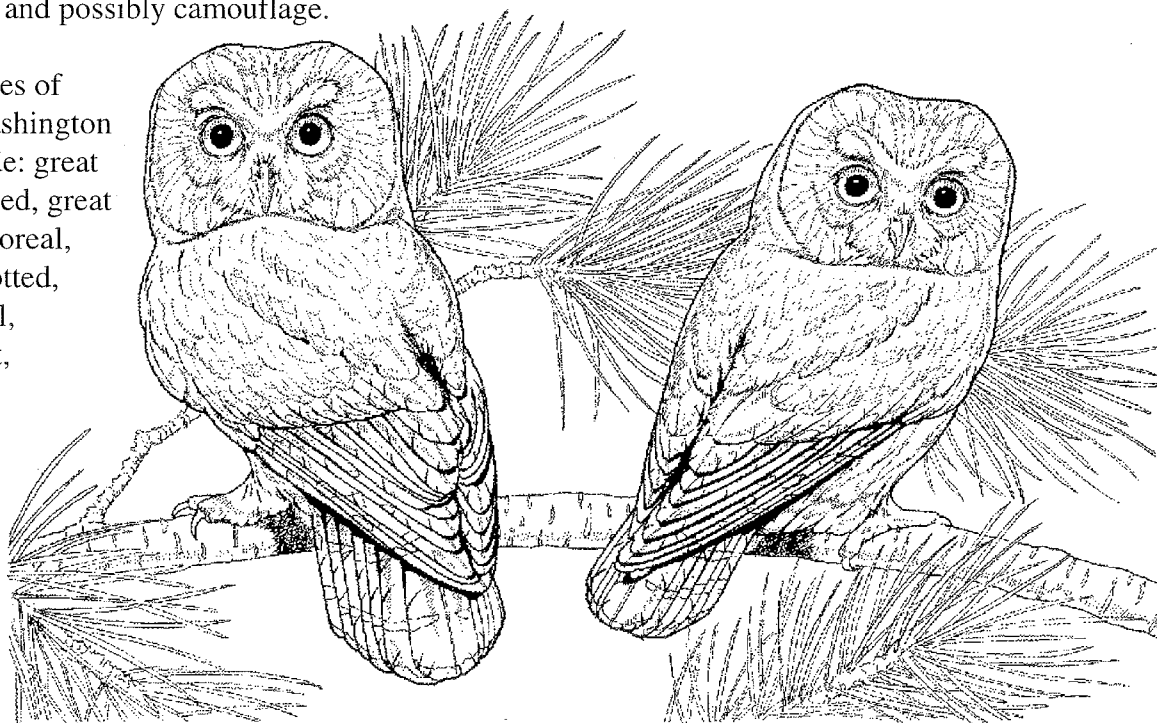


Family Tytonidae

Barn Owls

Barn owls are found throughout the world except in Antarctica. All 17 species of owls in this group look very similar. Barn owls have many of the same features of typical owls except they all have white, heart-shaped faces and lack ear tufts. Barn owls usually live in wide-open areas with few trees and therefore they have longer wings than do most typical owls.

There is one species of barn owl in Washington. They are common in open areas such as farm fields and parks throughout the state.



RAPTOR SPECIES OF WASHINGTON

Buteos

Red-tailed Hawk
Rough-legged Hawk (winter)
Ferruginous Hawk (t)
Swainson's Hawk (summer)

Eagles

Bald Eagle (t)
Golden Eagle

Accipiters

Sharp-shinned Hawk
Cooper's Hawk
Northern Goshawk

Falcons

American Kestrel
Merlin
Prairie Falcon
Peregrine Falcon (e)
Gyr Falcon (winter)

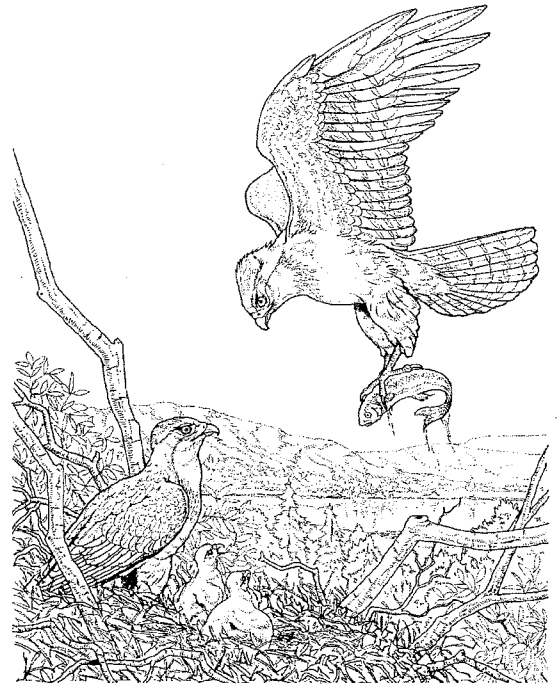
Other raptors

Turkey Vulture (summer)
Osprey (summer)
Northern Harrier
White-tailed Kite

Owls

Barn Owl
Barred Owl
Spotted Owl (t)
Great Horned Owl
Flammulated Owl
Northern Saw-whet Owl
Great Gray Owl
Western Screech Owl
Burrowing Owl
Northern Pygmy Owl
Northern Hawk Owl (winter)
Short-eared Owl
Boreal Owl
Long-eared Owl
Snowy Owl (winter)

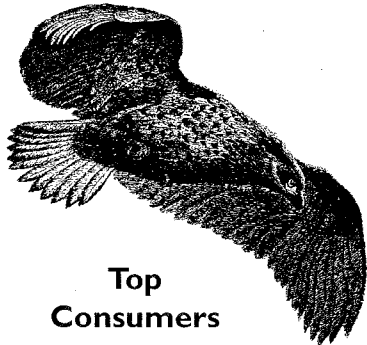
(e) - denotes an endangered species
(t) - denotes a threatened species



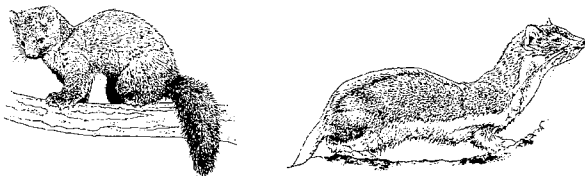
ECOLOGY

Web of Life

The plants and animals in a community live in a web of interdependence. In this web each species contributes to the functioning of the overall system while also relying on other members of the community for its own needs. Within this web of relationships there are producers, consumers and decomposers. **Producers** are the plants that use the sun's energy to produce starches and sugars, the carbohydrates that are the basis for sustaining the food needs for all animals. **Consumers** are animals that eat plants and/or other animals. A **primary consumer** eats only plants, whereas a **secondary consumer** eats plants and/or other animals. An animal is said to be at the top of the food chain if it is a consumer which is not hunted by any other nonhuman animal. **Decomposers** help to break down dead plant and animal material into organic substances which can then be used by the producers.



Top Consumers



Secondary Consumers



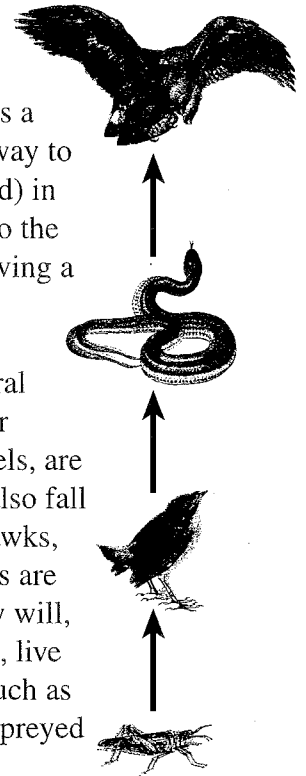
Primary Consumers



Producers

The relationship between the plants and animals in a community is often illustrated as a food chain or web. This is one way to show the flow of energy (or food) in the system from one organism to the next. A typical food chain involving a raptor might look like this:

Raptors may participate at several layers in the food chain. Smaller raptors, such as American kestrels, are secondary consumers but they also fall prey to larger raptors such as hawks, owls and larger falcons. Vultures are generally decomposers, but they will, on occasion, hunt and kill small, live prey. Only the largest raptors, such as eagles and large hawks, are not preyed on by others.



CARRYING CAPACITY

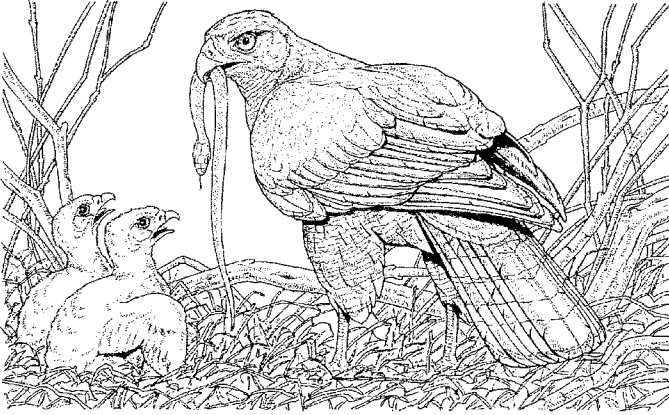
There is a limit to the number of plants or animals that can live in a given area. This number is called the **carrying capacity**. The influences that limit the life in an area are called **limiting factors**. Limiting factors may include: food supply, rainfall or the number of available nesting sites. Living things tend to reproduce in numbers greater than their habitat can support but population sizes are brought under control by the limiting factors.

If the population becomes too large and expands beyond the carrying capacity, there will not be enough food, shelter or other resources to go around and the habitat will not be able to sustain all the demands placed on it. Unchecked, overpopulation will eventually lead to overcrowding, starvation and disease. These conditions increase mortality, bringing the population back to manageable numbers.

Human influence often alters the carrying capacity of habitats due to pollution, habitat encroachment or destruction, and other factors. Thus, human populations often throw off the balance of nature.

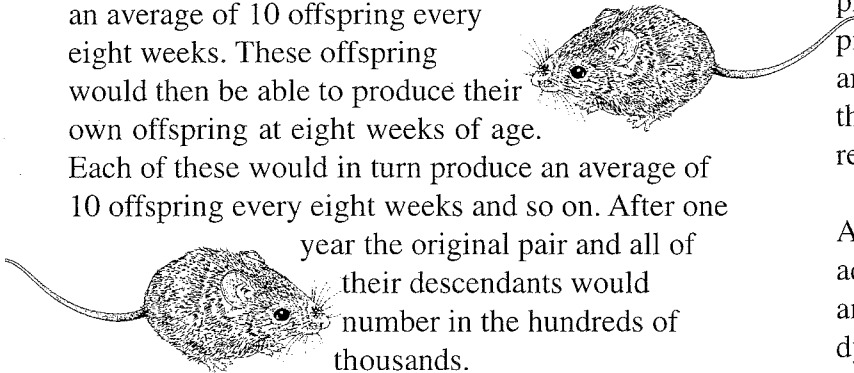
BALANCE OF NATURE — MAINTAINING POPULATION

Raptors are important to the stability of natural environments. As **predators** (animals that kill and eat other animals) they help to control the populations of the animals that they eat, their **prey**.



Raptors, as well as all other predators, play an important role in keeping prey populations in check and by preventing these populations from growing so large that they damage or destroy their habitat. If a prey species population were allowed to grow unchecked, there would be so many animals that they may use up all the available resources.

Imagine what would happen if a pair of mice reproduced continually without losing offspring to predators. The original pair of mice would produce an average of 10 offspring every eight weeks. These offspring would then be able to produce their own offspring at eight weeks of age. Each of these would in turn produce an average of 10 offspring every eight weeks and so on. After one year the original pair and all of their descendants would number in the hundreds of thousands.



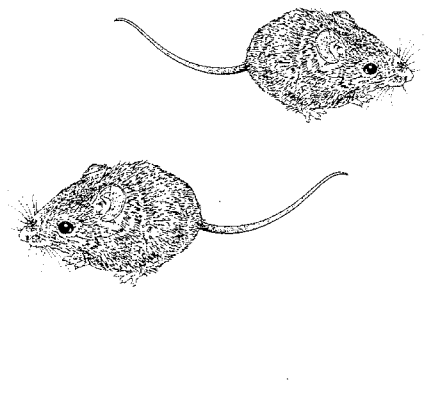
Most people understand that an owl depends on mice and other small rodents as a source of food, but few also recognize that those same mice depend on owls and other predators to control their numbers. When predators keep the numbers of prey species down, they help ensure there are adequate resources available for the prey species.

But who controls predator numbers? The prey. If a predator population increases beyond the carrying capacity of its environment then there will not be enough prey to go around and only the best predators will be able to catch enough food to survive. Fewer still will be able to find enough food to produce and raise offspring successfully.

Even during periods when food is plentiful, mortality is high for young raptors. Accidents and disease take their toll on young fledglings as they leave the nest for the first time and learn to live on their own. Young raptors know instinctively how to hunt but their skills are undeveloped. Those that cannot develop the skills to catch prey consistently will become weak or sick and many will die. Only a small percentage of the raptors that leave the nest will survive to become breeding adults. Weak or unskilled predators will starve leaving only the strongest and healthiest members of the community to reproduce and pass their genes on to the next generation.

Even under good conditions and with all their adaptations for hunting, raptors may only be successful at catching prey about one out of every four or five attempts. Just as raptors have evolved adaptations to catch and kill prey, their prey have evolved many ways to avoid being eaten. Generally weak, old or sick animals are more likely to fall prey to other animals. So, the predator keeps the prey population strong by hunting the less-fit animals and the limited availability of prey means that only the most fit predators will survive to reproduce.

As predators adapt greater skills and physical adaptations for hunting, prey adapt greater skills and physical adaptations for escaping. Adaptation is dynamic!



CONSERVATION

EXTERMINATION OF PREDATORS

Since the settlement of North America by Europeans, raptors and most other predators have faced many perils. Although many people admired the skill and beauty of raptors, most still considered all raptors to be inherently "bad" because they competed with humans for small game and because they were considered livestock killers. Although livestock, especially free-ranging chickens or young sheep, were occasionally taken by some raptor species, all raptors were persecuted regardless of their potential for harming livestock. This perceived loss of livestock was often used as justification for government bounties on raptors, some of which lasted into the 1950s and 1960s.

As poultry farms have moved indoors and more has been learned about the natural history of raptors, most people in this country have come to understand that raptors are not the detrimental animals they were previously thought to be. Although it is now illegal to kill, harm or harass raptors in the United States, poisoning and shooting continue.

ENVIRONMENTAL BAROMETERS

Since many raptors are at the top of the food chain, they help us to monitor the health of the whole biological community and its environment.

When a top predator is declining in numbers it is often an indicator of problems further down the food chain. These species are therefore often referred to as **indicator species**. For example: when the number of bald eagles, peregrine falcons, osprey and brown pelicans began to decline seriously in the 1950s and 1960s scientists began to look for answers.

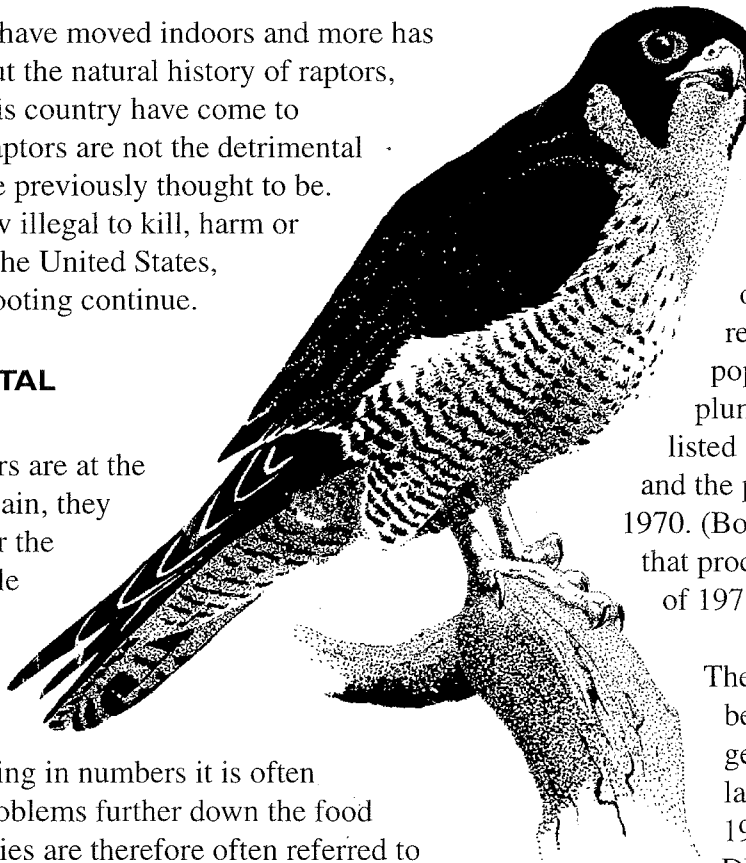
What they discovered was that a pesticide called DDT was present in the food chain. DDT was used widely on cropland throughout the United States after World War II. Animals that ate plants sprayed with the pesticide became contaminated with the chemicals. In addition, residue washed into lakes and streams and was then absorbed by aquatic plants and small animals; these were then eaten by fish. Animals low on the food chain were not often adversely affected by the low levels of DDT and the problem initially went undetected.

Predators such as bald eagles and peregrine falcons, however, accumulated high levels of pesticide in their tissues after eating large numbers of

contaminated fish, small mammals or birds. The high level of chemicals in their bodies interfered with the female birds' ability to develop strong egg shells. As a result many birds laid eggs with shells so thin that they broke during incubation or otherwise failed to hatch. With their reproductive success dwindling, populations of these birds began to plummet. The bald eagle was officially listed as an endangered species in 1967 and the peregrine falcon followed suit in 1970. (Both species were listed under a law that preceded the Endangered Species Act of 1973.)

The adverse effects of this toxin became more widely known to the general public in the late 1960s, in large part due to Rachel Carson's 1969 book *Silent Spring*. In 1972 DDT was banned for most uses in the

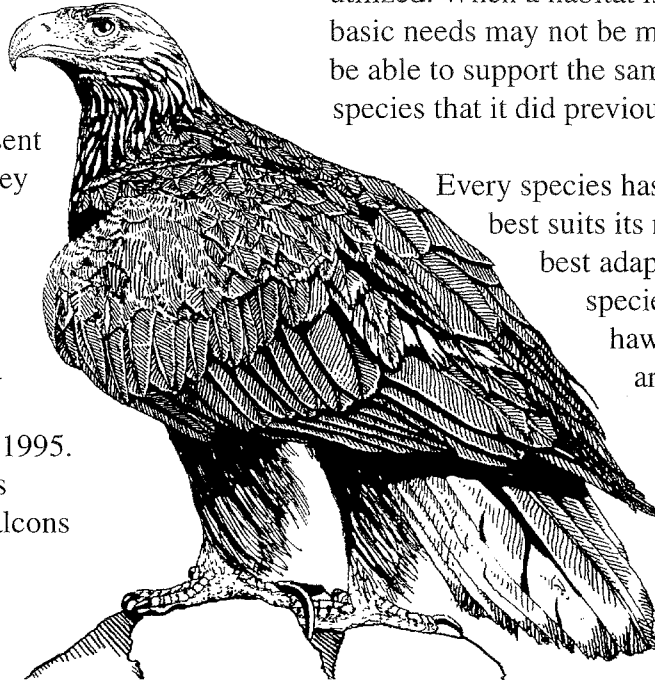
United States. These predatory birds acted like canaries in a coal mine, indicating that something was not right in the environment. Had the adverse effects of DDT remained undetected, and its use continued, many more animals would have been lost and ultimately humans may have been directly affected.



The ban on DDT combined with captive breeding and release programs, habitat improvement projects and other conservation programs soon began to have a favorable effect on bald eagle and peregrine populations as well as other animals affected by the toxins. Since 1971, Woodland Park Zoo has contributed to conservation efforts by caring for, and when possible, releasing rehabilitated injured or sick bald and golden eagles to the wild. As of 1997 over 180 bald and golden eagles have been brought in for treatment and over 80 of these were released. Those that survive but are not releasable are sent to zoos or other facilities where they can be used to educate the public.

Due to their steady increase in numbers, the status of bald eagles was downgraded from endangered to threatened by U.S.F.W.S. (U.S. Fish and Wildlife Service) in July 1995. The U.S.F.W.S. currently (1997) is considering removing peregrine falcons in the United States from the Endangered Species list.

Although these birds are increasing in numbers they are still not completely out of danger. DDE, a breakdown product of DDT, can still be found in some parts of the country. DDT is still used in many other countries, including those in Latin America, where migratory birds, including some peregrines, and many prey birds spend their winters. Although DDT is less of a problem now than it used to be, pesticides, lead and other chemical pollutants continue to threaten wildlife. Efforts must be made to limit or eliminate these chemicals and other threats to wildlife.



HABITAT

Habitat destruction also poses an imminent threat to many raptor species. All animals need **habitat**, a home that meets all their basic needs for survival including food, water, air, shelter and space in which to move around. A habitat must also provide for the animal's needs in such an arrangement that the animal can make use of them. For example, water must be in liquid rather than solid form to be utilized. When a habitat is destroyed or altered, basic needs may not be met and the habitat may not be able to support the same number or types of species that it did previously.

Every species has a preferred habitat that best suits its needs and for which it is best adapted to survive. Some species, such as the red-tailed hawk, are generalists. They are able to live or even thrive in a wide variety of habitats and hunt an equally wide variety of prey. Other species, however, are more specialized and have specific nesting and prey requirements. For example, bald eagles

nest in large trees and eat primarily fish and water birds. A bald eagle's habitat must therefore contain large trees near a large body of water.

Unfortunately, bald eagles must compete with people who also like waterfront property. As trees are cut down to make room for houses, valuable bald eagle habitat is destroyed. Water activities and pollution also affect the bald eagle's habitat and the availability of food.

Habitat changes can also shift the balance away from one species in favor of another. For example, northern spotted owls require large areas of old-growth forest, and for whatever reason they do not adapt quickly to forests that are a patchwork of young and old forests. Their inflexibility and their diminishing habitat has put the spotted owl in a precarious position. However, as old-growth forests are logged to supply ever-growing human demands for lumber and space, other species may actually benefit. The barred owl is an example of such a

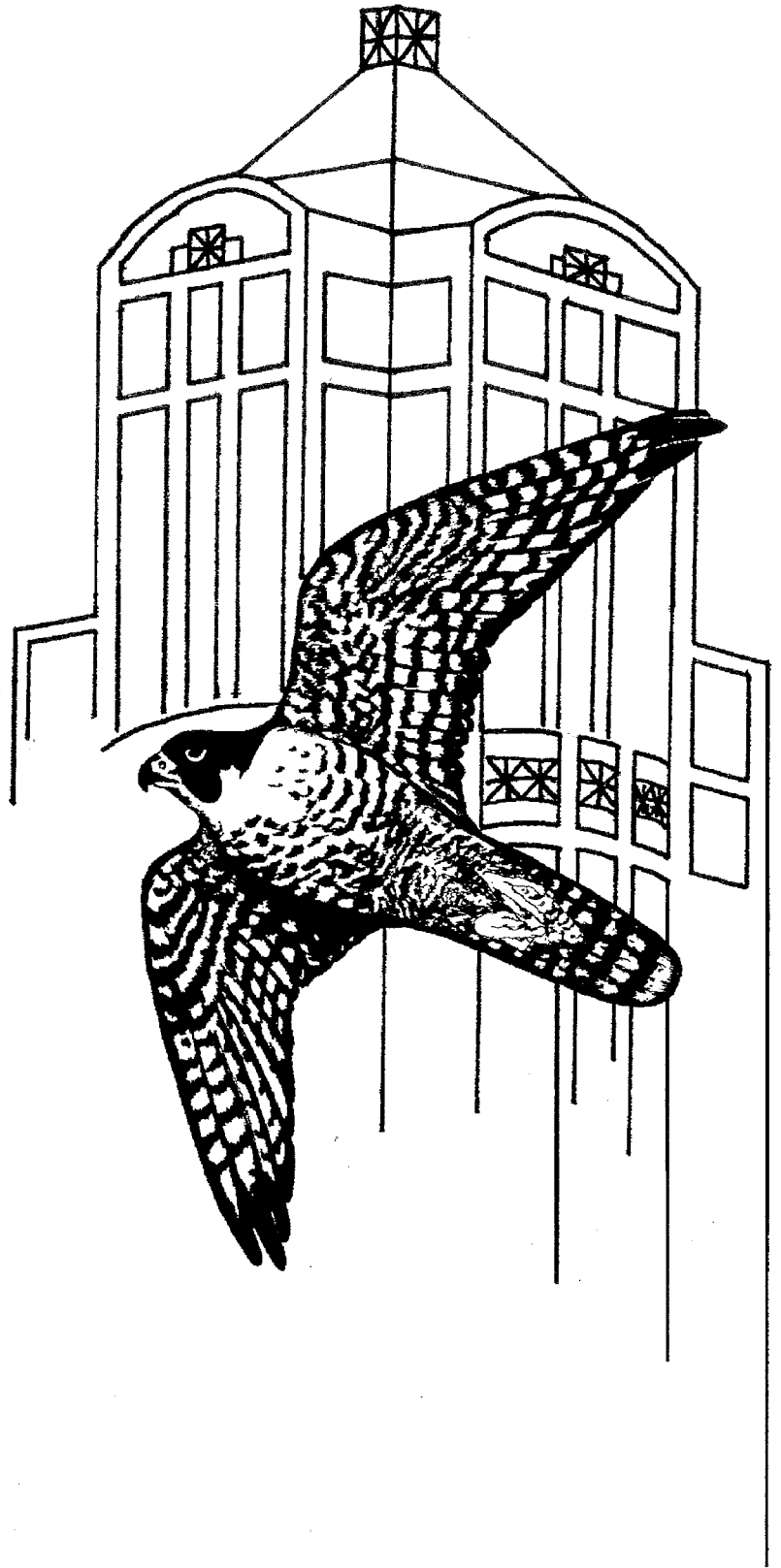
species. Barred owls thrive in young forests but also penetrate into virgin forests and compete with spotted owls. Where their paths meet, the more aggressive barred owl often wins territorial disputes. The barred owl's habitat preferences and more aggressive nature have allowed the species to expand its range to the detriment of its close relative, the spotted owl. Red-tailed hawks have also expanded their range. They prefer open areas with trees or posts for perching, just the kind of landscape that is created by farming and even highway construction.

In some instances a species is able to adapt its requirements to take advantage of a unique environment. The peregrine falcon is a good example of this. Peregrines, which normally require cliff ledges for nesting and an ample supply of ducks and other small birds for prey, are beginning to settle in large cities. This may seem strange until you look closer and see that their basic needs are still being met. City skyscrapers provide the "cliff ledges" while pigeons and starlings become standard prey.

Although some species benefit from human-altered landscapes and thrive, a greater percentage of animal species are adversely affected. The result is that a few well-adapted species become very common or widespread, while many more species become rare or confined to smaller and ever-decreasing patches of habitat. These conditions place these rare or confined species at greater risk of having disease, severe weather or drought wipe out an entire population.

It is also important to note that many raptor species rely on several habitats or locations during their lifetime. Many raptors, including several Washington state species, are migratory. For these birds it is crucial to protect not only habitat in their northern breeding grounds but also habitat in their southern wintering range, and throughout their migration route.

The amount and quality of a habitat is a limiting factor in the number of raptors that can be maintained in an area. The less habitat area or poorer the quality of the habitat, the fewer species and number of each species it will support.



RAPTOR BIOLOGY

PHYSICAL FEATURES OF RAPTORS

Raptor species vary from continent to continent and even region by region; however, they fill very similar **ecological niches** or roles in their respective habitats. Since all raptors have similar predatory life-styles, they have evolved similar adaptations for those life-styles. Yet, each species lives in a different habitat and hunts different prey, so in addition to their similarities, each species has different adaptations for survival.

The adaptations of any animal are a combination of physical and/or behavioral features that enable the animal to survive in its habitat. These adaptations have evolved over time in response to environmental conditions, prey availability and hunting requirements. We will now look more closely at the adaptations that make raptors the superb hunters that they are.

SKELETON

Many of the most amazing adaptations of any bird are those features that reduce the bird's weight to make flight possible. Bird skeletons have several adaptations for weight reduction. Birds' bones are thin-walled and their long bones are virtually hollow with thin, criss-crossing support struts which make the bones extremely lightweight, yet still structurally very strong. Birds also have partially-fused bones in their pelvic and shoulder regions which give them greater strength even though they are light in weight. The elimination of teeth lightens birds up even more.

What do you guess a bald eagle weighs? Most people are surprised to learn how lightweight birds really are. A male bald eagle typically weighs between eight and 10 pounds, the larger females rarely weigh over 14 pounds. A robin-sized American kestrel weighs only about four ounces.

Because they use their feet as hunting tools, raptors have more substantial leg bones than those of other birds of a similar size. In addition, these leg bones have many ridges for the attachment of the powerful muscles that control the raptors' feet.

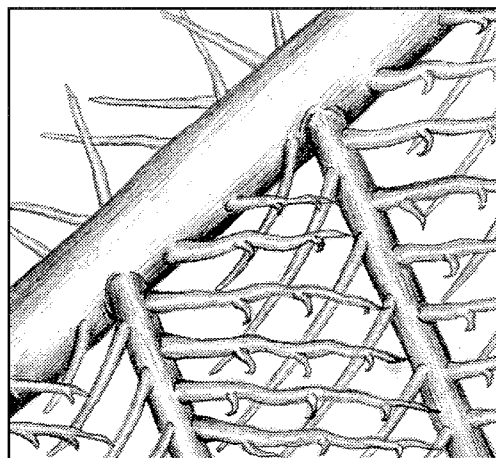
WINGS AND FEATHERS

The shape of a raptor's or any bird's wings is determined by its habitat and its type of flight. Hawks, eagles and vultures that soar in wide-open areas have long, broad wings. Forest-dwelling hawks and owls have shorter, more maneuverable wings for moving among trees. Falcons have long, pointed wings built for speed.

Feathers are a lightweight way to insulate the body and give birds an aerodynamic wing profile which helps provide lift for flight. Owls also have fringed flight feathers which muffle their wing beat and allow them to silently swoop down on their prey. The drab colors of most raptors probably help to camouflage them from their prey and from predators, such as larger raptors, that may try and attack them.

Birds have many types of feathers, each with a different function. The design of the feather depends on where it comes from on the body and what its function is. Raptor feathers are typical bird feathers in structure and function.

A typical feather consists of a central **shaft** which is generally stiff and provides structure to the feather. The flat **vane** on either side of the shaft is made up of many interlocking barbs. The barbs branch further into **barbules**, which have microscopic hooks running along their length that catch on each barb and hold the barbs together like Velcro. Birds preen themselves to smooth out their feathers and to rejoin barbs that have become separated. Preening also helps to remove dirt and parasites as well as to spread waterproofing oils from a gland at the base of the tail.

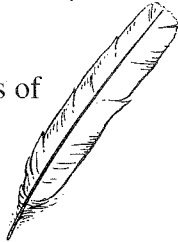


Types of Feathers

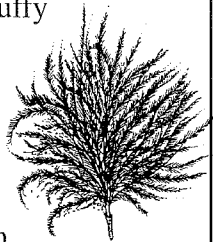
Contour feathers are the feathers that cover the surface of a bird's body, wings and tail. These sleek feathers also help to streamline the bird's body and provide a water-resistant covering.



Flight feathers are the feathers of the wing and tail that birds use for flying. These often have vanes that are asymmetrical.



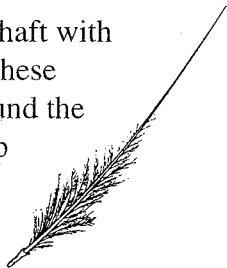
Down feathers are soft and fluffy and lack or have an extremely reduced shaft. Down feathers help to trap warm air close to the body for insulation. The base of many contour feathers is also downy to provide extra insulation.



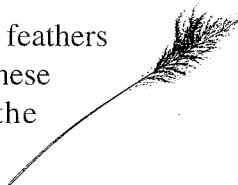
Semiplumes are midway in structure between a typical contour feather and a down feather. These feathers help to insulate and give the bird a smooth aerodynamic body shape.



Bristles have only a central shaft with few or no barbs or barbules. These feathers are found mostly around the eyes and nostrils and may help protect these sensitive areas. They may also be sensory.



Filoplumes are long, hairlike feathers embedded in nerve bundles. These feathers help to monitor the position of the flight feathers.



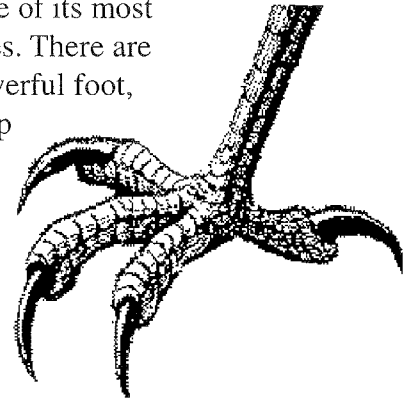
Powder down feathers have barbs that disintegrate into a fine powder which may be important for preening.



Feet and Talons

A raptor's feet are one of its most distinguishing features. There are four toes on each powerful foot, each with a long sharp talon or claw.

Generally three toes on each foot face forward while the fourth toe, often with the largest talon, points backward.



Owls have the ability to spread their toes so that two face forward and two face backward, thus giving them a better chance of grabbing their prey in the dark. Osprey also have two backward-facing toes which help them grab and hold fish more easily.

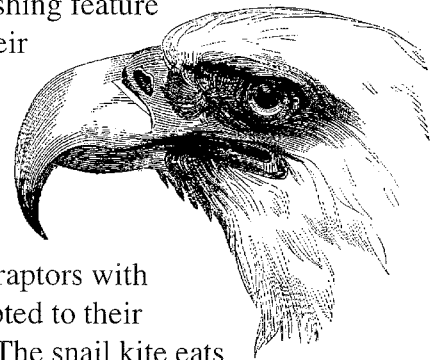
The size and structure of a raptor's feet are determined by the type of prey it hunts. Osprey, bald eagles and some owls primarily catch fish so they have specialized **spicules**, or bumps, on the bottoms of their feet to help grip their slippery prey. Harpy eagles have talons the size of bear claws and legs as thick as a child's wrists, enabling these South America raptors to catch monkeys. American kestrels hunt very small prey such as insects, small rodents and birds; their legs are thinner than a pencil. Since vultures do not use their feet to capture living prey they have much weaker feet and shorter, blunt nails. Some New World vultures are unable to even close their feet completely to grab.

Beaks

Another distinguishing feature of all raptors is their sharp and deeply-hooked beak.

This beak shape is an adaptation for tearing flesh.

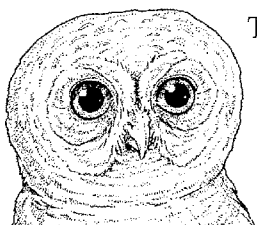
There are several raptors with beaks further adapted to their specialized diets. The snail kite eats snails which hold tightly to their shell, so this kite has a long, curved beak to reach in and extract the snails. After catching prey with their feet, falcons use their notched beaks to immobilize their prey by severing the animal's spine.



Eyes

Raptors have very keen eyesight and are able to see at least two to three times better than humans. This may not seem that impressive unless you realize how keen human eyes are compared to those of many other species. The resolution power, or ability to see distant objects clearly, is especially well defined. Most diurnal raptors are almost exclusively visual hunters.

Like most predators, raptors' eyes face forward. Forward-facing eyes produce an area of visual overlap known as **binocular vision**. This binocular vision is what enables an animal to judge distances, a very important capability for a hunter.



The eyes of owls are adapted for night vision. Large eyes allow more light to enter and hit light-sensitive receptors at the back of the eye. Some owls have eyes as large as

human eyes even though their head is much smaller. If our eyes were as large as owls' eyes in proportion to our heads, our eyes would be the size of softballs. Not only are owls' eyes large, they also have a unique tapered, cylindrical shape and additional receptors for picking up more light in low light conditions.

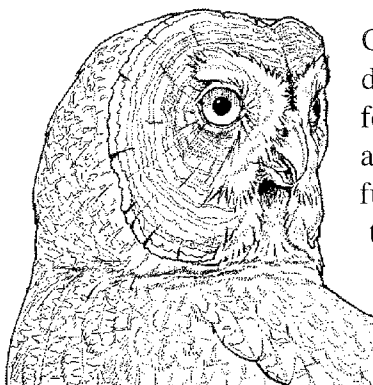
There is a ridge above the eye of many raptors that helps to minimize glare. This ridge, which gives raptors a serious and sometimes scowling appearance, may also help to provide some protection to the birds' eyes while flying through dense cover. A **nictitating membrane** or "third eyelid" also serves to protect the eyes. This clear membrane can be drawn across the eye at the moment of attack or while feeding young to protect the eye from being scratched or damaged.

Ears

All raptors have excellent hearing but it is most highly developed in the nocturnal or nighttime hunters, the owls. Owls have very large, crescent-shaped ears and the ability to regulate the size of the opening to some extent. The ears are also asymmetrically placed, with one higher than the other. This means that an owl can triangulate, or

hear a sound from two different vantage points, making it easier to pinpoint the source of the sound. This excellent hearing allows owls to catch a prey they can't even see.

Birds' ears are at the side of their heads much as they are in people, but we cannot see their ears because they are covered by feathers. Some owls have ear tufts, or small patches of feathers that stick up on top of their heads. These tufts are not for hearing but are used instead for nonverbal communication and possibly for camouflage.



Owls also have facial disks. These special feather arrangements around the eyes act to funnel sound waves to the animals' ears much as our own outer ears do. Some owls can hunt in complete darkness relying

solely on auditory clues. Harriers are unusual among diurnal raptors in that they rely heavily on their ears while hunting. Harriers also have facial discs but lack the asymmetrical ears of owls.

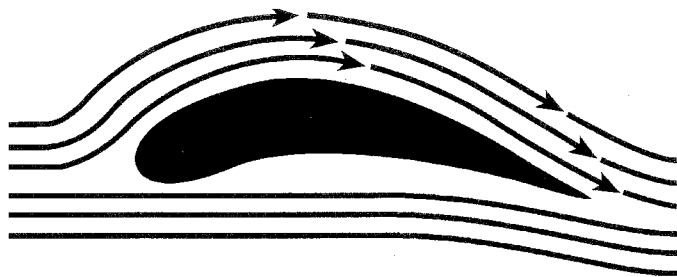
Size

In many species of birds, males are more brightly colored than the females. In most raptors species however, both the males and the females look the same or are **monomorphic**. The best way to tell them apart is by their size. In most raptor species females are on average larger than males. In some species, such as some of the falcons and accipiters, this difference may be very significant.

There are many theories to explain the gender-based size difference. One theory suggests that since males and females are different sizes they are more likely to hunt different sizes and species of prey. This may help males and females to avoid competing with each other for food. Another theory is that the female's larger size may also prevent her from being attacked as prey during mating; or since she does most of the incubation, brooding and nest defense when the chicks are young, her larger size may help in these activities.

FLIGHT

Birds are able to fly because their wings create lift. Bird wings are an **airfoil shape**—rounded on top and flatter below with the leading edge thicker than the trailing edge. When air passes over the top of a curved wing it is forced to travel faster than the air taking the shorter route past the flat underside of the wing. When this happens the air pressure above is reduced creating lift. Aircraft are designed with similar airfoil-shaped wings.



Unlike airplane wings however, bird wings are not static. Birds are able to control the position of their wings and even of their feathers. When birds flap their wings they propel themselves forward. To slow themselves for landing, birds move their wings forward, fan their tails and extend their feet out. Wings may be held in a wide fan shape for soaring, be pulled in closer to the body to dive or **stoop** in pursuit of prey, or be adjusted slightly to control speed, direction or altitude. A special group of feathers at the wrist, called the **alula**, helps control takeoff, landing and other maneuvers.

Raptors also use **updrafts** and thermal air currents often referred to as thermals, to help push them skyward. When wind encounters a mountain range or steep cliff the air is forced upwards. Raptors use these updrafts to buoy themselves and can soar for miles along such ridges. When the air near open ground heats up on a warm day it rises in columns forming **thermals**. Raptors ride these upwards-spiraling thermals. Some larger birds, such as eagles, need strong thermals to lift their weight. They may wait until later in the day to fly when the ground has had more time to warm up. Raptors can glide from one thermal to the next to make long flights.

The shape of a bird's wings depends on what type of flying it does. Birds such as eagles, vultures and hawks, which live in open areas, often spend long periods of time soaring in search of prey. These birds have long, broad wings that are built for soaring and help them take advantage of thermals and updrafts. The long, pointed wings of a falcon are not built for soaring but for speed and maneuverability which they need for chasing their avian prey in wide-open areas. Forest-dwelling hawks such as the accipiters have short, broad wings that provide rapid acceleration and a long tail to help them turn quickly. These birds use surprise attack to catch their prey but quickly tire and break off pursuit after a short chase if they have not succeeded in catching their quarry.

TYPES OF FLIGHT

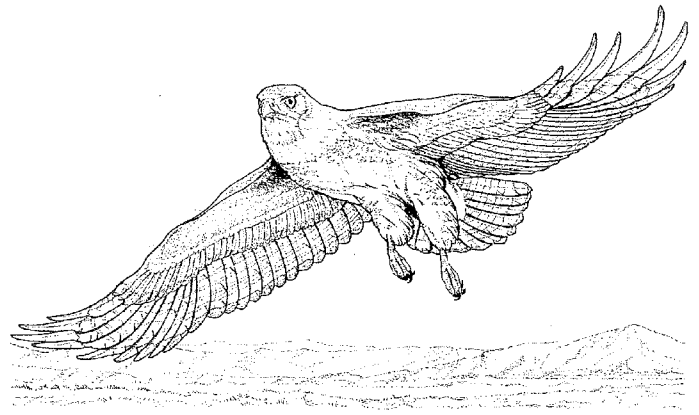
Raptors use several different forms of flight depending on the circumstance. Some forms are used by all birds at least in a limited fashion, while others are only used by select groups. Some of the most common types of flight are listed below:

Active flight occurs when a bird is flapping its wings. This type of flight, used by all raptors, consumes a lot of energy and so it is often punctuated by a glide. The pattern of flapping and gliding can be used to help identify raptors in the wild. For example, accipiters have a characteristic flap-flap-glide pattern that makes them easy to distinguish from the steady flap-flap-flap of a falcon.

Soaring is used by most raptors at one time or another but it is a hallmark of vultures, eagles and some hawks. These raptors hold their broad wings outstretched to help them take the best advantage of thermals and updrafts. Unlike soaring, which increases the altitude of a bird, **gliding** is a downward slide. The closer the wings are held to the body the faster the glide. During migration raptors may use a combination of soaring and gliding to increase their altitude and then glide long distances "down hill." A stoop or dive is an extremely fast glide where the wings are pulled very

close to the body. A stooping peregrine falcon may reach a speed of 200 miles per hour. During active flight or while gliding, raptors typically fly 20 to 40 miles per hour.

Hovering is a form of flight where a bird flaps its wings back and forth to remain in one spot to watch for prey. Since there is no lift associated with hovering it uses a lot of energy and requires sheer muscle power. Hovering is used primarily by smaller raptors such as kites and American kestrels, but some large birds such as osprey and rough-legged hawks routinely hover as well. Another technique for staying over one spot is **kiting**. As the name suggests kiting means to hang motionless in



the air by facing into the wind. Kiting raptors hold their wings partially folded and can be seen to make constant adjustments of the wings and tail to maintain their position.

BEHAVIOR

Raptors, like most other higher animals, have many behaviors which help them communicate with others of their species. Some sounds or behaviors are also used to communicate with other animals, for example, a vulture may hiss to warn off a potential predator. Vocalizing, display flights and body position are all used in communication.

Most raptors are generally solitary except during the breeding season. There are, however, species that are more social at least during part of the year. Although primarily solitary, bald eagles often gather in large groups during the winter months to take advantage of the ample supply of spawned-out salmon. Many raptors, such as Swainson's hawks, can be seen in large groups during migration. Some raptors are even gregarious. This is most often true of the vultures, both Old and New World, which often forage, roost and even breed in flocks.

One of the unique social structures among raptors can be found in Harris' hawks of the southwestern United States, Central and South America. These birds live in family groups of adults and immature birds which hunt and raise offspring cooperatively, in much the same way a wolf pack does. Hunting together means that Harris' hawks can take down much larger prey than an individual bird can.

Raptors that are not social maintain a **home range** that includes all the land the bird uses. This home range may overlap the home ranges of other raptors, even those of the same species. During the breeding season most raptors defend an area around the nest called the breeding territory. The **breeding territory** is defended from other raptors, especially those of their own species, but also from species that pose a threat to the nest or those with whom they compete with for prey.

The size of a raptor's breeding or home range varies, depending on the size of the raptor and the abundance of food. The gyrfalcon, a large falcon of the Arctic, may have a home range of up to 400 square miles per pair. The average territory of an American kestrel may range from less than one square mile to several square miles, depending on the abundance of prey.

Although it is rare among most birds, raptors often steal food from one another; this is called **kleptoparasitism**. Usually larger birds steal from smaller birds but a truly hungry bird may steal prey from a larger bird. Raptors, especially those that live in open habitat, often try and hide their food from other raptors by mantling. **Mantling**, or the covering of prey with the wings, makes it harder for other birds to detect the prey and steal it. Mantling may also help prevent the escape of prey. This behavior is already well developed in fledgling falcons.