STEPPE HABITATS

Columbia Basin Region

The Columbia Basin, in southeastern Washington, covers approximately 39% of the state and extends beyond Washington into Oregon and Idaho. Though often referred to as a plateau, the region is a topographic basin surrounded by mountains — the Okanogan Highlands to the northwest, the Kettle and Selkirk Mountains to the north, the Rocky Mountains to the east, the Blue Mountains to the south, and the Cascades to the west.

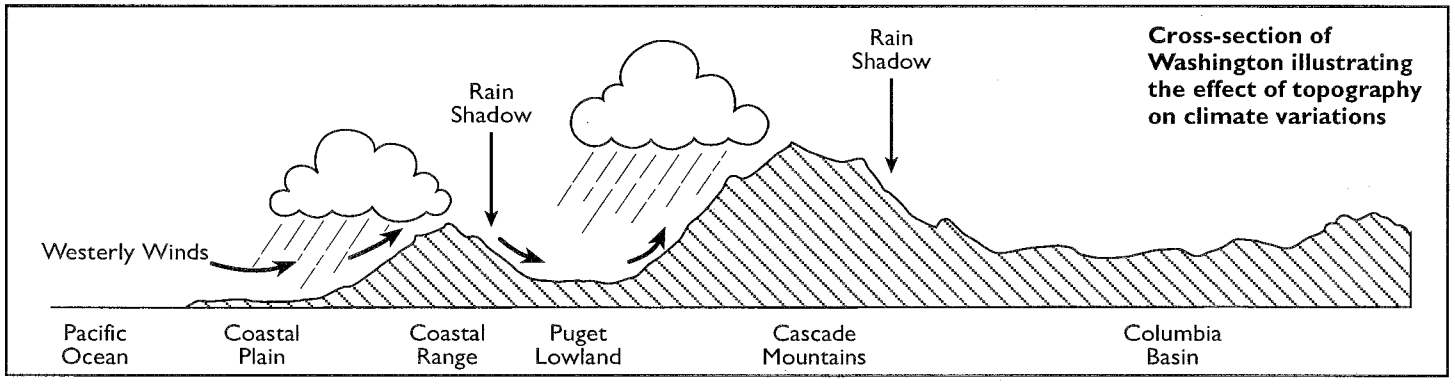
Formation of the Columbia Basin

About 13-16 million years ago the area of the Columbia Basin was covered in lava flows that erupted from the earth and cooled to form layers of **basalt**, a smooth, dark type of rock. These flows, called flood basalts, did not occur all at one time, but rather in several episodes over a period of about four million years. Basalt tends to fracture into vertical columns as it cools. Exposures of these basalt columns can be seen across the Columbia Basin, particularly in the northeast portion. The basalts covering the eastern portion of the Columbia Basin have remained relatively flat, while the basalts of the western portion have since been buckled into small ridges and valleys.

A distinctive feature of the Columbia Basin is the Palouse Hills in the southeastern part of the region. These rolling, dune-like hills are deposits of windblown dusts, or **loess**, on top of the basalt bedrock. Loess accumulated to depths of 200 feet (60 m). It is unclear during what period of time the loess was deposited, though this took place between the cessation of volcanic basalt flows and the beginning of the last ice age. Soils that develop from loess are extremely fertile. Moderate annual precipitation has aided in the development of thick, rich, dark-colored soils from the loess deposits.

Another topographic feature of the Columbia Basin is channeled scablands. The scablands run in a southwesterly direction along the central portion of the basin and consist of dry channels and larger **coulees**, dry stream beds. Around 16,000 years ago an enormous glacier pushed its way out of Canada into northern Idaho. A lobe of the glacier created a dam just northeast of Spokane, blocking the Clark Fork River. Water backed up behind the dam and produced a huge lake that filled in the mountain valleys of western Montana. Eventually, as most ice dams do, the dam floated and gave way, releasing a large wall of water that rushed towards the Columbia River to the southwest and scoured out the channeled scablands. As the glacier continued moving southward, the dam kept reforming and breaking away again, causing a recurrence of floods. This catastrophic flooding occurred 25 to 40 times during the last ice age, creating more channels and coulees each time (Alt and Hyndman, 1984).

The Olympic and Cascade mountains, lying to the west of the Columbia Basin, work together to form an effective barrier to moisture-laden marine air. When the marine air reaches the mountains, the air rises and cools, dropping its moisture on the west side slopes before descending into the Columbia Basin. The annual amount of **precipitation** falling east of the Cascades is drastically lower than that of western Washington. Most of the Columbia Basin region averages about 10 to 15 inches (25 to 38 cm) of



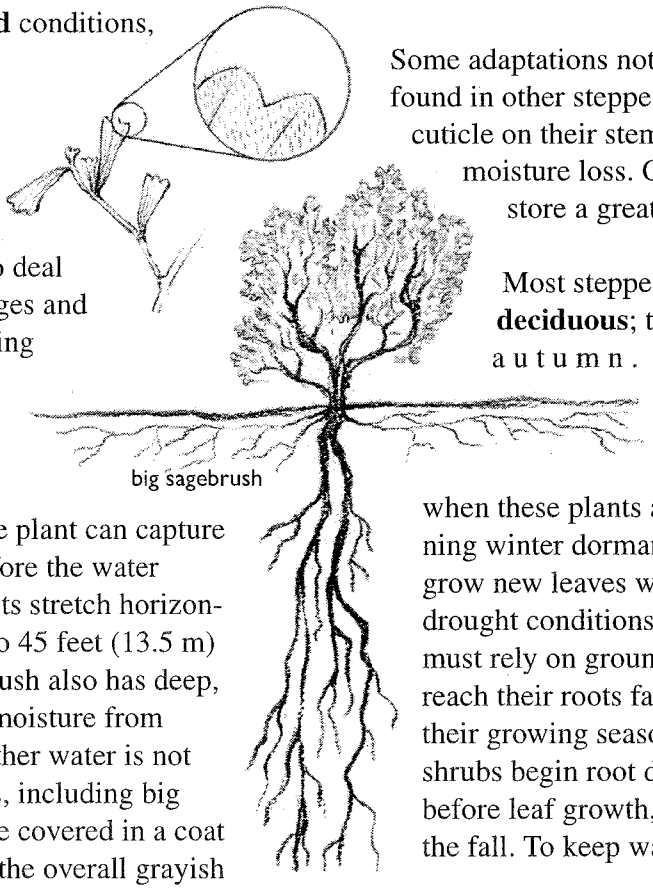
Cross-section of Washington illustrating the effect of topography on climate variations

precipitation per year. Also, the contrast between winter and summer temperatures is greater east of the Cascades. Average temperatures in January range between 22° and 35° F (-5.5° and 1.5° C), and average July temperatures range between 65° and 76° F (18.5° and 24.5° C). (See Table of Temperature, Precipitation and Snow Depth in Activities section for comparisons.) In the Columbia Basin, as in the rest of Washington, the majority of yearly precipitation is confined to the cold months, mainly November to February, and the warm growing season is often a time of drought. Much of the precipitation never soaks into the soil because it falls in the cold season when the ground surface may be frozen. The frozen ground causes the water to run off rather than be absorbed. In addition, strong winter winds flow across the basin, drying out the vegetation and posing the threat of soil erosion.

Due to the climatic conditions and the associations of plants and animals of the Columbia Basin, the region can be characterized as **steppe**. In steppe regions, precipitation is high enough to allow for the growth of grasses, but too low to support trees. In deserts, by contrast, there is insufficient precipitation even for grasses, though other plants, such as cacti, which are adapted to very **arid** conditions, are able to grow there.

Adaptations of Steppe Plants

Steppe plants of the Columbia Basin have **adaptations** to deal with extreme temperature ranges and lack of water during the growing season. For example, big sagebrush, a common steppe shrub, has developed a two-level root system. Shallow roots reaching far out from the plant can capture moisture from rain storms before the water evaporates. These shallow roots stretch horizontally away from the plant up to 45 feet (13.5 m) in every direction! Big sagebrush also has deep, coarse roots that can take up moisture from groundwater supplies when other water is not available. Many steppe shrubs, including big sagebrush, have leaves that are covered in a coat of fine hairs, which results in the overall grayish appearance of steppe plant communities. The hairs reflect sunlight, which could otherwise dry out the leaves. The hairs also trap a layer of still air next to the leaf, preventing loss of moisture. The leaves of big sagebrush are small. The reduced surface area of the leaves minimizes evaporation through the **stomata**, or pores, on the undersides of the plant's leaves.


big sagebrush

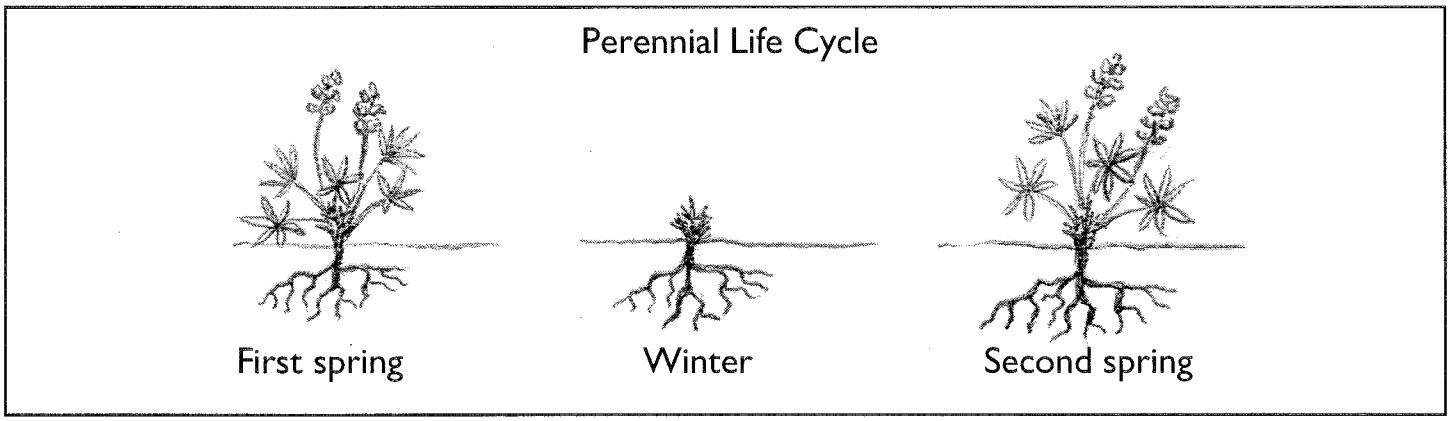
Big sagebrush produces two types of leaves. Larger, lobed leaves persist on the plant throughout the year, but in early winter the plant produces smaller, softer, non-lobed leaves at the branch tips. These temporary leaves help the plant increase **photosynthesis** during the short winter days, which enables it to complete early growth while moisture is available from seasonal rains. The temporary leaves drop off before the summer drought conditions, allowing the plant to conserve water and energy during the dry period. Another interesting characteristic of big sagebrush is that the **inflorescences**, or flower clusters, emerge in late spring and continue growing and blooming into autumn. Parts of these flower clusters are green and can carry out photosynthesis, giving the plant the ability to provide energy for itself after dropping its temporary leaves.

Some adaptations not exhibited by big sagebrush are found in other steppe plants. Some plants have a waxy cuticle on their stems and leaves that helps prevent moisture loss. Other plants have the ability to store a great deal of moisture in their tissues.

Most steppe shrubs, except big sagebrush, are **deciduous**; they drop all of their leaves during autumn. This puts the shrubs at a disadvantage since autumn rains, which provide moisture necessary for growth, begin to fall when these plants are losing their leaves and beginning winter dormancy. In addition, deciduous shrubs grow new leaves when spring rains taper off and drought conditions begin again. Thus, steppe shrubs must rely on groundwater supplies and therefore reach their roots far down to get moisture during their growing season. For this reason, many steppe shrubs begin root development in early spring, before leaf growth, and continue root growth into the fall. To keep water in their roots, some steppe

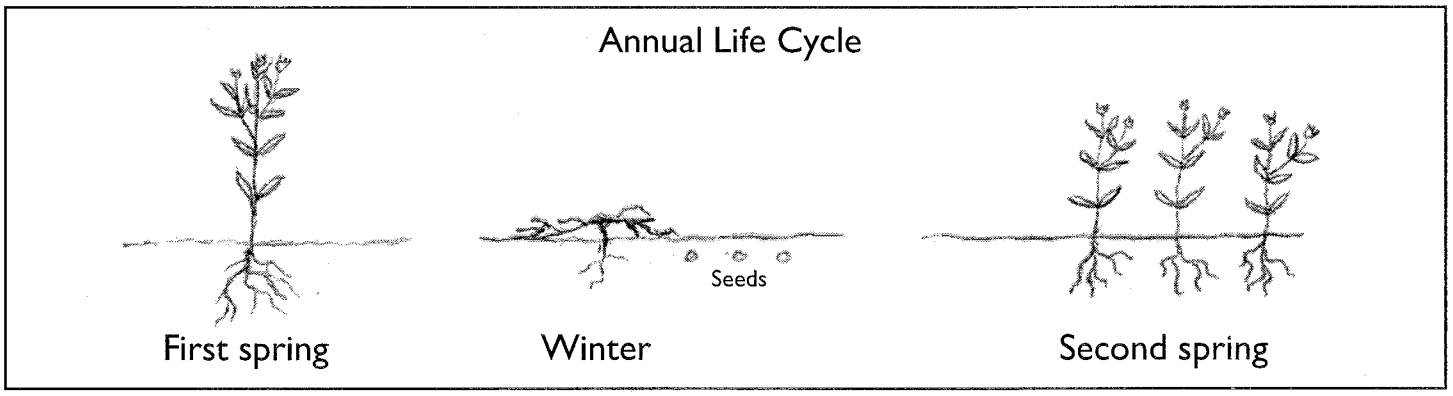
shrubs have high internal salt concentrations. Thus, in a process called **osmosis**, water flows inward to root tissues where salt concentrations are high and do not flow outward to the soil.

following spring. **Annual** steppe plants avoid drought conditions altogether by completing their life cycle during moist times. Annuals usually germinate in spring, then flower and produce seeds. When summer



Both perennial and annual grasses, with extensive, shallow root systems, survive in the steppe by soaking up available surface water during winter and spring. **Perennials** germinate in fall, grow slowly through winter, and then grow vigorously in spring. These plants usually flower in May or June and then produce seeds. The visible shoots of many perennial grasses wither during the dry summer, but the roots survive through the winter. The shoots begin growing again the

drought arrives, these plants have died. Their seeds, however, remain in the soil ready to germinate when spring warmth arrives. In annuals, seed dormancy is common. This means that the seeds can stay in the ground for long periods waiting for favorable germinating conditions. However, perennials are more prolific on the steppe because they have permanent root systems which give these plants a head start on the growing season.



Steppe Vegetation Zones of the Columbia Basin

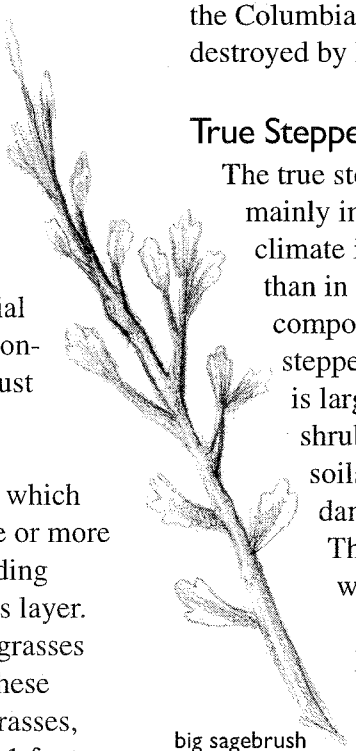
There are two major vegetation zones covering most of the Columbia Basin: the sagebrush steppe zone (or shrub-steppe) and the true steppe zone. Within each zone, several different plant communities have been identified. Biologists define an association of many individual plants and animals commonly living together in a certain **habitat** as an **ecological community**. Vegetation communities are usually named by a dominant plant species and a subordinate plant species. The two plant names are joined by a hyphen; for example, the big sagebrush-bunchgrass community. **Dominant species**, due to their size or density, have the greatest influence on the community. **Subordinate species** are common associates of the dominant species.

Sagebrush Steppe Zone

The sagebrush steppe zone is the most widespread of the two vegetation zones. This zone primarily encompasses the interior and western side of the Columbia Basin where moisture is limited and soils are rocky and not deep. Generally, the vegetation consists of big sagebrush-bunchgrass communities. Approximately six species of shrubs and six species of grasses comprise the major part of this zone's vegetative cover.

Well-developed sagebrush steppe is composed of four layers of vegetation. From the highest to the lowest, the layers include: a canopy layer of shrubs, a layer of high perennial grasses, a layer of low grasses and **forbs** (all non-woody plants except grasses), and a ground crust formed of mosses and lichens.

The **canopy** layer is formed by big sagebrush, which grow spaced well apart and to a height of three or more feet (one or more meters). Other shrubs, including other sagebrush species, are also present in this layer. The second layer is formed by high perennial grasses consisting mainly of bluebunch wheatgrass. These perennial grasses, which are primarily bunchgrasses, tend to grow in widely scattered clumps about 1 foot (30 cm) apart and usually less than 2 feet (60 cm) high.



big sagebrush

The third layer of sagebrush steppe consists of low grasses, and annual and perennial forbs, growing to a height of 4 inches (10 cm). These plants, taken together, account for only a small percentage of the total vegetative coverage. A low perennial grass, Sandberg's bluegrass, makes up the majority of this layer. The annuals tend to grow in cracks in the soil created by freezing and thawing cycles of the steppe. In these cracks, seeds are protected from predation and have sufficient moisture for germination.

Mosses, lichens, fungi and bacteria have colonized the harsh steppe soil surface, together forming a **cryptogamic crust**. Plants that reproduce by way of spores and do not produce flowers or seeds are called **cryptogams**. Cryptogams require moisture to carry out their reproductive cycles; however, they have the ability to go dormant when moisture is not available and can therefore persist in arid regions. Cryptogamic crust serves the important function of stabilizing the easily-erodible soil and holding in moisture. These crusts take long periods of time to form and are very vulnerable to **disturbance**. Because cryptogamic crust takes so long to recover, footsteps made in the crust can still be seen 40 years later. Cryptogamic crust once spread across the Columbia Basin, but most of the crust has been destroyed by human activity.

True Steppe Zone

The true steppe zone of the Columbia Basin occurs mainly in the region of the Palouse Hills where the climate is slightly wetter and the soils are deeper than in the sagebrush steppe zone. This zone is composed of the same layers as the sagebrush steppe zone, except that the canopy shrub layer is largely absent. Grasses can out-compete shrub seedlings for moisture on the fertile soils of this region. This results in an abundance of grasses and an absence of shrubs. The true steppe is dominated by bluebunch wheatgrass and Idaho fescue.

Ponderosa pines may also be present in small patches throughout the sagebrush steppe and true steppe zones. The appearance of these stands of Ponderosa pine may be influenced by small, local changes in climate or soils.

Plant communities along the margins of the Columbia Basin differ slightly from those of the basin itself. In the foothills extending southward from Spokane to Pullman and east into Idaho, the usual steppe shrubs are absent. Common in this region are thickets of common snowberry and wild roses. Throughout this snowberry-rose community, in moister areas bordering streams or in ravines, black hawthorns grow in tall thickets. (See "Riparian Woodlands" in the Wetlands section.)

The descriptions above represent **native** plant communities as they may have existed prior to extensive disturbance associated with settlement of the Columbia Basin by European-Americans beginning in the early 1800s. Due to vast changes in the vegetation of the steppe region, many of the plant communities have been significantly altered. In fact, the majority of plants listed as endangered by Washington state are found in the Columbia Basin region.

Human Use of Steppe Habitats

Prior to the arrival of Euro-Americans, the Columbia Basin was inhabited by Native Americans of two linguistic groups. The Interior Salish group included the Wenatchee and Spokan tribes. The Sahaptin group included Yakima, Umatilla, Cayuse, Palouse and Nez Perce tribes. The magnitude of their impact on the Columbia Basin **ecosystem** has been debated. The estimated populations of Native Americans in the region, before the time of Euro-American settlement, are small. Most of their food was obtained by gathering and hunting. Some burning was enacted to promote the growth of plants foraged on by deer and plants that produced berries and root vegetables. The tribes of the Columbia Basin region did not need to cultivate food; the abundance of food hunted and gathered from the earth was a central theme of tribal religions. Above all, land use practices of Native Americans in the Columbia Basin maintained the natural productivity of the land upon which the survival of the tribes depended.

Tribes usually settled along river valleys where fish and water could easily be obtained. Salmon was particularly important for Native American cultures of the Columbia Basin. With the aid of horses, introduced to North America by the Spanish in the mid-1700s, people were able to travel longer distances in search of resources. These movements took place in seasonal cycles. Some tribes would travel south to the Columbia River to catch chinook salmon during the spring **spawn**. Salmon, steelhead and blueback were caught using dip nets, spears and hooks. Traveling to and from the river in spring and summer, women extensively collected common camas bulbs. Common camas, a perennial of the lily family, grew in abundance in moister regions of the Columbia Basin. Camas bulbs are rich in carbohydrates and were an important food source for the Palouse and other local tribes. For example, settlements were relocated and tools were altered between 4,000 and 2,500 years ago in response to environmental changes that reduced salmon numbers and increased camas populations. Women harvested the bulbs by digging with pointed sticks, taking only the larger bulbs, and allowing the smaller ones to grow. In a good camas field, a woman could gather in only three or four days enough camas to feed her family for an entire year.

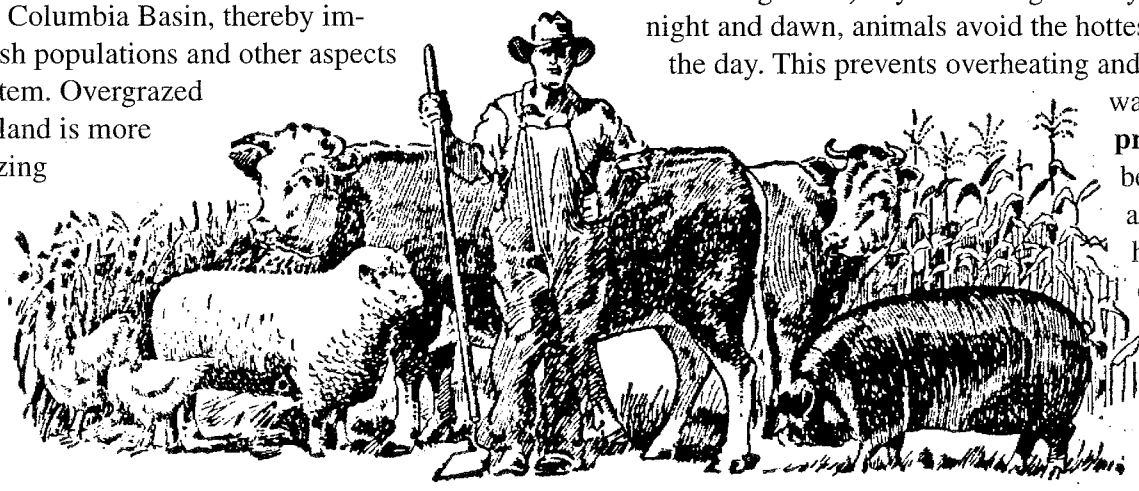
Intensive hunting and gathering occurred during late summer and fall. In forested areas of foothills and mountains, men would hunt mule deer, elk and bears. The smaller fall salmon runs were also utilized. In addition to camas, women would dig bulbs and stems of plants of the genus *Lomatium*, some species of which were called "kouse" or "biscuit-root." Women also collected berries, wild onions, rhubarb, strawberries, wild carrots (or "yampah") and parsnips as well as seeds and stalks of wild sunflowers.

By the latter part of the 19th century, the Columbia Basin was heavily settled by Euro-Americans who had migrated from the east. The settlers were drawn by reports from explorers about the good grazing land and rich, fertile soil. Ranching was the main occupation of the first settlers, the majority of whom eventually turned to cultivating crops. Ranching and cultivating are two intensive land uses which greatly impacted the natural environment of the Columbia Basin, as they still do today. Before the arrival of white settlers there was only limited grazing by small numbers of native ungulates, such as deer, elk, pronghorn and, to a lesser extent, bison (the latter two are no longer present in Washington state). But the increasing number of horses, after their introduction in the 1700s, and cattle, sheep and pigs in the 1800s brought new stresses for the native vegetation. The previously abundant camas fields were largely destroyed by the foraging of

settlers' hogs. Fences, used to enclose livestock, concentrated grazing and trampling to specific areas and increased the damage done to native plants. While the abundance of sagebrush often increased where grazing occurred, other native plants of the community could not survive. Native grasses were replaced by **nonnative** grasses, predominantly downy cheatgrass and Kentucky bluegrass, introduced by settlers. The **introduced** grasses have evolved for centuries under high grazing pressures and are therefore well-adapted to survive when disturbed by grazing animals. The native grasses of the Columbia Basin, however, have only been subjected to intensive grazing in relatively recent times. In areas where grazing has ceased for several decades, introduced species persist and the native vegetation, such as grasses and cryptogamic crust, has not recovered.

Taking advantage of the fertile soils and available moisture, particularly in the eastern part of the Columbia Basin, settlers began to cultivate crops and develop new agricultural practices. In the Palouse Hills of the east, the land is still actively farmed without using irrigation, a technique called dryland farming. Winter wheat has been a main crop in the past, with the cultivation of split peas and lentils increasing in recent times. In the western part, much of the land has been heavily irrigated since the 1950s. Here, field corn, fruits, nuts, hops, mint, wheat and grapes are grown, particularly in the Yakima Valley. Cultivation has had drastic effects on native vegetation. Abandoned croplands, like grazing land no longer in use, are invaded by downy cheatgrass and other introduced species and show no signs of reverting to native vegetation.

Both grazing and farming have also affected water quality in the Columbia Basin, thereby impacting the fish populations and other aspects of the ecosystem. Overgrazed or cultivated land is more prone to freezing during the winter. When the soil surface freezes, precipitation runs off, rather than seeping into the soil to be stored as an important groundwater source. This runoff combined with the absence of native vegetation contributes to the erosion of topsoils, reducing the productivity of the land. Erosion of soils into rivers and streams also affects the survival of fish by covering eggs, which prevents needed oxygen from reaching them. Chemicals used on crops and waste left behind by livestock are often carried by runoff, polluting rivers and streams.



Adaptations of Steppe Wildlife

The animal communities of the Columbia Basin have also changed over time due to the impacts of various human land uses. Some species have proven unable to adapt and their numbers have declined as a result of habitat changes. Other species have managed to adapt, and even thrive, in this altered environment.

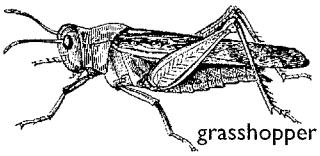
Animals living in the steppe region, like the plants, face several challenges posed by their environment. Differences in body structures and functions, and various patterns of behavior can aid in surviving environmental challenges. The temperature ranges between seasons in the steppe are extreme; thus animals in the steppe must have ways to prevent overheating in hot seasons and ways to keep warm in cold seasons. Due to the lack of water in this region, steppe animals also have adaptations for obtaining and conserving water. In addition to their means of adapting to the climate, steppe animals must be able to avoid their **predators,** while still getting enough food to survive in this harsh environment.

Most animals living in the steppe are **nocturnal** (active at night) or **crepuscular** (active in the early morning or late evening hours). By restricting activity to dusk, night and dawn, animals avoid the hottest parts of the day. This prevents overheating and loss of water. For **prey** species, being active at night may help them escape detection by predators.

Because they are mainly active when it is dark, animals in the steppe are difficult to observe. In addition many steppe animals are burrowers, making them hard to find.

Burrowing is another good survival strategy. During hot times of the year, hiding in cool underground burrows helps animals conserve water and keep from overheating. Some animals are not active at all during the hottest times of year when many food and water sources are not available. They spend this time in their burrows in a state called **estivation**. During estivation all the functions of the body, such as heart rate and metabolism, are greatly slowed down. In winter, underground burrows can provide insulation from cold temperatures, wind and snow and are often used for **hibernation** or **torpor**. Hibernation is a state similar to estivation except that it takes place during cold weather. Different animals exhibit different degrees of hibernation. Torpor is like estivation and hibernation except it is only for short periods of time. Estivation, hibernation and torpor help animals avoid wasting energy through times when food sources are scarce. In addition to temperature control, burrowing can help animals in other ways. Many steppe animals escape their predators by fleeing into burrows. In many areas of the Columbia Basin thick, well-drained soils provide prime habitat for burrowing animals. In fact, 47% of mammal species living in steppe regions are burrowers, as compared with six percent of forest mammal species (Curry-Lindahl, 1981).

Tiny Creatures


grasshopper

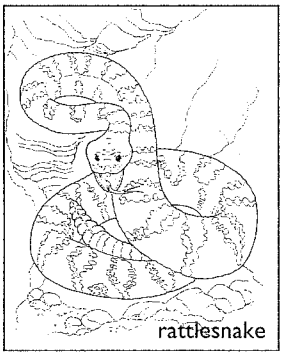
Insects are the most abundant animals in the steppe, as they are throughout the world. Many species of grasshoppers, ants, beetles, true bugs (order Hemiptera) and moths inhabit the steppe. Many insects die before the cold of winter comes, leaving their eggs in protected places to hatch when warm weather returns. In early spring, insects are subject to drastic changes in weather. Some insects have substances in their blood that protect them from freezing. Many insects can also warm themselves up by vibrating their muscles, similar to shivering in humans. During the hot summer, insects are protected from drying out by their hard exoskeletons which retain moisture.

Amphibians

Amphibians of the Columbia Basin are largely restricted to wetland habitats, due to their dependence on water for laying eggs and for **larval** life stages (see "Amphibians" in the Wetlands section). The Great Basin spadefoot is an example of an amphibian that is well-adapted to life in the steppe. This nocturnal toad estivates in burrows for months at a time to survive dry periods. Spadefoots emerge when they sense vibrations in the ground created by heavy rainfall. Spadefoots can use temporary water sources, such as ponds, puddles and the like, for laying eggs. Tiger salamander larvae live in ponds and lakes of the steppe region. Adult tiger salamanders, however, are terrestrial and have been found resting in piles in burrows. It is thought that piling up may reduce the surface area of each salamander's skin exposed to evaporation. Adult tiger salamanders are rarely seen due to their subterranean (underground) lifestyle.

Reptiles

Reptiles are better adapted to the steppe than are amphibians because reptiles have tough skin that prevents moisture loss and they lay eggs with leathery shells that retain moisture. All reptiles of the Columbia Basin region hibernate during winter. Most lizards in eastern Washington are either **diurnal** or crepuscular and many prefer rocky areas in the western part of the basin. The short horned lizard, which eats primarily ants, digs burrows to escape midday heat, while the sagebrush lizard, which eats a variety of small arthropods, finds cover under shrubs and also buries its eggs under them. The rubber boa, a small constrictor in the same family as the world's largest snakes (boas and pythons), occurs in both the western and eastern sections of the Columbia Basin. The rubber boa is nocturnal and is a burrower, so it is rarely observed. Washington state's only truly venomous snake is the northern Pacific rattlesnake. These rattlesnakes are usually most active in mornings and late afternoons, but this depends on daytime temperatures. Rattlesnakes are ambush predators that most often sit and wait for their prey. A northern Pacific rattlesnake can be seen in the

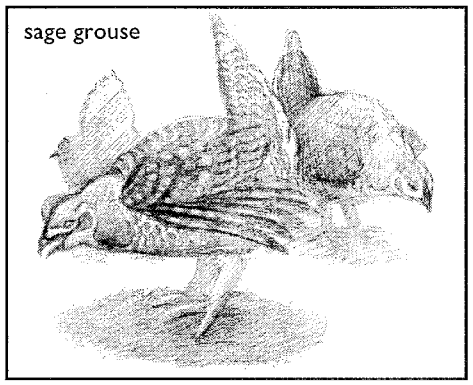

rattlesnake

Day Exhibit at Woodland Park Zoo. Two types of nonpoisonous snakes common in the Columbia Basin region are gopher snakes and garter snakes. Gopher snakes, as opposed to rattlesnakes, actively hunt their prey, such as rabbits and ground squirrels.

Birds

Various layers of sagebrush foliage provide nesting cover for many birds. Three species in particular are rarely found outside of sagebrush habitat. Sage sparrows hide their nests within the sagebrush and usually forage close by the shrubs. Sage thrashers locate their nests high in brush but forage for beetles and locusts on the ground. Gray flycatchers nest low in sagebrush and catch insects around the shrubs. Other small birds, such as larks and various species of sparrows, rely more on bunchgrasses than on sagebrush for nesting cover.

Sage grouse are also dependent on sagebrush. These birds build their nests underneath the bushes, and also feed on the leaves and buds of the shrubs. Sage grouse have interesting mating rituals which include extravagant displays. The males gather in large groups on displaying grounds, called leks, and space themselves evenly apart. Each male performs his best display by inflating his yellow throat pouch, which makes a large sound when air is suddenly expelled, and fanning his tail feathers over his back. The females wander among the show-offs, only mating with the best displayers. Usually the most vigorous and aggressive displayers will occupy the center of the lek and will mate with the majority of the females. Grouse use the same areas for their leks year after year. The sharp-tailed grouse is another steppe bird that displays in leks. Populations of sage grouse and sharp-tailed grouse have been greatly reduced in past years mainly due to habitat loss. Both of these birds were added to the state list of threatened species in 1998. Efforts are being made to preserve their dwindling habitat.


sage grouse

The black hawthorn, snowberry and rose communities growing in moist areas of the foothills to the south and east of Spokane and Pullman are also very important for bird populations. These three plants provide autumn food sources for fruit-eating birds, especially rosehips which persist throughout the winter. Additionally, the structure of hawthorn bushes provides cover and nesting spots. Black-billed magpies have been found to nest primarily in hawthorn. Old magpie nests make good foundations for nests of long-eared owls. Thrushes and vireos also nest in hawthorn. In the 1970s in parts of the Columbia Basin region, there was a decline in bird populations. The decline was linked to eradication of hawthorn with herbicides. With the decreasing use of these herbicides, hawthorn thickets have regenerated and bird populations have been recovering.

Birds of Prey


turkey vulture

Raptors are easily seen in the Columbia Basin due to the openness of the terrain. Some raptors have benefited from changes made by humans in the steppe region. Telephone poles make excellent lookout perches and it is easier for raptors to hunt for rodents in cultivated, open fields than it is in natural brushy areas. Red-tailed hawks often soar for long periods, searching for rodents, reptiles, small birds and other prey. The much larger golden eagle may also be seen soaring high in the air. Golden eagles prey mainly on rodents but may scavenge **carrion**, meat of dead animals. Turkey vultures are migratory and may be seen in Washington during the summer. Turkey vultures are primarily **scavengers**, feeding on carrion.

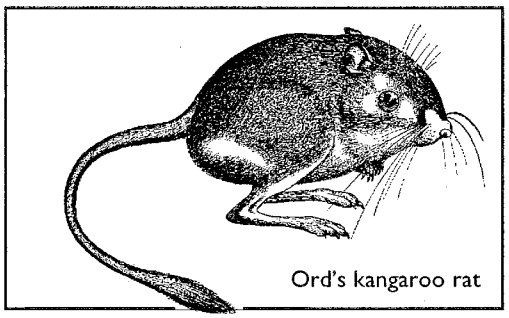
The burrowing owl is a small owl, 9 inches (22.5 cm) long, that nests and raises its young in burrows. Burrowing owls take over abandoned burrows but often enlarge them and dig sharp curves at the end for protection of their eggs and owlets. A burrowing owl

will flatten itself against the ground when threatened, rather than fly away. These owls are most active during the day, catching small rodents on the ground or insects in the air. Great horned, long-eared, short-eared, and pygmy owls are also common inhabitants of the steppe. Great horned and long-eared owls are nocturnal hunters, while short-eared and pygmy owls often hunt during the day. Burrowing and pygmy owl populations have been greatly reduced over the years due to loss of habitat.


burrowing owl

Mammals

Grasses produce high energy seeds and are an abundant food source for small mammals of the steppe.

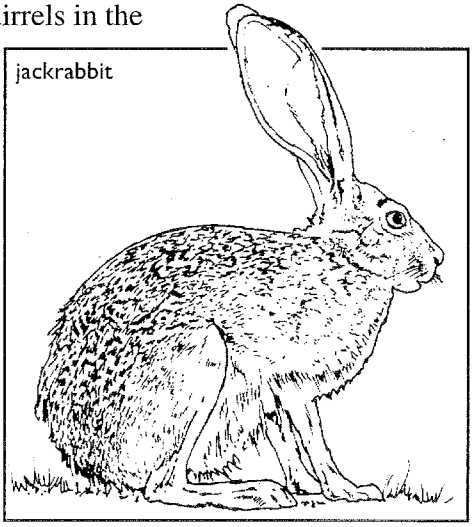

Ord's kangaroo rat

Ord's kangaroo rats of the Columbia Basin, which are neither kangaroos nor rats but are related to pocket gophers, have several adaptations to steppe life. Like other seed eaters, kangaroo rats horde large amounts of food in their burrows. This ensures that the animals will have food at all times of year. Hoarding also aids in seed dispersal because the uneaten, cached seeds may germinate. Most animal species that have no way of storing food have to migrate when food sources become low; or they estivate in hot months or hibernate during cold times, eliminating the need for food. Another common characteristic behavior of steppe mammals exemplified by kangaroo rats is the aggressive defense of **territory**. When food sources are not abundant, animals will actively protect a territory in which they can find sufficient food. Since conservation of water is vital for survival in arid climates, kangaroo rats have extremely efficient kidneys and are able to recycle water through their system. This allows kangaroo rats to be largely independent of water. Due to the recycling of water in their bodies, kangaroo rats produce the most concentrated urine of any mammal!

The pallid bat, found in eastern Washington, has an interesting feeding strategy. Like other bats of Washington, pallid bats are insect eaters. Rather than catching insects in the air, however, pallid bats land on the ground and grab insects, such as crickets, grasshoppers and cockroaches, in their mouths. Pallid bats consume many insects that are considered by farmers to be pests.

Pygmy rabbits are currently listed as an endangered species in Washington. Pygmy rabbits are the only North American rabbits that make and use their own extensive burrows. Other rabbit species use burrows abandoned by other animals. Sagebrush makes up 99% of pygmy rabbits' winter diet and the majority of their summer diet. Pygmy rabbits require dense stands of sagebrush and soft, deep soils for burrowing, but much of their prime habitat has been overtaken by agriculture. With this loss of habitat, pygmy rabbit numbers have declined. The only known pygmy rabbit colonies in Washington are located in Douglas County.

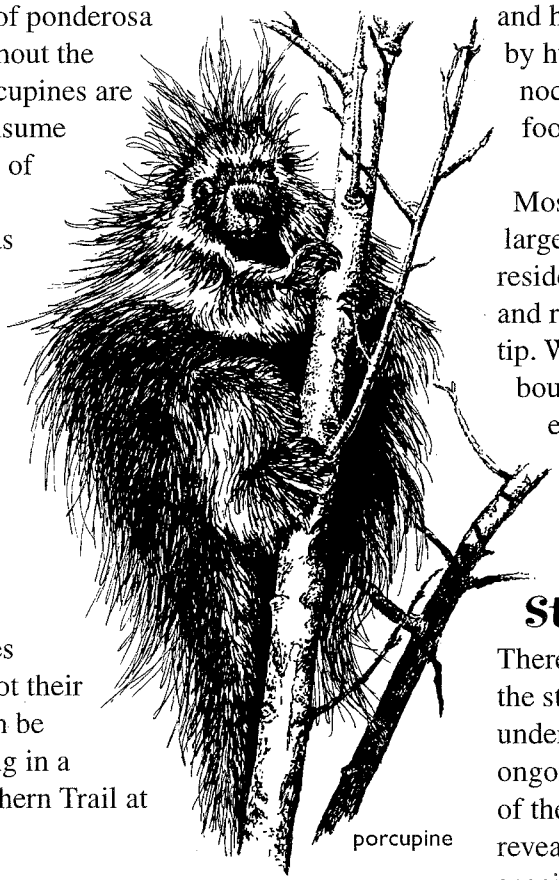
Some mammals, such as pocket gophers and ground squirrels, are rarely seen in the steppe due to their habits. Northern pocket gophers live in burrows and also forage primarily underground. While moving through their burrows, pocket gophers eat and collect roots, bulbs and tubers of various plants which they store underground. By utilizing their underground habitat, pocket gophers are not exposed to the extremes of the steppe climate and can remain active year-round. Townsend's ground squirrels and Columbian ground squirrels are very active in spring, but they may go into estivation in the dry, hot period of summer. Ground squirrels may also hibernate if the winter is very cold. Thus, ground squirrels in the steppe may only be active for around four months out of a year!


jackrabbit

Jackrabbits have a typical adaptation to the high temperatures of summer — big ears.

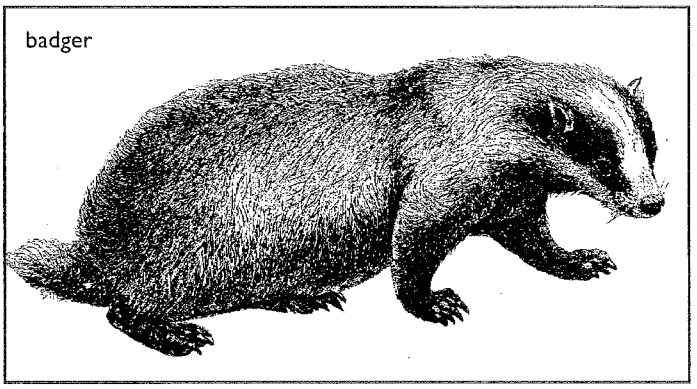
Large ears help radiate body heat which keeps the animal cool. Jackrabbits do not burrow. Instead, they find cover under shrubs, such as sagebrush, for cool shade in hot weather and protection from snow and wind in the winter. Native white-tailed jackrabbits have not adapted well to the recently altered habitat of the Columbia Basin. Black-tailed jackrabbits, expanding their range from the southwest, spread into eastern Washington in the early part of the 1900s and began displacing the white-tailed jackrabbit. White-tailed jackrabbits prefer feeding on bunchgrasses, while black-tailed jackrabbits prefer sagebrush. In grazed lands, sagebrush has become more prevalent than bunchgrasses, making the environment more hospitable to black-tailed jackrabbits.

Porcupines may be found up in trees or waddling across the ground in stands of ponderosa pine scattered throughout the Columbia Basin. Porcupines are large rodents that consume buds, leaves and bark of trees. Porcupines are covered by as many as 30,000 quills, which provide a unique defense. The quills are barbed, like tiny fish hooks, on the exposed ends. When the barbs get stuck into an attacking animal, the porcupine can easily shed them. Porcupines cannot, however, shoot their quills. Porcupines can be observed, often resting in a dead tree, in the Northern Trail at Woodland Park Zoo.



porcupine

Although many steppe animals burrow to escape their predators, there's no escaping the voracious badger. Badgers can burrow to find food and will eat small mammals, reptiles, amphibians, insects and earthworms hiding underneath the soil surface. Badgers are **omnivores**, however, so they also consume seeds, fruits and roots of plants. Badgers exploit a wide variety of food sources and are very adaptable animals, as are coyotes.



badger

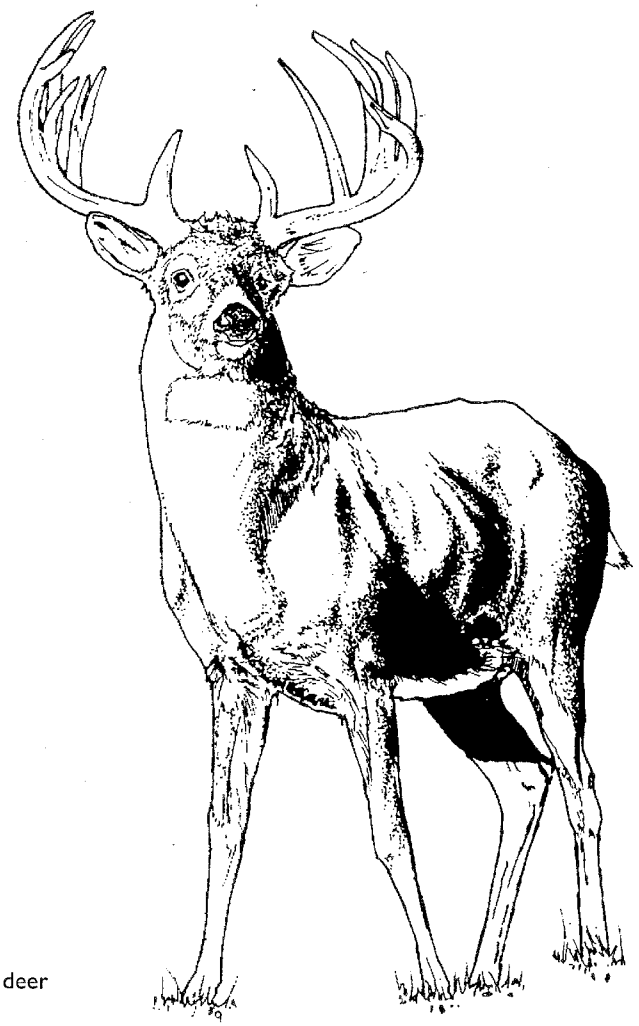
Both animals have been successful at adjusting to changes in their habitat. Coyotes mainly prey on ground squirrels in the steppe region, but they will eat much smaller animals, such as grasshoppers, when favored food sources are scarce. Coyotes, being both hunters and scavengers, utilize numerous food sources and have adapted well to changes in the steppe caused by human activity. Coyotes hunt either diurnally or nocturnally depending on the habits of their main food source, which varies with location and season.

Most steppe mammals are small or medium-sized, but larger mammals, such as mule deer, are also common residents of the steppe. Mule deer have white throat and rump patches, and tails that are white with a black tip. When fleeing, mule deer have a conspicuous bouncing gait. Mule deer are primarily **browsers**, eating mainly shrubs, as opposed to **grazers** that eat mainly grasses and forbs. Mule deer feed during the morning and afternoon and may rest during the day in cool, secluded places.

Steppe Conservation Projects

There are many research projects occurring throughout the steppe region that are increasing our ecological understanding of native steppe plants and animals. An ongoing biodiversity study in uncontaminated regions of the Hanford site in the central Columbia Basin has revealed more than 18 species of insects and several species of plants previously unknown to science. The study, conducted from 1994 to the present, has been carried out by scientists working for the Nature Conservancy in conjunction with the Department of Energy, which owns the land. The areas studied, the 90,000-acre (36,000 hectare) North Slope on the banks of the Hanford reach and the 75,000-acre (30,000 hectare) Arid Lands Ecology Reserve, were closed to

human activity over the last 50 years, and thus remain relatively undisturbed. Currently, surveys are expanding to include inventories of small mammals, including ground squirrels, rabbits, voles and bats. The portions of land at Hanford preserve some of the last remaining expanses of native shrub-steppe vegetation and wildlife. Recently, the Partnership for Arid Lands Stewardship (PALS) formed to promote the education of Washington's teachers, students and community members about steppe ecosystems. The partnership includes the Nature Conservancy, the U.S. Fish and Wildlife Service and Washington State University/Tri-Cities' Arid Lands Institute among others. PALS presents workshops, conducts teacher institutes, produces teacher information and leads educational field trips to places such as the Arid Lands Ecology Reserve. (See Contact Information list for further information.)

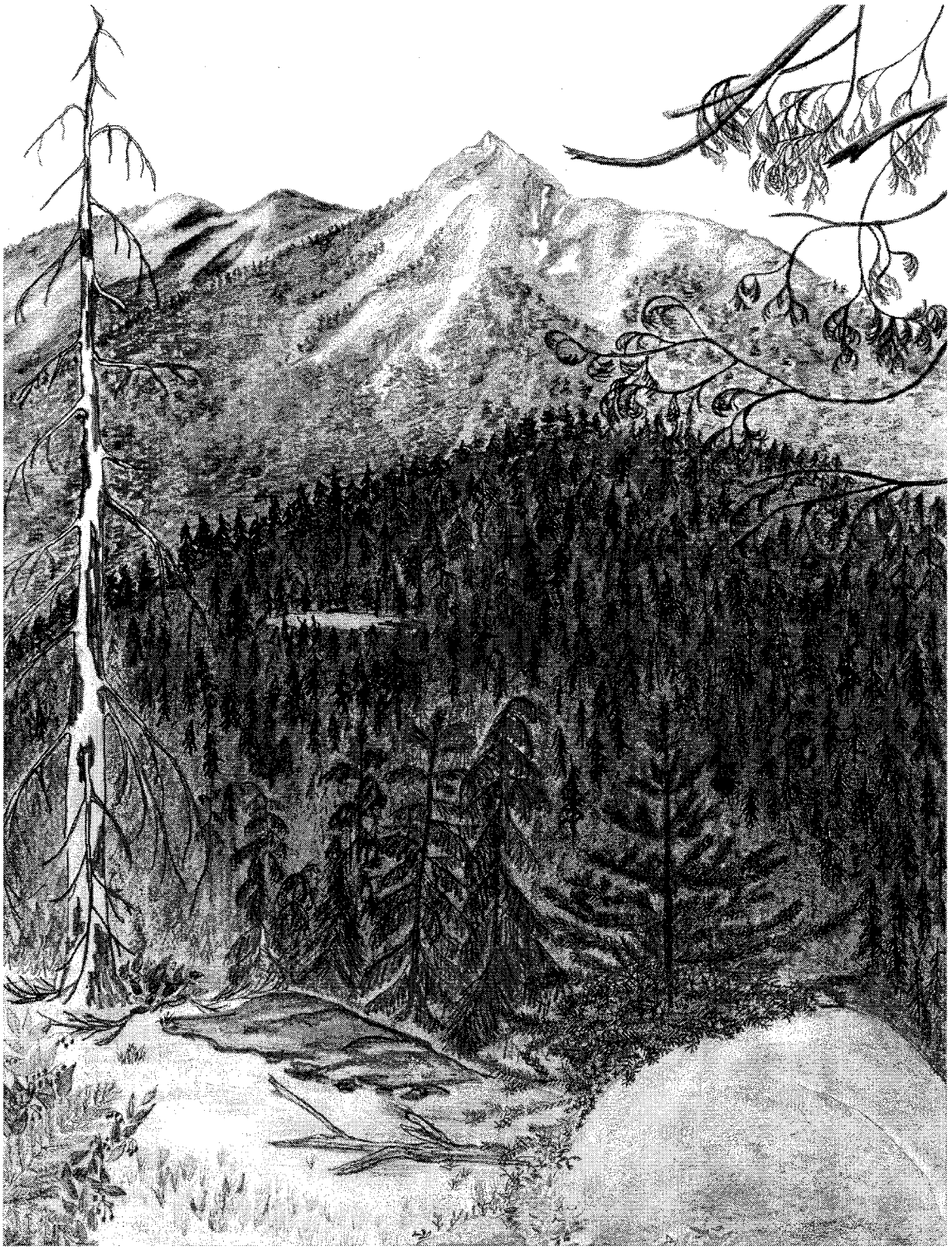


deer

Wahluke Wildlife Area, southeast of Vantage along the Hanford Reach, is a great place to explore the sagebrush steppe. This area, bordered by the last free-flowing stretch of the Columbia River, is host to numerous birds, including golden eagles and wintering bald eagles, and other animals including mule deer, coyotes, black-tailed jackrabbits and several species of reptiles.

Caring About the Steppe

Of the different habitats of Washington state covered in this packet, the steppe has probably been the most drastically changed by human activity. Across most of the Columbia Basin over 75%, and in certain areas possibly over 95%, of the native habitat has been destroyed by agriculture and development. The remaining native steppe habitat exists only in isolated patches that are unsuitable for human habitation or agriculture. The reduction of habitat has caused populations of some species to decrease. Species that are unable to adapt to rapid changes in their environments have been most affected by habitat destruction. In order to protect and aid animal and plant species, it is important to identify and make efforts to preserve remaining native steppe habitat. Attempts must also be made to restore native vegetation in abandoned agricultural lands as well as in regions, such as along streams, that have been overtaken by introduced species. Individual people can make a big difference by sharing their knowledge with others and by volunteering for and supporting local restoration projects. These efforts will ensure that the wildlife of Washington's steppe, including economically important species, such as deer, and species threatened with extinction, such as pygmy rabbits and sage grouse, have sufficient habitat to survive.



MONTANE HABITATS

Montane Forest, Subalpine and Alpine Zones

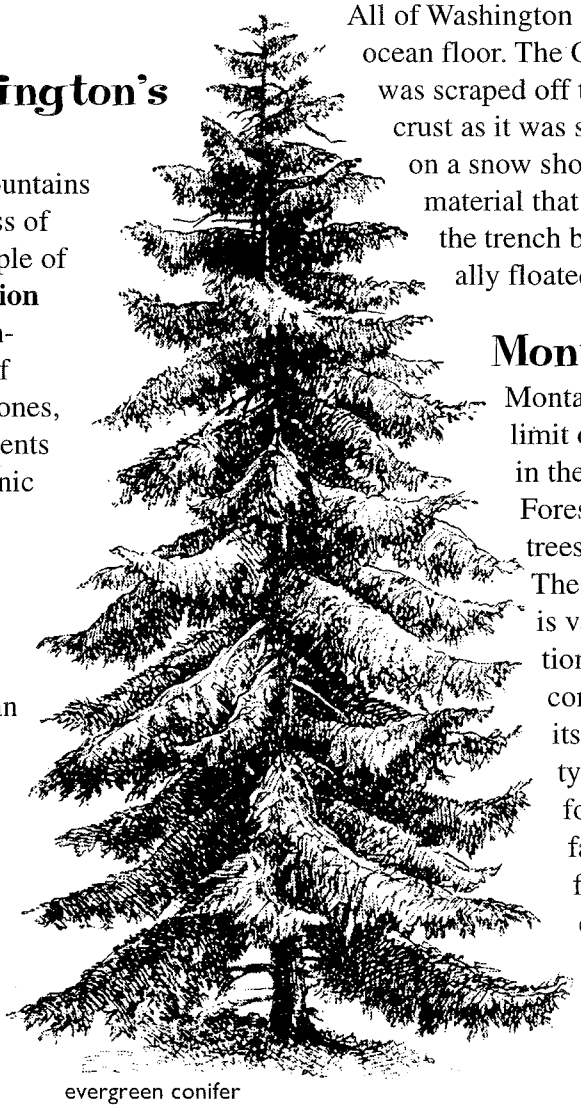
Washington state hosts the Olympic mountain range and portions of five others. The Olympic mountains, on the Olympic Peninsula, are coastal mountains and receive the highest amount of yearly **precipitation**. The Cascades, running the length of the state north and south, act as a climatic barrier, resulting in a wet western Washington and an overall dry eastern Washington. In the northeast are the southern arms of the Selkirks, the Kettle Range, and the Okanogan Highlands, all extending south from Canada. These three ranges are often together referred to as the Okanogan Highlands. In the southeast corner of the state lie the northernmost foothills and peaks of the Blue Mountains, extending north from Oregon. All six ranges support **montane** forests and **subalpine** zones, while only the Cascades and Olympics are high enough to support extensive **alpine** zones.

Formation of Washington's Mountain Ranges

The formation of Washington's mountains is explained by the geologic process of plate tectonics. The relevant principle of plate tectonics focuses on **subduction zones** where oceanic plates are constantly pushing against the edges of continental plates. At subduction zones, the continental plate scrapes sediments off of the oceanic plate as the oceanic plate dives under the edge of the continental plate. In the area of Washington state, two large land masses carried by oceanic plates collided with what was then the western edge of the North American continental plate. The Selkirk and Kettle ranges, and most likely the Blue Mountains as well, were formed when the first land mass docked onto the continent and crumpled the landscape into these mountains about 100 million years ago (Alt and Hyndman, 1984). Rocks called the Kootenay arc, which are sediments scraped off the oceanic plate, are present between the old North American continent edge and the land mass. When the second land mass docked and crumpled the landscape between 40 and 50 million years ago, the Okanogan Highlands and the Cascades were formed (Alt and Hyndman, 1984). Between the first and second land masses are rocks, called the Okanogan trench, that were scraped off the oceanic plate before the second land mass docked.

As oceanic plates were subducted under the continental plate and subjected to pressure and heat, molten material was formed and surfaced through volcanoes, further building up the mountains. Today, this action continues. The subduction zone currently active off of Washington's coast is the driving force behind volcanic activity in the five Washington Cascade volcanoes: Mt. Baker, Glacier Peak, Mt. Rainier, Mt. St. Helens and Mt. Adams.

All of Washington west of the Cascades was once ocean floor. The Olympics are a mash of rock that was scraped off the leading edge of the oceanic crust as it was subducting. Like snow building up on a snow shovel as it is pushed along, the material that forms the Olympics collected in the trench between the two plates and eventually floated up to rise above sea level.

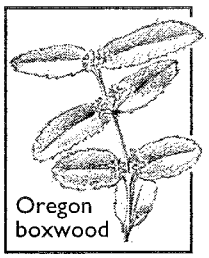


evergreen conifer

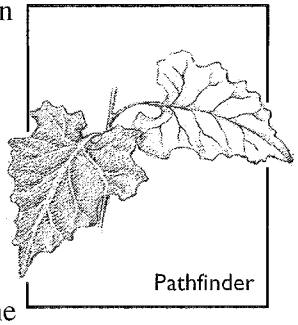
Montane Forests

Montane forests exist from the upper limit of low-elevation forests (described in the following section, Temperate Forest Habitats) up to the zone where trees cease to grow closely together. The upper elevation of montane forests is variable depending on many conditions including the slope's **aspect** (the compass direction that a slope faces), its location within the range, and the type of rocks or soils underlying the forest. Generally, shady north-facing slopes support montane forests at higher elevations than do drier south-facing slopes. In mountains throughout Washington, more precipitation falls with increasing elevation, but tempera-

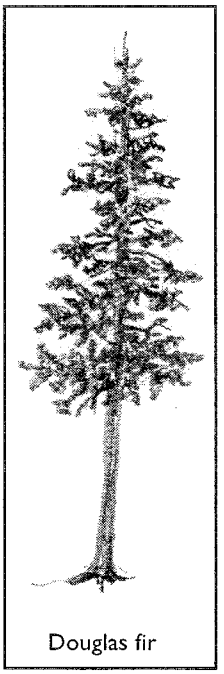
tures decrease. Yet, montane forests are drier than low-elevation forests because, although there is more precipitation, most of it falls as snow. Thus, the water is frozen and not available for use by plants. As compared to low-elevation forests, montane forests are colder, drier and more open. Therefore, species of plants found at higher elevations may be different than those found at lower elevations. However, montane forests, like low-elevation forests in Washington, are dominated by **evergreen conifers**.


Oregon boxwood

In ranges east of the Cascade crest, including the east slopes of the Cascades, montane forests grow between 3,000 and 6,000 feet (900 and 1,800 m) on the mountains. East side montane forests are characterized by lodgepole pine, whitebark pine, ponderosa pine, Douglas fir, grand fir and western larch in the middle elevations, as well as subalpine fir and Engelmann spruce at higher elevations. Western hemlock and western red cedar grow in wet places on the east slopes of the Cascades. The growing season in montane forests is cool and short. Soils become very dry during the summer after the snowpack melts completely and most of the water runs off the slopes. **Understories** of these montane forests contain shrubs of the same species found throughout the low-elevation forests of eastern Washington, which are often the same species that grow out in the steppe (see Plant List: Steppe). However, Oregon boxwood and black huckleberry, shrubs not commonly found in low-elevation forests, often dominate the understory of montane forests. East side montane **forest floors** also contain species of **forbs**, or non-woody plants besides grasses, that are uncommon in the low-elevation forests and the arid steppe. One of these plants is pathfinder. An observant person can follow the path taken by something moving through the forest by following the light green undersides of bent pathfinder leaves.


Pathfinder

Montane forests of western Washington grow between 2,000 feet (600 m) and approximately 4,000 feet (1,200 m) on the mountain slopes. The snow pack of west side montane forests can be from 3 to 10 feet (1 to 3 m) deep. Pacific silver fir is often the dominant tree. Western hemlock, noble fir, Douglas fir, western red cedar and western white pine are also present. At higher elevations, mountain hemlock, Alaska cedar and subalpine fir are more prevalent. The understory vegetation of west side montane forests is more sparse than understory vegetation of west side low-elevation forests but contains many of the same plant species (see Plant List: Temperate Forest Habitats) with the addition of Pacific rhododendron, several huckleberry species and wintergreens.


Douglas fir

Subalpine Vegetation

The subalpine zone lies between the upper limit of continuous montane forest and the lower limit of the treeless alpine zone. East of the Cascade crest, the subalpine zone generally lies above 6,000 feet (1,800 m), while on the west side the beginning of the subalpine zone lies anywhere from 4,000 to 5,500 feet (1,200 to 1,650 m). Subalpine vegetation is characterized by a mosaic of tree "islands" interspersed with meadows. With high precipitation and cold temperatures, snowpack has a significant influence on the upper limits of vegetation in the subalpine zone. Where snowpack lingers, the growing season becomes too short for trees to establish themselves before the onset of the next frost and snow. Thus, **herbaceous**, non-woody, vegetation makes up most of the ground cover.

In small, flat areas where snowmelt or rainwater collects during the growing season, montane wet meadows often form. Some plants in these montane wet meadows grow and bloom just as the snow is beginning to melt, often pushing up through the snow crust. As the season progresses, other wet meadow species replace the short-lived early bloomers.

In the harsh environment of the subalpine zone, many trees take on different growth forms than those exhibited by the same species growing at lower elevations. Wind breaks branches or tree crowns, causes plant tissues to dry out, and scours trees with small, airborne particles of ice. This wind action can damage limbs

which face into the wind resulting in a condition called **flagging**, where the branches grow only on the lee (out of the wind) side of the tree. When their roots are at or near freezing and can only absorb water very slowly, trees may also suffer from "winter drought," which, along with other conditions, causes trees to be stunted. Underneath the protective and insulating snowpack, stunted trees may grow wide skirts of branches. In some trees, these low-lying branches take root where they touch the ground. An erect stem grows up from the newly-rooted branch and the part of the branch connecting the parent and young tree dies. This method of regeneration is called **layering**. Layering often results in trees growing together in small islands within subalpine meadows. These islands provide adequate shelter from the harsh climate for other plants and animals.

Timberline is the transition between the subalpine and alpine zones and is usually a broad band, not a single line as implied by the name, in which trees become increasingly less frequent and eventually absent. Within the band of timberline, trees grow as **krummholz**. Krummholz, literally "crooked wood," refers to trees that are excessively stunted and misshapen by wind. The two most drastic krummholz growth forms are trees that grow as cushions and trees that grow entirely prostrate. Krummholz cushions are sprawling, circular mats of shrubby conifers which only grow up to 3 feet (1 m) tall. A single conifer growing as a cushion can reach 50 feet (15 m) across. Understory species may find significant shelter within these cushions. Trees growing **prostrate** have their trunks growing along the ground. Many conifers, such as subalpine fir and Alaska cedar, growing at high elevations may grow prostrate. Some shrubs grow this way as well, with their branches pressed against or even embedded in the soil. Trees and shrubs with these extreme growth forms are mainly found in the upper limits of timberline. Growing closer to the ground reduces exposure to high winds and helps plants to retain heat.

East of the Cascades, the subalpine zone is found above 6,000 feet (1,800 m). The highest peak of the Blue Mountains reaches 6,400 feet (1,920 m), that of the Selkirks and Kettles is 7,300 feet (2,190 m) and that of the Okanogan Highlands is 8,800 feet (2,640 m). The subalpine zone of the east side is dominated by subalpine fir, Engelmann spruce, whitebark pine, lodgepole pine, and alpine larch with the addition of mountain hemlock on the east slopes of the Cascades and other wetter areas. Because it is better adapted to conditions at alpine elevations, alpine larch is able to grow tall and erect where other tree species show krummholz growth forms. Alpine larch, and its lower elevation cousin western larch, are Washington's only **deciduous** conifers. Plants associated with east side subalpine trees and growing in the adjacent meadows include species of huckleberries (particularly grouse whortleberry), mountain ash, partridgefoot, mountain heathers and sedges. Grassy subalpine meadows may be dominated by green fescue.

krummholz

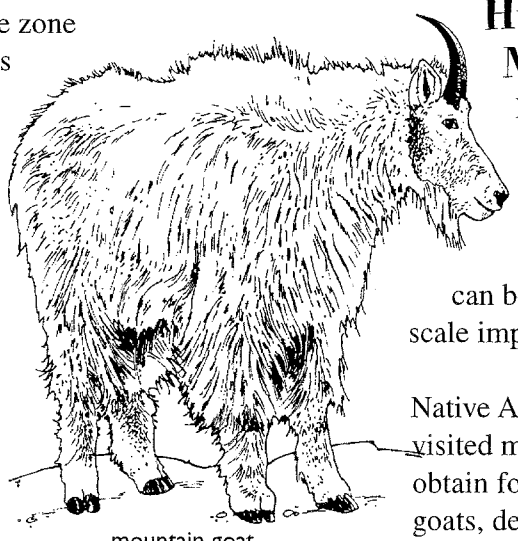
On the west side of the Cascades, the subalpine zone begins anywhere from 4,000 to 5,500 feet (1,200 to 1,650 m). On the west slopes of the Olympics, the subalpine zone begins at lower elevations due to the deep and lingering snowpack which inhibits tree regeneration. Snowpack can accumulate to more than 25 feet (7.5 m) deep in subalpine zones west of the Cascade crest. The dominant conifer in the subalpine zone west of the Cascades is mountain hemlock, growing in conjunction with Alaska cedar, Pacific silver fir, western white pine and noble fir with subalpine fir and lodgepole pine in colder, drier regions. Shrubs and herbaceous plant species are essentially the same as those found in the east side subalpine zone. In wet meadows, steer's head and yellow glacier lily are early blooming plants, while false hellebores are commonly seen later in the growing season.

Alpine Vegetation

The alpine zone is the treeless zone that lies above the upper limit of timberline. Alpine zones are found mainly in the Olympics and Cascades, generally above 6,000 feet (1,800 m) in elevation. Less extensive alpine zones exist in those areas of the Okanogan Highlands that lie above 7,000 feet (2,100 m). In Washington state, due to the high amount of snowfall, much of our alpine zones are blanketed year-round with snow fields and glaciers. Thus, the area of the alpine zone covered with vegetation in Washington's ranges is not as extensive as it is in ranges in other parts of the country where alpine zones are snow-free for part of the year.

High elevation life poses difficult conditions for alpine plants. Fierce winds can damage and dry out vegetation. Temperatures often fluctuate from very cold to very hot, due to a higher degree of solar radiation. Alpine soils are generally rocky and unstable. Snow and ice are present most of the year and little moisture is available during the summer months. Thick layers of snow insulate plants throughout the winter, so exposed ridges where snow is blown away are generally free of vegetation. Alpine plants have several adaptations to withstand these conditions. For example, alpine plants generally grow more slowly and are much smaller than plants at lower elevations. They grow close to the ground where wind speed is lower and they develop large root systems to capture what little moisture is available. Alpine plants often take on a cushion shape which also provides protection from wind and promotes heat retention. Some alpine plants have high concentrations of dissolved nutrients in their tissues that act as an antifreeze. Some plants have dark green leaves that absorb heat or waxy leaves that seal in moisture. Other plants have hairy leaves which help to retain moisture, prevent heat loss, and filter intense solar radiation. It is interesting that some of these adaptations, such as waxy or hairy leaves, are also found in steppe plants to prevent moisture loss (see "Adaptations of Steppe Plants" in the Steppe section).

Washington's alpine vegetation consists of sedges, grasses and other herbaceous plants which begin blooming from late spring to midsummer. Two species of alpine moss (*Polytrichum lyalli* and *Pogonatum alpinum*) commonly grow in association with black alpine sedge. Mountain-heathers may also be present. Hardy lichens are able to colonize rocky surfaces in the alpine zone. Alpine meadows of the Olympics host several species of plants found nowhere else in the world including Piper's bellflower, Olympic mountain butterweed and Olympic onion.


mountain goat

Human Use of Montane Habitats

Due to the rough terrain, montane **habitats** of Washington have been less impacted by human activity than other habitats of Washington. However, this region is fragile and can be irreversibly altered by only small-scale impacts.

Native Americans throughout Washington visited many areas in the mountains to obtain food such as huckleberries, mountain goats, deer, elk, bears and marmots. An area on the southeastern slopes of Mt. Adams was a fall meeting place for Native American tribes from eastern and western Washington. People would spend time on the mountain slopes picking huckleberries and playing games together. Evidence of pony racetracks, furrows 10 feet (3 m) wide and 3 feet (1 m) deep, used during these gatherings are still visible.

Settlers swarmed Washington's mountains to mine for gold, silver and lead in the North Cascades in the late 1800s and for sulfur on Mount Adams in the 1930s. Challenges posed by climate and terrain, as well as the small amounts of resources found, doomed these mining operations not long after they began. Currently, gold mining operations are active in the Kettle Range (Ferry County) and the Okanogan Highlands (Chelan County).

East of the Cascades, grazing and trampling of vegetation by livestock, primarily sheep, affects the composition of forest understories, usually causing the replacement of **native** plants with more competitive nonnative species. The reduction of native vegetation impacts the entire food chain, from animals that feed on the native plants to the animals that eat the plant eaters.

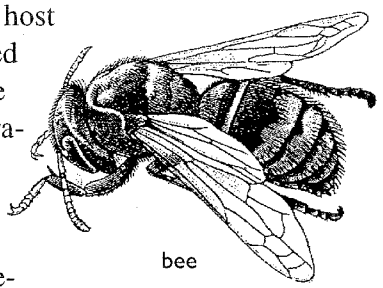
Logging is another human activity that has huge impacts on montane habitats. Within the montane region, the majority of logging has occurred in the latter half of the 1900s to meet the demand for this resource. Logging, though it has decreased greatly in the last decade, continues to impact montane habitats. Logging in the mountains not only affects the plants and animals in the forest itself, but every habitat downstream from logged areas is connected and therefore affected as well. Increased runoff and soil eroding into streams from logged land can cause flooding and destruction of aquatic wildlife habitat downstream.

Additionally, recreational activities, such as hunting, hiking, riding horses or all-terrain vehicles, mountain climbing and berry picking, all have impacts on montane environments. These activities cause **disturbance** and, due to the slow rates of **decomposition** and regeneration of vegetation, even small disturbances have lasting effects. Any traces left behind by people, from trash to trampled plants, remain for long periods of time.

Montane Wildlife

Animals inhabit all elevations of Washington's mountains. Some montane animals seasonally move to higher elevations in the warm months and range lower to avoid deep snows during winter. These elevational migrations eliminate the need to migrate long distances to more northerly or southerly latitudes. Most animals that do not migrate store food or **hibernate** to survive through the winter. Higher elevations pose special environmental challenges that animals, like plants, must be able to survive. But some animals find refuge from human disturbance in higher, isolated areas. Thus, Washington's mountains, particularly the northern ranges which border Canada, host small populations of animals that can no longer find suitable habitat in other parts of the state.

Tiny Creatures


bee

Glaciers and snow fields host segmented worms (related to earthworms) called ice worms. The ideal temperature for these worms is 32° F (0° C). In fact, if temperatures are any higher, the worms disintegrate! Ice worms feed on snow fleas, bacteria, algae and pollen grains also found in the snow. Flying insects often get blown up into the alpine zone by high winds. They are unable to survive there but provide food for other animals in alpine habitats, such as birds. Certain species of butterflies thrive at subalpine and alpine elevations, such as Vidler's alpine and arctic blue butterflies (found only above 6,500 feet [1,950 m]). Arctic blue butterflies lay their eggs only on shooting star plants because the caterpillars (**larvae**) rely on these plants for food. Mosquitoes, bumble bees and ten-lined June beetles, as well as deer, horse and black flies are all common in montane forests and subalpine zones.

Amphibians

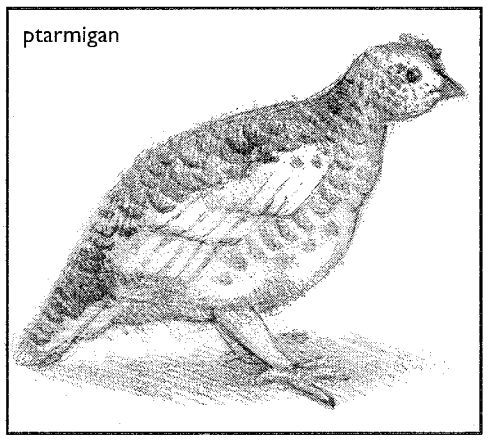
Several amphibians of Washington are closely associated with montane environments. In mountain streams, larvae of Pacific giant salamanders can be found. These are the largest terrestrial salamanders in North America and they eat a wide variety of invertebrates as well as some small vertebrates such as snakes, shrews, mice and other salamanders. Cascades frogs are generally found in wet areas at higher elevations, from about 3,300 feet (1,000 m) up to timberline, in the Olympics as well as the Cascades.

Reptiles

Northern alligator lizards are found ranging up to 4,500 feet (1,350 m) in mountains throughout Washington. Western fence lizards can occur up to 3,500 feet (1,050 m) on the east slopes of the Cascades and occasionally in the Blue Mountains. Both lizards eat insects and other small invertebrates. Rubber boas inhabit nearly all of Washington state but are not common. They have been found at 4,200 feet (1,260 m) in the Blue Mountains. Rubber boas prey on small mammals, birds, other reptiles and amphibians. They suffocate their **prey**, like other boas and pythons, by constriction. Western fence lizards lay leathery-shelled eggs that hatch after two months in soil or under rocks or logs. Northern alligator lizards and rubber boas, however, carry thinly coated eggs inside their bodies until they hatch, then give birth to live young. This allows these two species to inhabit colder areas because they can move around to bask in the sun, warming themselves and their eggs.

Birds

Several birds inhabiting mountains are important seed dispersers. These include Clark's nutcrackers, gray jays, red crossbills, and pine and evening grosbeaks. Clark's nutcrackers rely mainly on seeds from whitebark pines. They often cache seeds in the soil for later use. Uneaten seeds sometimes sprout into new pine trees.

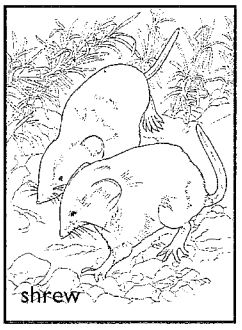

ptarmigan

Subalpine tree islands are important for many birds. Mountain bluebirds require trees for nesting, but find insects to eat in the surrounding meadows. A few bird species, among them white-tailed ptarmigans, rosy finches and water pipits, nest in alpine meadows. Ptarmigans are rarely found below timberline and their plumage becomes pure white in winter to camouflage the bird from **predators**. Water pipits migrate to lowlands for the winter.

Small, slate-gray water ouzels, or dippers, can be seen year-round diving to the bottom of high mountain streams in search of aquatic invertebrates. Gyrfalcons occasionally visit Washington's mountains during winter when food becomes scarce in their regular habitats further north in Canada and Alaska. These raptors prefer to hunt small mammals, such as voles, in open areas, especially near rocky outcroppings at high elevations. A gyrfalcon can be observed at the Raptor Center at Woodland Park Zoo.

Small Mammals

A variety of small mammals inhabit subalpine and alpine regions, where meadow vegetation forms the base of the food chain. Voles remain active year-round and breed in subalpine meadows. In the warm months they make shallow burrows in the soil. In winter, they dig their way through the snow. Heather voles feed on mountain heathers, kinnikinnick and huckleberries and use mosses and lichens to build their winter nests underneath the snow. Pocket gophers also burrow in the ground in summer and through the snow in winter. Pocket gophers mainly eat the underground parts of plants. Predatory birds, such as gyrfalcons, take advantage of the lack of cover in open meadows to prey on these small mammals.

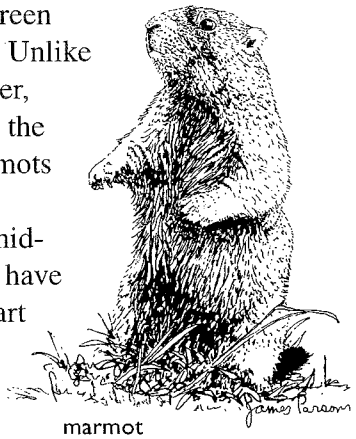

shrew

The pygmy shrew is North America's smallest mammal and lives only in northeastern Washington and adjacent areas of northern Idaho and southern British Columbia. Pygmy shrews inhabit dense pine woods and grassy meadows in the lower elevations of montane forests. These shrews, like others, feed mainly on insects.

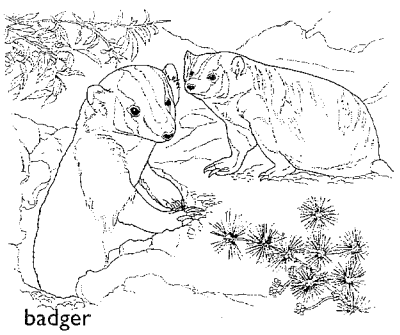
Talus slopes provide habitat for a number of animals at high elevations. Talus slopes are formed when chunks of rock fall to the bottom of steep slopes and pile up. These rock piles, with their holes of varying sizes, provide shelter for a variety of animals. Smaller animals prefer rock slides consisting of smaller rocks, larger animals prefer rock slides consisting of larger rocks. This allows the animal access to its home while excluding larger animals, especially predators.

Pikas only live within rock piles. These small relatives of rabbits harvest, dry out and store plants to eat during the winter. Bushy-tailed wood rats, which are small rodents, often live in rock slides, but may also find adequate shelter in other areas. Wood rats are also referred to as "packrats" due to their habit of collecting assorted shiny items, usually things left behind by human visitors, along with plants and fungi. Pikas and wood rats are active throughout the winter, surviving on food stored in their rocky homes.

Marmots, which are medium-sized rodents, also make their homes in talus slopes, eating grasses, sedges and other green vegetation growing nearby. Unlike pikas and wood rats however, marmots hibernate through the winter. Yellow-bellied marmots of eastern Washington may begin their hibernation in mid-summer when green plants have dried up. In a sense they start out **estivating** (a state similar to hibernation occurring during hot months) and continue through the winter hibernating. Marmots are considered to have the most complete hibernation of the animal kingdom. Their body temperatures drop as low as the air temperature in their burrows and their heartbeat slows from four beats per second to only four beats per minute. Hoary marmots, native to subalpine and alpine regions of the Cascades and Okanogan highlands, live in the mountain goat exhibit in the Northern Trail at Woodland Park Zoo but are often difficult to see, especially when they are hibernating!


marmot

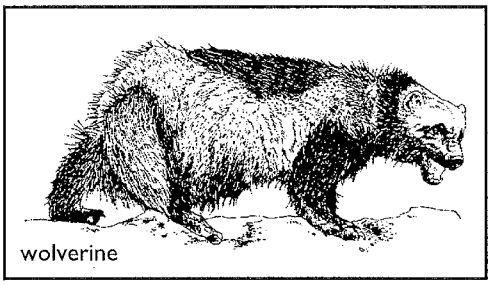
Badgers, inhabiting slopes of eastern Washington mountains, dig out and eat burrowing ground squirrels, marmots and pocket gophers. Yellow-bellied marmots, which are also found east of the Cascade crest, often make their homes in talus slopes in order to avoid predation by badgers. In the Olympic mountains, however, where there are no badgers, Olympic marmots often burrow in loose meadow soils since they do not need the protection offered by talus slopes.


badger

The Olympic mountains, due to their geographic isolation from other mountains of the Pacific northwest, do not have native populations of some species, such as pikas, porcupines and ptarmigans, but do have some animals not found anywhere else, including Olympic marmots and Olympic chipmunks.

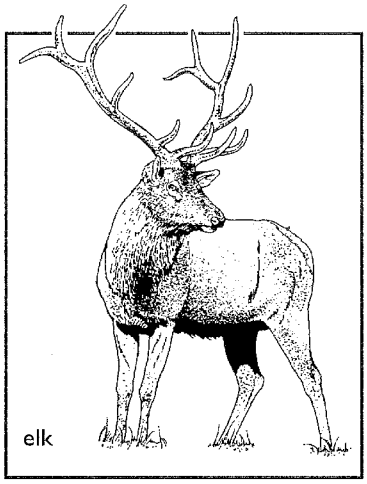
Two species of weasels, the long-tailed and short-tailed, range over most of Washington state and can be found at all elevations. Weasels are predators with big appetites, feeding on many small rodents, rabbits, birds and occasionally frogs and fish. Long-tailed weasels, which spend more time in non-forested areas than do short-tailed weasels, are quite adept at hunting burrowing animals such as pocket gophers and ground squirrels. Weasels can grow white winter coats which serve as protective camouflage when snow covers most of the ground. This camouflage helps them to escape detection by their main predators — owls. Weasels living at low elevations, however, tend to keep their brown coats throughout the year due to the absence of winter snow.

Large Mammals


wolverine

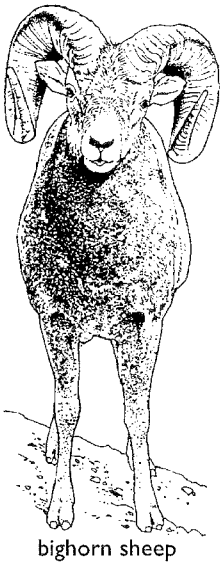
Wolverines are the largest members of the weasel family and are formidable predators. They prefer timberline habitat with its mosaic of tree islands, open space and rocky areas. Wolverines are opportunistic **scavengers**, meaning they generally eat what they find. In the winter, wolverines eat carrion but they also dig up hibernating rodents. In summer wolverines eat small mammals, eggs of ground-nesting birds, insects, and some berries and nuts. Wolverines have vast **home ranges**, up to 300 square miles (780 km^2), and thus require large amounts of suitable habitat. Due to past persecution by humans in attempts to eliminate predators and to obtain their fur, wolverines are now restricted to remote uninhabited areas of Washington.

The numbers of wolverines in Washington and other parts of the western United States are considered to be very low and biologists are recommending that the wolverine be added to the threatened or the endangered species list in the lower 48 states. The recommendation is still under debate in 1998.


elk

Elk and deer often migrate seasonally between high and low elevations. Western Washington's subspecies of elk is the Roosevelt elk. Most Roosevelt elk migrate elevationally, while some remain at low elevations year-round. Washington's other subspecies of elk, Rocky Mountain elk, live in the southeastern Cascades and in the state's northeastern mountain ranges. Rocky Mountain elk seasonally move between subalpine elevations and low elevations. Rocky Mountain elk are descendants of elk reintroduced to the area from Yellowstone in the 1910s. Because elk were extremely popular game animals in the early part of the century, especially when wearing an elk tooth on a watch chain became highly fashionable, they were nearly eliminated from the Cascades prior to the reintroduction effort. The elk were reintroduced to allow for continued but regulated sport hunting. By the mid-1980s reintroduction efforts had proven successful and there were 57,000 Rocky Mountain elk in Washington. Roosevelt elk, a small herd of females and one male, can be observed in the Northern Trail at Woodland Park Zoo.

Washington has two subspecies of mule deer. The subspecies west of the Cascade crest is called black-tailed deer and the eastern subspecies is called mule deer. In the Okanogan Highlands, white-tailed deer are also present. In warm months when most of the snow has melted and lush vegetation flourishes, deer and elk roam as high as subalpine meadows in search of good grazing and browsing. When winter comes, they return to the snow-free lowlands.

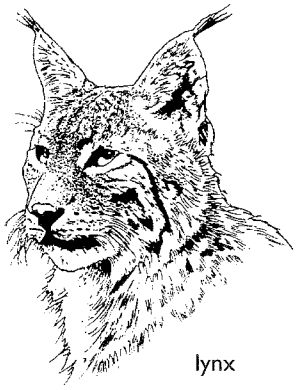

bighorn sheep

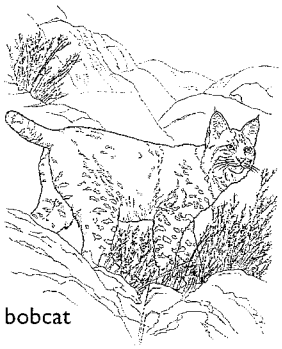
Bighorn sheep living in the Blue Mountains, on rocky slopes of the southeastern Cascades, and in the Okanogan Highlands are descended from animals reintroduced in the late 1950s. Mountain goats are native to alpine and subalpine regions of the Cascades but were introduced in the Olympic mountains in the 1920s as game animals for hunting. Mountain goats had never before inhabited the Olympics and their increasing numbers are presently causing much disturbance of native alpine and subalpine vegetation. This problem has caused wildlife managers to consider removing the animals from Olympic National Park, though exactly how this is to be accomplished is up for debate. Both bighorn sheep and mountain goats feed primarily on grasses and other herbaceous vegetation, but during winter mountain goats depend heavily on mosses and lichens growing on subalpine firs as well as the trees' foliage. Both species usually remain at high elevations throughout the winter, though they will migrate to lower elevations if snow becomes excessively deep. Several mountain goats can be seen grazing in a meadow or perching on rocky cliffs in the Northern Trail at Woodland Park Zoo.


moose

The Selkirks in Washington's northeast corner host both moose and mountain caribou, hoofed mammals not found elsewhere in the state. Moose are the largest terrestrial mammals found in Washington. They eat a variety of leaves and aquatic vegetation. Mountain caribou are an endangered species in Washington. Over the past 10 years, several successful relocations of caribou from Canada to Washington's Selkirks have taken place. Lichens, mostly fallen from coniferous trees, are an important food source for caribou, particularly in the winter when little else is available.

The Okanogan Highlands are home to the largest population of Canada lynx in the lower 48 states. Lynx spend most of their time in the subalpine zone or in the upper elevations of montane forests. Lynx are similar in size to bobcats and have very short tails, but lynx generally have longer fur and legs than do bobcats, giving them a larger appearance. Lynx have very large paws in proportion to their body size and long back legs. These physical characteristics help lynx maneuver adeptly through snow in order to hunt their primary prey, snowshoe hares. Lynx are not often seen due to their solitary, nocturnal habits. Their numbers have decreased in the past century largely due to high demand for their fur in the late 1970s and early 1980s. Canada lynx are currently listed as threatened in Washington and will soon be protected under the federal Endangered Species Act. The federal status of the Canada lynx, threatened or endangered, will be decided by June 1999. (See "Montane Habitat Conservation Projects" in this section for more information on lynx.)


lynx


bobcat

Bobcats and cougars are not generally found in open areas of the subalpine and alpine zones. Cougars keep to areas of closed forest, but will follow deer, their preferred prey, as they migrate to higher or lower elevations. (See "Temperate Forest Wildlife" for information on cougars and bobcats.)

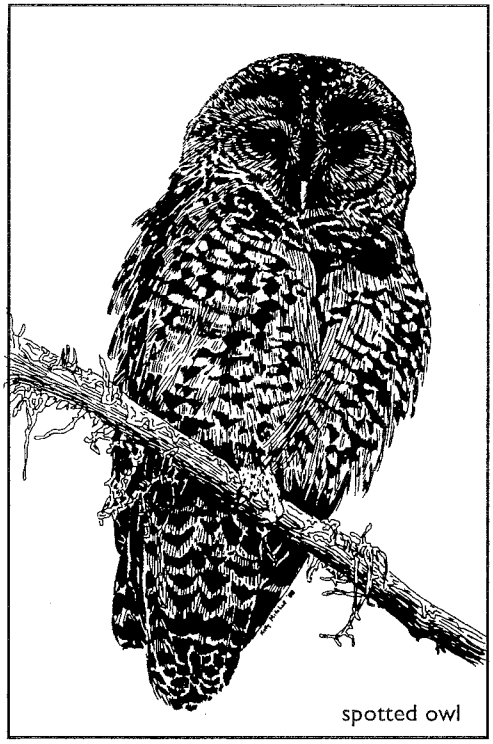
Red foxes range from the crest of the Cascades into eastern Washington. These foxes prefer the area around timberline, where trees and meadows are interspersed. Because native red foxes use openings in rocky areas for dens, they often inhabit subalpine elevations with abundant talus slopes. Foxes readily hunt small mammals, frogs and insects and will also eat berries when available. Red foxes did not historically occur west of the Cascades crest, but red foxes which descended from captive animals (raised for fur) are present throughout lowlands of western Washington.


gray wolf

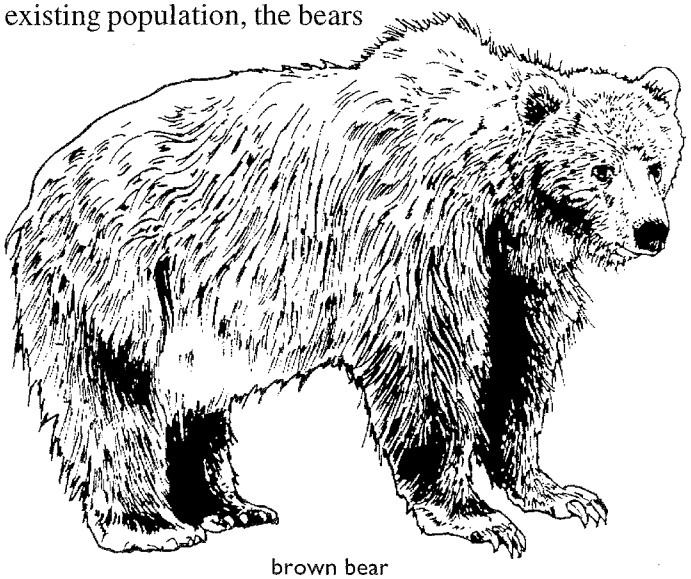
Gray wolves once roamed throughout Washington state. However, most of Washington's wolves had been killed by the 1920s because it was believed that wolves preyed heavily on domestic **ungulates** (hoofed mammals) as well as game animals. We are now beginning to understand the important role played by wolves in their habitat. Wolves primarily prey on elk and deer and are opportunistic hunters, killing the most vulnerable animals in a herd. In this way, wolves help to regulate the health and size of the herd by taking the old and weak as well as some of the young. Generally, if there are enough native prey in an area, wolves will not bother domestic animals. Wolves can inhabit almost any habitat from grassy plains to arctic tundra. Due to human activity throughout North America though, wolves have become restricted to isolated areas, particularly mountainous regions in western North America. There have been sporadic sightings of wolves in unpopulated forested areas of northeastern Washington. These wolves range southward into Washington from Canada. Because gray wolves are listed as an endangered species in Washington, plans to reintroduce them to suitable habitats in the state, such as Olympic National Park, are currently being considered. Woodland Park Zoo displays public information on this reintroduction process in the zoo's Northern Trail where a small pack of gray wolves can be observed.

Grizzly bears, unlike black bears (see "Temperate Forest Wildlife"), prefer open high country and spend less time in closed forest. Also unlike black bears, grizzlies are not good tree climbers. The grizzly bear is a subspecies of the brown bear. The long claws of grizzlies are not used for defense or fighting, but primarily for digging up nutritious plant roots and for breaking into rotting logs in search of insects. Grizzly bears have limited elevational migrations but their patterns are opposite the migrations of hoofed mammals; grizzlies den up for the winter at high elevations and range to lower elevations to find food in the spring.

Grizzly bears eat a wide diversity of plants, including sedges, the underground bulbs of lilies, a variety of huckleberries and even devil's club. Plants can make up to 90% of a grizzly bear's diet. Carrion, fish and occasional deer or elk calves are also eaten. Bears are good swimmers and enjoy wallowing on hot days. In the Northern Trail at Woodland Park Zoo, two grizzly bears can be observed, often swimming and play-fighting in their water hole.


spotted owl

Grizzly bears are not as widespread and are far fewer in number in Washington than are black bears. Only about 25 grizzly bears are thought to live in the Selkirks and from five to 20 in the North Cascades. These bears most likely move back and forth between British Columbia and Washington, and it is doubtful that these small populations will ever reach great numbers. This is due to the very slow reproduction rate of grizzly bears. A female grizzly, in her lifetime, will only produce from four to seven offspring that will go on to reproduce. This is the second slowest reproductive rate of North American mammals (muskoxen have the slowest). Because grizzly bears are listed as an endangered species in Washington, it is possible that efforts will be made to augment the populations in the North Cascades by introducing more grizzlies, probably from elsewhere in British Columbia. By adding some grizzlies to the existing population, the bears will have a better chance of producing enough individuals to attain what is referred to as a viable population. In order for a population to be viable over a long period of time, there must be enough genetic diversity and enough individuals for the population to survive natural threats, such as diseases and natural disasters. Ecologists have determined that a viable population of grizzlies in the North Cascades ecosystem, which includes Washington and British Columbia, would number from 200 to 400 animals.


brown bear

Montane Conservation Projects

Currently, many projects are focusing on plants and animals of montane habitats. Using innovative research methods, our knowledge of these species is constantly increasing. Recently, new techniques have been developed to research wildlife populations. Geneticists are now able to obtain DNA "fingerprints" of animals from the roots of their hair. Field biologists in the western United States use this technique to study Canada lynx populations and have devised a way to easily collect lynx hairs. "Rubbing pads," small pieces of carpet, are nailed to trees at lynx height and scented with a variety of substances attractive to lynx. The cats find the pads and instinctively rub their cheeks against the pads, leaving behind numerous hairs which are then collected by the biologists and run through DNA analysis. With several collections of hair from various locations, biologists can better assess Canada lynx populations, their genetic health, and what types of habitats they prefer. This allows researchers to keep track of these elusive animals without disturbing them to obtain blood or to radio-collar them, and without even seeing them. This type of information about the Canada lynx has helped the animal to achieve its status as a federally protected species.

The ability to obtain genetic and hormonal information from animal feces has also been developed recently. Researchers with the Center for Wildlife Conservation (CWC) at Woodland Park Zoo have used these methods to assess stress levels of northern spotted owls, which were shown to be significantly higher within a quarter mile (40 m) of logging roads. Genetic information from animal feces is also aiding research on the size and health of grizzly bear and wolf populations. In addition, dogs originally intended to detect narcotic drugs are now being trained by CWC staff to sniff out animal feces for DNA analysis. With the aid of dogs, researchers are able to locate a much greater quantity of animal feces than had previously been possible. As with lynx hairs, obtaining information from feces makes it possible to study animals in the wild without disturbing them in the process.

Woodland Park Zoo has also provided financial support, in conjunction with Idaho Fish and Game, the U.S. Fish and Wildlife Service and other private donors, to a grizzly bear recovery project in the Selkirk ecosystem of north-western Washington and northern Idaho. The project uses radio-collaring and tracking to determine the population density, dynamics and distribution of the bears and causes of grizzly bear mortality. The project includes conservation education for people who live, work or recreate in grizzly bear habitat in an attempt to reduce human-caused grizzly bear deaths. Since education began in 1989, grizzly bear deaths due to humans have shown a decline.

All three of Washington's national parks, Olympic, Mt. Rainier and North Cascades, were created around core montane habitats. These parks offer the chance to explore the vegetation of montane forests, subalpine and alpine zones as well as opportunities to observe montane wildlife.

Caring About Montane Habitats

Because of the rugged conditions, humans have had less physical impact on montane environments than they have had on other environments in Washington state. Therefore, montane regions are increasingly important as our last remaining wild landscapes. In 1964, the National Wilderness Preservation System Act was passed to protect these areas. This act, and subsequent additions, defines **Wilderness** as an area where "the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain" (National Wilderness Act, 1964). Designated Wilderness areas are on federal lands and managed by the National Forest Service, National Park Service, U.S. Fish and Wildlife Service and the Bureau of Land Management. Although not all Wilderness areas are in the mountains, many montane areas were not yet impacted heavily by people and became protected under the Wilderness Act.

Mountains are the source of Washington's watersheds. We rely heavily on fresh water from glaciers and snow fields, particularly in summer when relatively little precipitation falls. Of the approximately 1,650 glaciers in the lower 48 United States, Washington contains 950! Any alterations to these water sources affect the human population and the wildlife along the entire length of the rivers.

So, when we take good care of Wilderness areas, we are looking after our water sources and the overall quality of our environment, from the top down.

Additionally, Wilderness areas are reservoirs for biological diversity, serve as unique living laboratories for medicinal and scientific research, support natural life systems, provide wildlife habitat, protect historic and cultural sites, clean our air and water, serve us spiritually and aesthetically as havens from industrial society, provide numerous recreational opportunities, benefit our economy, and are living classrooms for education. Nearly 10% of Washington state is designated as 30 individual Wilderness areas, the majority of which are in the Cascades but some are also found in the Olympics, Okanogan Highlands and Selkirks. We truly have something to celebrate in our state's diverse beautiful areas.

Although federal agencies are legally responsible for managing Wilderness areas, we all have a role in their protection. More and more people are recreating in Wilderness areas and discovering their beauty. Exploring montane forests, subalpine meadows and alpine snow fields can be a wonderful learning experience. But, as visitors our behaviors and actions must be appropriate and we must strive to leave no trace of our presence. As citizens, we need to be aware of the impact our lifestyles have on our country's wild lands. And as teachers, we can help protect Washington's Wilderness areas by nurturing a land ethic in our communities.

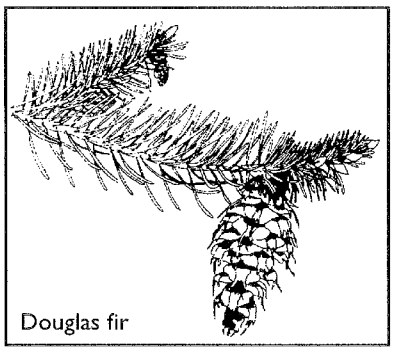
TEMPERATE FOREST HABITATS

Much of Washington is blanketed by low-elevation coniferous **temperate forests**. These include the drier forests of eastern Washington (the east slopes of the Cascades, southern arms of the Okanogan, Kettle and Selkirk ranges, and the northern arm of the Blue Mountains), to the wetter west slopes of the Cascades and east slopes of the Olympics, to the wettest west slopes of the Olympics.

Formation of Temperate Forest Lands

Much of the top third of Washington state, including the Olympic Peninsula, the Puget Sound region, the North Cascades, the Okanogan Highlands, the Kettle Range and the Selkirks, was covered by ice sheets during the ice ages which ended about 12,000 years ago. At one time, the southern extension of the ice sheets in eastern Washington almost reached as far south as Wenatchee. In western Washington, the ice sheets extended down to cover the entire area of what is now Puget Sound. The Puget Sound lowlands were filled in with very thick deposits of **glacial till** from the glaciers as they melted and retreated northward. In some places the glacial sediments are up to 3,000 feet (900 m) thick! The north-south orientation of Puget Sound illustrates the movement of the glaciers, which extended southward and retreated back to the north. The nutrient-rich glacial till supported the growth of temperate forests at low elevations throughout much of Washington. Temperate forests also grew over oceanic **basalts** and **sediments** covering southwestern Washington and flood basalts east of the southern end of the Cascades.

Temperate forests grow throughout the world at mid-latitudes in areas lying between the hot tropics and the cold polar regions. Temperate forests grow where the climate is relatively mild year-round. Temperate forests of Washington are dominated by needleleaf (as opposed to broadleaf) trees, most of which are evergreen **conifers**. The conical shape of many conifers helps the trees to capture as much of the cloud-filtered light as possible, especially in winter when the sun is perpetually low in the sky. This shape and their flexible boughs also help trees shed heavy snow in winter. Most conifers are **evergreen** (they retain their needles year-round) which increases their capacity to photosynthesize throughout the year. This ability is especially important in the Pacific Northwest, where most **precipitation** falls in winter and droughts are common in the summer. The occurrence of summer droughts limits the distribution of **deciduous** trees because they need moisture during the summer, when they have leaves, to carry out **photosynthesis**. Due to their large size, conifers can hold great amounts of water which can be drawn on during dry times. Thus, the Pacific Northwest climate favors needleleaved evergreen trees.


Douglas fir


Douglas fir

Temperate Forests of Eastern Washington

The low-elevation temperate forests of eastern Washington form a ring around the Columbia Basin. These forests range from 1,800 to 3,000 feet (540 to 900 m) in elevation. East side temperate forests are far drier than the forests of western Washington. The Olympic and Cascade mountains cause air flowing off the Pacific Ocean to rise and drop most of its moisture in western Washington. Thus, eastern Washington lies in the "rainshadow" of the Cascades. Precipitation in the low-elevation forests of eastern Washington ranges from 15 to 30 inches (38 to 75 cm). (See Table of Temperature, Precipitation and Snow Depth in the Activities section for comparisons.) Most of this precipitation falls in the winter as snow. In the lowest elevations bordering the steppe, ponderosa pine, a very drought-tolerant conifer, dominates. At slightly higher elevations than the ponderosa pine forests, Douglas fir is the dominant conifer, growing along with lodgepole pine, grand fir and western larch. Douglas firs on the east side of the mountains, called Rocky Mountain Douglas fir, are actually a subspecies of coastal

Douglas fir. Due to the dry conditions, Rocky Mountain Douglas firs do not reach the great sizes that Douglas firs are capable of on the wetter west side. Western larch is one of Washington's two deciduous conifers, the other being alpine larch. These trees, which grow primarily east of the Cascades, annually lose their needles in the fall.

As a result of dry conditions, fires are frequent in forests east of the Cascades. Forest fires are an important part of the natural cycle of forest life. Fires help to maintain the openness of drier forests, which enhances the diversity of plants in the lower levels of the forest. Many forest floor species grow back vigorously after being burned, providing an abundance of food for grazing animals. Several conifers, such as ponderosa pine, Douglas fir and western larch, have thick bark and are very fire resistant. Lodgepole pine trees cannot survive a hot fire but their seeds require fire to initiate germination. After a fire, many lodgepole pine seedlings sprout up and these trees dominate the forest until other conifers gradually replace them.


quaking aspen

Quaking aspen and Garry oak are two broadleaf, deciduous trees that grow in association with east side conifers. These trees are adapted to the dry conditions of east side forests. Many of the shrubs and **herbaceous** plants making up the forest floor and understory are the same ones that grow throughout the steppe region (see Plant List: Steppe). Most of the wildlife found in east side forests are the same species that inhabit west side forests (see Animal List: Temperate Forest Habitats).

Temperate Forests of Western Washington

Temperate forests east and west of the Cascades differ from each other, though many similarities are apparent. In western Washington, temperate forests grow from sea level to 2,000 feet (600 m). The remainder of this section is focused around the distinctive **temperate rain forest** on the west side of the Olympics, which embodies many important characteristics of low-elevation temperate forests.

The temperate rain forest of the Olympic Peninsula is one of Washington's remarkable ecosystems. The Olympic rain forest supports coniferous trees of impressive size and age, among them champions of their species, and also a host of other plants and animals intertwined by amazingly complex interactions.

Temperate rain forests, and the combination of special conditions that help create them, exist only in a few regions of the world. In addition to the Pacific Northwest, temperate rain forests can be found along the coasts of Australia, New Zealand and Chile, as well as small patches along the coasts of Japan, the United Kingdom and Norway. Of the total acreage of temperate rain forest worldwide, two-thirds is found along North America's northwest coast.

As described in Kirk and Franklin (1992), botanists have agreed that several of the characteristics which define a temperate rain forest include:

- several layers of vegetation which overlap with one another
- trees that are long-lived and of great size
- an abundance of organic debris on the ground
- cool, wet, acidic soils
- an abundance of **epiphytes** including mosses
- dominated by coniferous trees
- abundant networks of flowing water
- negligible disturbance by insect attack or fire

In Washington, temperate rain forests grow on the west side of the Olympic mountains along four river valleys: Quinault, Queets, Hoh and Bogachiel. These wide, U-shaped valleys were sculpted by glaciers that repeatedly extended down from the mountains into the river valleys and then retreated back during climatic cycles of the last ice age. The glaciers deposited large amounts of coarse sediments which covered the valley floors. The layers of sediment were subsequently cut into **terraces** by large amounts of runoff from melting glaciers. It is on these terraces within the river valleys, in the deep, rich soils that formed there, that temperate rain forests grew.

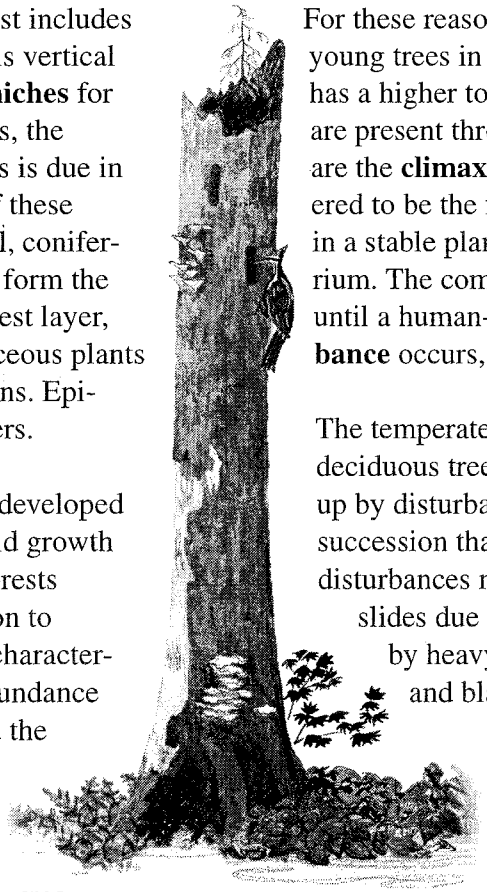
The availability of moisture is an important factor in the growth of temperate forests. Rain forest trees obtain water not only from the wet river valleys they grow along, but also from rain, snow and moisture that condenses from fog. Annual precipitation in the valleys can reach an average of 120 to 140 inches (300 to 350 cm); the amount of precipitation increases with increasing elevation. In other low-elevation forests west of the Cascades, precipitation ranges from 35 to 120 inches (90 to 300 cm) per year. Up to 90% of this precipitation falls between September and May.

Fog is an important contributing factor to moisture in rain forests. Fog that rolls in off the ocean condenses on tree needles and drips down to the forest floor. Trees with thin bark may even absorb this water as it runs down the trunk of the tree. "Fog-drip" can add as much as 30 inches (90 cm) of moisture to the Olympic rain forest annually (Kirk and Franklin, 1992). That's close to Seattle's average annual rainfall of 38 inches (95 cm)! Additionally, in the Olympic rain forest twice as many days are cloudy as are clear. This cloudiness insulates the forest, minimizing temperature extremes and preventing loss of moisture.

Temperate Forest Vegetation

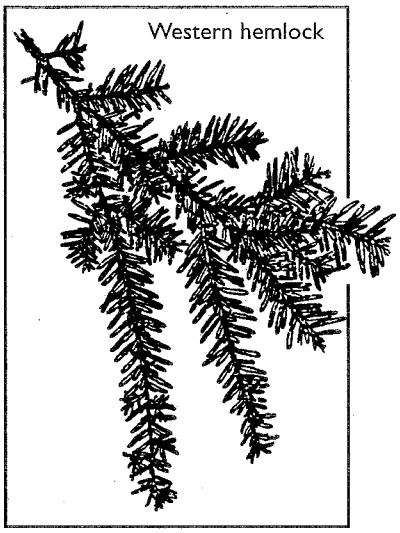
The basic structure of a temperate forest includes several overlapping vertical layers. This vertical variety of **habitats** creates numerous **niches** for many different animals to inhabit. Thus, the **biodiversity** found in temperate forests is due in part to the forest layers. The highest of these layers is the **canopy**, formed by the tall, coniferous trees. Small trees and large shrubs form the middle layer, the **understory**. The lowest layer, the **forest floor**, is covered with herbaceous plants as well as mosses, liverworts and lichens. Epiphytes are abundant in each of the layers.

The forest layers are particularly well-developed in old growth forests. Small areas of old growth forest can be found in low-elevation forests throughout most of the state. In addition to vertical layers, old growth forests are characterized by trees over 300 years old, an abundance of downed logs on the forest floor, and the presence of **snags** throughout the forest. These components add further structural diversity to old forests.



snag

Horizontal diversity is created when old trees fall and open up small areas of increased light which encourages young trees in the understory to grow and reach toward the canopy.



Canopy

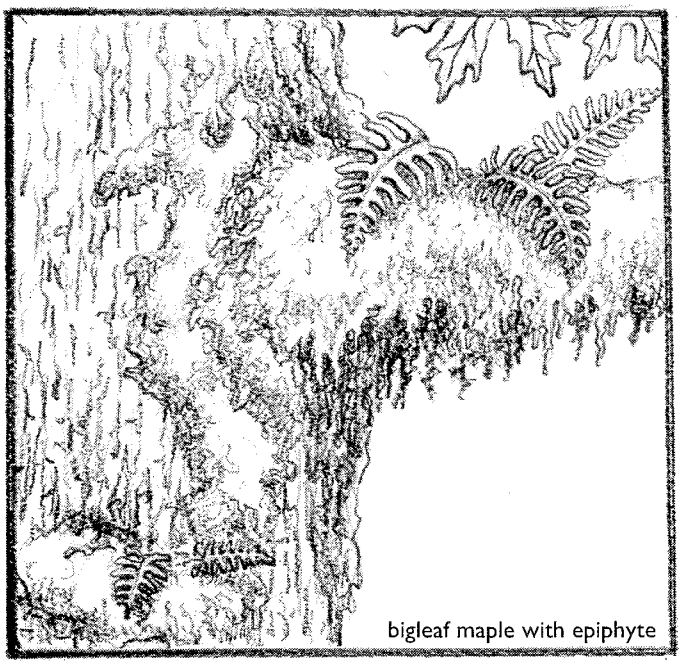
In the Olympic rain forest, Sitka spruce and western hemlock dominate the landscape. Other conifers include Douglas fir, western red cedar, grand fir and silver fir. Spruce and other conifers form the canopy of the rain forest, growing to heights of 165 to 280 feet (50 to 80 m). In order to start growth, Sitka spruce normally require sunny openings with bare soil, such as glacial deposits. In the Olympic rain forest, however, these fast-growing trees germinate almost exclusively on downed logs. Hemlock seeds can germinate anywhere they fall within a forest and the seedlings are very shade-tolerant. Other conifer seedlings are less able to grow in the shade of the canopy. For these reasons, hemlocks are the most common young trees in the rain forest. However, Sitka spruce has a higher tolerance of wind and salt spray, which are present throughout the rain forest, so these trees are the **climax** species. Climax species are considered to be the final stage of **succession** which results in a stable plant community that is in natural equilibrium. The community will remain in equilibrium until a human-caused or large-scale natural **disturbance** occurs, renewing the cycle of succession.

The temperate rain forest supports several species of deciduous trees. These trees thrive in areas opened up by disturbance and represent earlier stages of succession than do the dominant conifers. Forest disturbances may include floods, landslides, debris slides due to avalanches, and blow-downs caused by heavy winds. Stands of large bigleaf maples and black cottonwoods are prominent in the rain forest, especially along rivers. Red alders colonize more recently disturbed areas, but will eventually be replaced by conifers.

In west side forests other than the Olympic rain forest, Douglas fir is most often the dominant conifer. Douglas firs, which are taxonomically not true firs, are fast-growing, light-loving, long-lived, and relatively drought-tolerant trees. These trees are a "pioneer" species which means they can readily colonize a light-filled area following disturbance and will remain the dominant tree for hundreds of years. However, western hemlock and western red cedar are the climax species of these forests. Young hemlock and red cedar trees can grow slowly in the shaded understory for many years but will quickly take advantage of increased light made available when large trees fall. If the forest were to continue its development without major disturbance it would begin to reach its climax stage after 800 years. Hemlocks and red cedars would grow up to form the canopy, gradually replacing the Douglas firs, and become the dominant forest species.

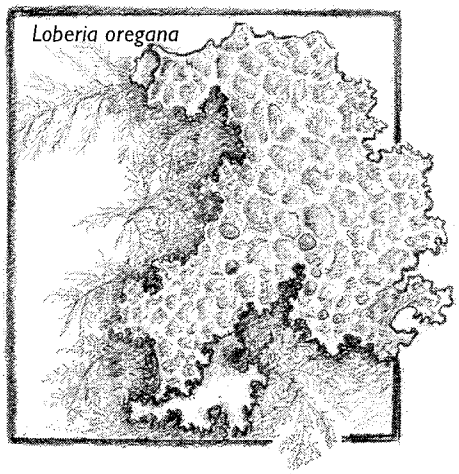
Other conifers in these Douglas fir forests are the same as those found in the Olympic rain forest, with the addition of western white pine. Wet, disturbed sites may be inhabited by the same deciduous trees found in the Olympic rain forest, while dry, rocky bluffs in low-elevation forests may be inhabited by Garry oak and Pacific madrone.

A characteristic of temperate forests, particularly rain forests, is the presence of epiphytes. Epiphytes are nonparasitic (not harmful) plants that grow on other plants. In the Olympic rain forest most epiphytes are mosses, liverworts (closely related to mosses), lichens, club mosses and ferns. By growing on trees, epiphytes can take advantage of increased light in the canopy. For reasons not yet discovered, bigleaf maples support the most developed epiphyte gardens. On maples, epiphytes can grow from six to 10 inches (15 to 25 cm) thick and can weigh four times as much as the host tree's **foliage** (Kirk and Franklin, 1992)! It has been discovered that deciduous trees grow rootlets out of their trunks to reach into the layer of epiphytes and absorb water and nutrients. This is a good example of a **symbiotic relationship**, in which both organisms involved (epiphyte and tree) benefit and neither one is negatively affected. Bigleaf maples are covered predominantly by selaginella, a club moss, and *Isothecium stoloniferum*, a stringy true moss. In western Washington, licorice ferns are the most common epiphytic fern growing on deciduous trees.


bigleaf maple with epiphyte

Canopy tree needles, particularly of older forests, are colonized by an assortment of tiny organisms. Taken together, these organisms — fungi, algae, yeasts and bacteria — are called "scuzz." Some scuzz organisms grow on the insides of needles, others cover the outside. Scuzz aids trees by warding off needle-eating insects and by passing on nitrogen taken from the air. Tiny invertebrates feed on the scuzz and are in turn eaten by spiders and **predatory** insects. Spiders and predatory insects offer great protection to the forest canopy by capturing and consuming needle-eating insects that invade the trees during summer. This greatly reduces the loss of needles to insect infestation.

Lichens are also important inhabitants of older forest canopies. Lichens are a close partnership (another symbiotic relationship) between certain fungi and algae. Some lichens also incorporate cyanobacteria (blue-green algae). The fungus provides the structure of the lichen, and the algae provides the carbohydrates needed for growth through photosynthesis. The cyanobacteria enable certain lichens, such as *Loberia oregana*, to absorb nitrogen from the air and convert it to a form

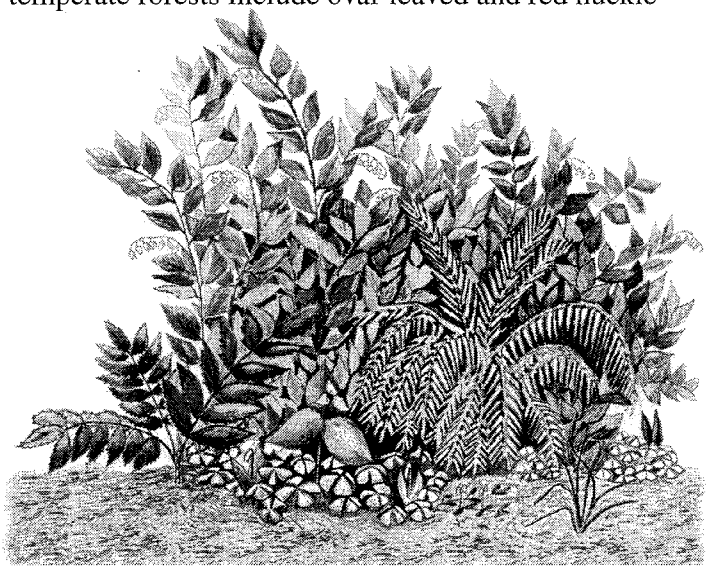

Loberia oregana

usable by plants and animals. Lichens often fall to the forest floor, usually during wind storms, where they serve as built-in fertilizer for plants and winter food for foraging animals.

Throughout the Pacific Northwest, a great deal of research has been conducted to unlock some of the mysteries of the forest canopy. Epiphytes, insects, photosynthesis rates, and the storing of carbon are just a few of the subjects that canopy researchers have been investigating.

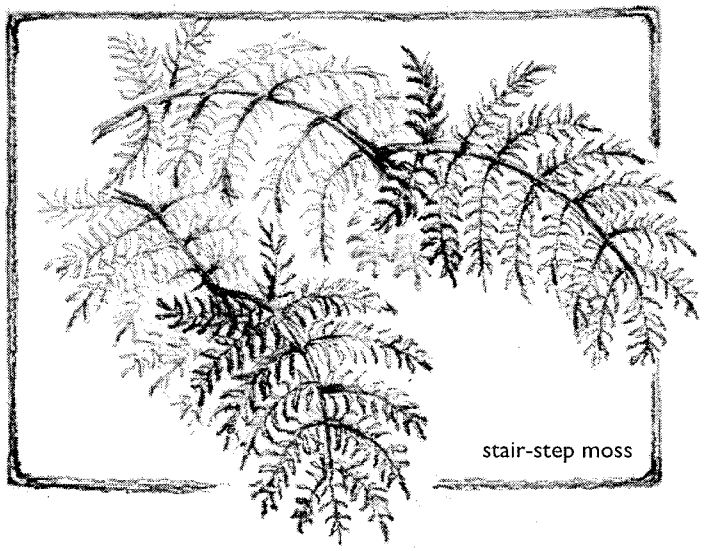
Understory

The understory of a temperate forest hosts a number of different small trees and shrubs. Plants that grow in the understory must be tolerant of very shady conditions due to the dense canopy overhead. Understory plants often have their leaves spread flat and wide to catch the maximum amount of available light. Western yew is a small, slow-growing, shade-tolerant conifer. With the right conditions, as found in canyons and river bottoms, yews can grow to a height of 60 feet (18 m). The bark of western yew has been found to contain high concentrations of a compound called taxol that is effective in combating certain cancers. Another shade-tolerant understory tree is Pacific dogwood, recognizable by the large white "flowers" (actually a whorl of modified leaves with tiny flowers at the center) that appear in spring. In the Olympic rain forest, clumps of vine maple grow in the otherwise open understory. Bent-over branches of vine maple, which can root into the ground they touch, create tangles of arches. Other understory plants of west side temperate forests include oval-leaved and red huckleberry as well as red elderberry, devil's club and salal. Shrubs, ferns, mosses and lichens are able to reach high into the understory when they grow on snags, stumps and large logs.



Forest Floor

The temperate forest floor in many places is a green carpet of herbaceous plants and mosses, which grow vigorously on decaying wood and other organic material, aiding in the decomposition process. Ferns are widespread forest floor dwellers, with sword fern being the most abundant. Redwood sorrel and vanilla leaf are among the other herbaceous plants that form extensive green patches. Numerous tiny tree seedlings can also be found, such as the shade-tolerant western hemlock.



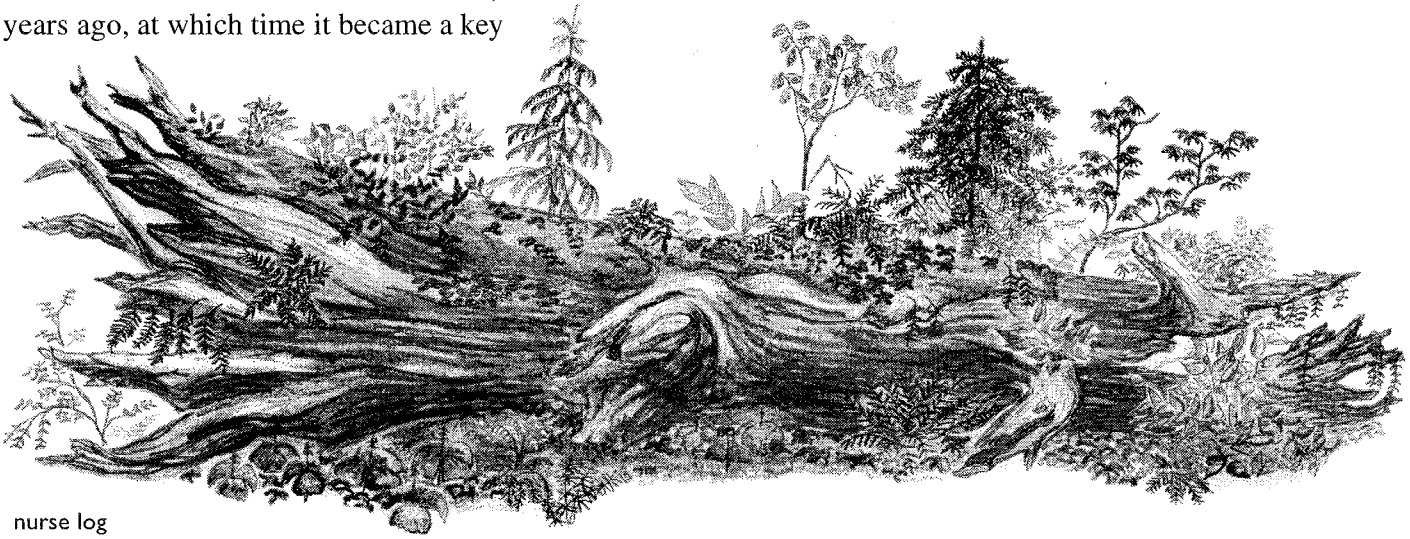
Some forest floor plants, such as Indian pipe, cannot make their own food through photosynthesis because they lack **chlorophyll**. These plants depend on decaying material on the forest floor or on fungi underneath the soil for nutrients and energy. Mosses, lichens and liverworts all lack roots and must absorb water directly through their leaves; thus, they thrive when they are constantly exposed to moisture. These plants can, however, go dormant in dry periods and quickly revive in favorable conditions. The availability of moisture in the Olympic rain forest supports a great variety and abundance of mosses. One of these, often called stair-step moss (*Hylacomium splendens*), is interesting to observe due to its growth form. These mosses grow a new stair-step each year, thus the age of the mosses can be determined by counting the number of stair-steps.

The presence of a great number of downed logs may be one of the most important characteristics of the Olympic rain forest as well as other old temperate forests. Virtually all tree seedlings in the Olympic rain forest establish on downed logs or decaying snags. These "nurse logs" and "mother snags" provide a constant supply of moisture and nutrients. They also boost the seedlings beyond the reach of browsing animals and up to the light that filters into the understory. Because they hold so much water, downed logs provide refuge for many creatures during forest fires. Downed logs that have fallen across slopes collect a thick layer of loose dirt and organic material on the uphill side, which provides burrowing **substrate** for small animals. The downhill side of logs on a slope also serves as refuge. Many organisms, including insects (especially beetles) and fungi, invade downed logs soon after they fall. While a mature tree is alive, only 10% of its mass is actually living at any one time. The rest is dead wood which provides structural support. When the tree dies, it can attain a greater ratio of living matter to dead mass due to inhabitation by animals, fungi and plant roots. Thus, it is aptly stated that a tree may be more dead when alive and more alive when dead.

Human Use of the Olympic Rain Forest

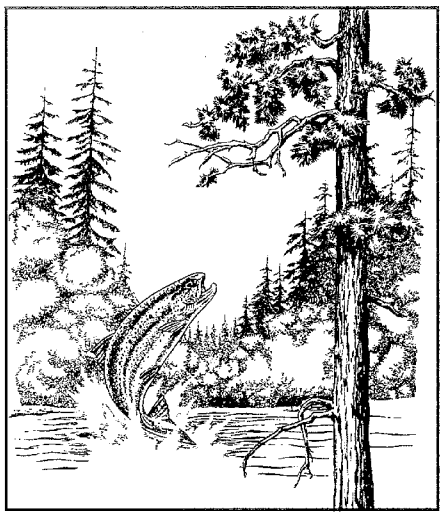
Humans have occupied the coast of northwestern North America for over 12,000 years. People in the Northwest have always relied on resources from the ocean, but have also used the plants and animals of the forest to meet their needs. Western red cedar was not common in coastal forests until about 4,000 years ago, at which time it became a key resource for coastal people. Red cedar was used by Northwest Native Americans for making many items that Native Americans in other parts of North America made from animal products or clay. The fibrous inner bark of red cedar was used to make clothing as well as ropes and baskets. Coastal Native American tribes used red cedar wood, which resists rotting, for many key items in their cultures such as dugout canoes, house planks and posts, totem poles and tools for everyday activities such as hunting and cooking. The availability of red cedar made the construction of impressive longhouses possible. Few red cedars were actually cut down. More often fallen logs were used or planks were split from living trees using wedges.

Salmon, other fish, marine mammals and elk were eaten as a source of protein, but Northwest coastal peoples also had a variety of uses for forest plants. Plants were important as medicinal and food resources. Permanent winter settlements were established along shores and waterways, but seasonal travels were made during spring, summer and fall to collect plants. Some plants produced tender shoots and greens that were harvested in early spring before they became tough. Other plants produced berries, such as red elderberries, blackberries and salmonberries, that ripened successively throughout the summer and fall. For northwest coastal tribes there was no need to cultivate food. The development of rich cultures has been attributed in part to the abundance of readily available food. The ability to obtain food and materials easily left time for art, music and other activities.



nurse log

When Euro-American settlers first began to inhabit the region of the Olympic rain forest, they cleared the land in order to farm. This early farming had limited impact but eventually, with improved technology, cutting trees for timber became more profitable and feasible than farming. With the use of increasingly modern technologies, from two-man crosscut saws and oxen to helicopters and logging trucks, Euro-Americans have had much greater impact on forests in one century than coastal Native Americans had in the thousands of years they inhabited the region.



Eventually, Americans, led by conservationist President Teddy Roosevelt, came to protect the Olympic rain forest from development by designating the lowlands as a national reserve in 1897 and the core of the Olympic mountains as Olympic National Park in 1938. The park has since been designated by the United Nations as a Biosphere Reserve in 1976, and as a World Heritage Site in 1982. Other regions of temperate forest, such as places where urban areas now lie, have been less protected and thus impacted more heavily by humans. Recreational activities such as hunting and hiking, when done responsibly, can benefit wildlife and natural forest areas. Money paid for hunting licenses and national park entrance fees support research, education, wildlife management and conservation throughout the state.

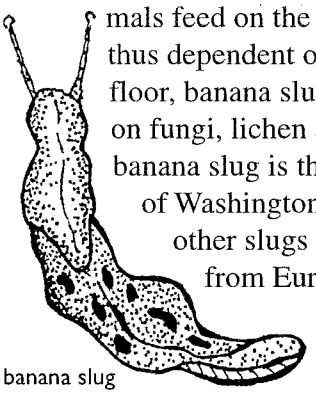
Many native forest plants, in addition to trees used for timber, have current uses in our modern society. The floral industry relies heavily on such decorative plants as bear grass, salal and boughs of conifers. Native forest mushrooms are highly-prized delicacies, both locally and in places as far away as Japan. Many northwest plants contain compounds that are, or may in the future be, important in modern medicines, such as antibiotic substances found in red alder. Through **ethnobotany**, the study of relationships between plants and people, much has been learned about how coastal Native Americans made use of forest plants for a variety of medicines. Many of these medicinal uses have yet to be thoroughly explored with current technologies.

Temperate Forest Wildlife

Temperate forests provide unique habitat for wildlife. The trees themselves hold moisture in the forest and moderate the local climate by providing shelter from temperature extremes, wind and snow. Forest plants and trees in all stages of life — young, mature, dying, standing dead and fallen dead — provide essential resources for all living things of the forest.

Tiny Creatures

From the highest needle in the canopy to the soil underneath the forest floor, tiny living things inhabit all parts of the forest. As previously described, one food web begins in the needles of the forest canopy with tiny invertebrates, such as mites, springtails and amoebae, grazing on the scuzz of the needles. These invertebrates are eaten by larger invertebrates, such as spiders and insects. Birds, bats and other larger animals feed on the insects and spiders and are thus dependent on this food web. On the forest floor, banana slugs spend their time feeding on fungi, lichen and leaves of plants. The banana slug is the most common native slug of Washington's temperate forests. Most other slugs in our region were introduced from Europe. When slugs eat fungi, the spores pass through their digestive systems undamaged but prepared to germinate. This digestive tract journey is necessary to initiate germination of many fungal spores.



banana slug

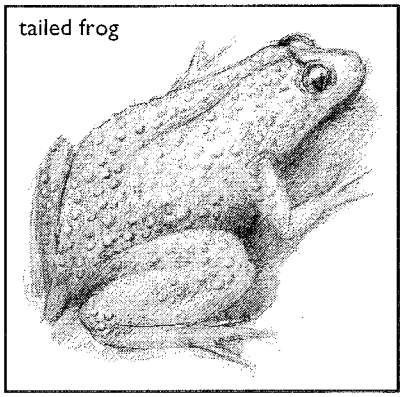
In logs on the forest floor, many insects and other arthropods find homes and food. These include bark beetles and wood-boring insects such as ambrosia beetles. Beetles are key species when it comes to the decomposition of logs because they bore tunnels into the wood, carrying with them bacteria and fungal spores that will continue the decaying process. Ambrosia beetles deposit fungal spores in holes they have bored and feed on the fungus that grows there. Once the beetles have started the process, the logs are further colonized by carpenter ants, termites, millipedes, mites, centipedes and other arthropods. Snags often

house carpenter ants, which in turn "herd" aphids that secrete a sweet liquid called "honeydew," derived from plant juices. The ants lap up the honeydew secreted by the aphids. Thus, in this food web, the aphids glean a necessary resource from plants, carpenter ants get nourishment from aphids, and, as will be described in the paragraph on birds, pileated woodpeckers feed on the carpenter ants. Carpenter ants can be observed in "Bug" World — Adventures with Arthropods at Woodland Park Zoo. Other arthropods that inhabit decaying wood can be found through close observation of logs and stumps in the Habitat Discovery Loop at the zoo.

Amphibians

Amphibians find prime habitat in wet west side forests. Olympic and Cope's giant salamanders are usually associated with flowing water. In fact, Cope's giant salamanders differ from other salamanders in that they usually do not complete metamorphosis to become terrestrial adults. Instead, Cope's salamanders remain as aquatic larvae that are capable of breeding. Larvae of other salamanders, such as ensatinas and western redbacks, become terrestrial adults and are often found in leaf litter or fallen logs on the forest floor. Salamanders eat aquatic invertebrates during their water life stages and terrestrial invertebrates during their land life stages. Salamanders and other amphibians help to control populations of invertebrates, such as insects, in temperate forests.

The tailed frog of the Pacific Northwest is the only species of tailed frog in North America. The only other tailed frogs in the world are found in New Zealand, where there are three species. Tailed frogs are nocturnal and spend most of their time in cool, clear, fast-flowing waters in forested areas, only foraging on land when humidity is very high. More common frogs of Washington's temperate forests include Pacific treefrogs and red-legged frogs. Pacific treefrogs are widespread across the state from sea level to high montane elevations, while red-legged frogs occur primarily west of the Cascades below 2,800 feet (850 m). Despite their common name, Pacific treefrogs spend most of their time moving along the ground or in low shrubs. Most frogs are **herbivorous** as tadpoles but eat small invertebrates as adults. Frogs are often preyed on by snakes and birds.

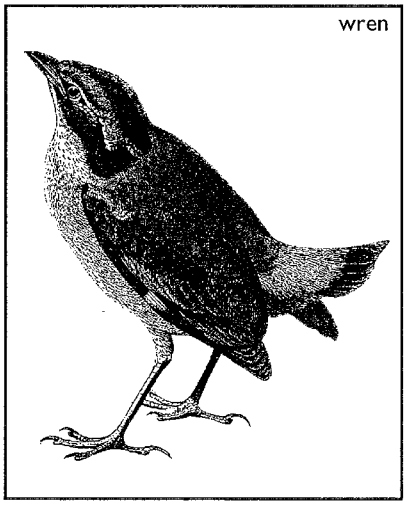

tailed frog

Reptiles

The only lizard inhabiting the Olympic rain forest is the northern alligator lizard. These lizards can be found at the margins of forests and in logged areas under downed trees and rocks. Northern alligator lizards eat all kinds of arthropods and sometimes small vertebrates, but do not eat roughskin newts and most salamanders, due to the toxic skin secretions of these animals. Common and northwestern garter snakes also inhabit the Olympic rain forest. The reptiles mentioned above also live in temperate forests of western Washington outside the Olympic rain forest. In addition, western fence lizards, painted turtles, rubber boas and western terrestrial garter snakes also inhabit western Washington low-elevation forests.

Birds

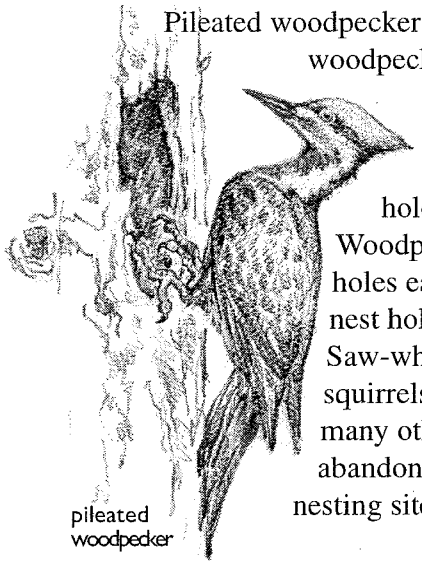
Temperate forests are home to numerous birds. Several bird species, such as those described below, rely on old growth forests, with downed logs on the forest floor and trees in all life stages from seedlings to snags, to fulfill their habitat needs. These birds occur in temperate rain forests and other forests of western Washington.


wren

The winter wren is a secretive, insect-eating forest bird. In order to hide their eggs and young and to confuse possible predators, winter wrens build several nests, but utilize only one. The others serve as decoys. The real nest even has a false, dead-end entrance, bigger and more prominent than the real entrance. Nests are usually built in or near decaying downed logs. An oversized replica of a winter wren nest with eggs can be explored in the Habitat Discovery Loop at Woodland Park Zoo.

Vaux's swifts are extremely fast flyers, up to five times as fast as the quickest similar-sized songbirds. They also have a high metabolism and must eat a steady supply of insects. Large, hollow, dead trees are important for their nesting sites.

Marbled murrelets are seabirds that can be spotted flying low over waves or diving under water in search of **prey**, primarily small fish. But unlike other seabirds, murrelets fly from the sea into the forests to build their nests, usually on broad branches covered with a thick layer of epiphytes high up in old trees. Because of the unusual and inaccessible locations of their nests, information about marbled murrelet nesting habits was unknown until relatively recently. In fact, Bent (1919) considered the nesting of marbled murrelets to be "one of the unsolved mysteries in American ornithology."


pileated woodpecker

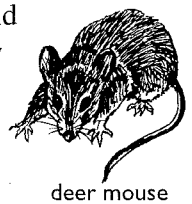
Pileated woodpeckers, Washington's largest woodpecker, eat carpenter ants which they find when they are chipping out rectangular-shaped nest holes in decaying snags. Woodpeckers excavate new nest holes each year, abandoning the nest holes of the previous year. Saw-whet owls, bats, flying squirrels and martens, among many other animals, rely on abandoned woodpecker holes for nesting sites.

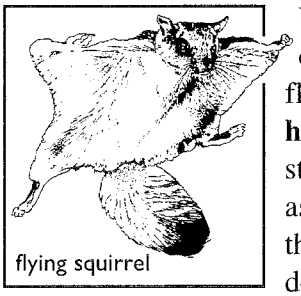
Spotted owls primarily prey on small mammals, especially flying squirrels. Due to their dependence on flying squirrels and the large home range required by a pair of spotted owls (estimated up to 3,000 acres [1,200 hectares]), spotted owls are most successful in old growth stands. Recently, spotted owls have had to compete for habitat with barred owls, which have been expanding their natural range further south and west into Washington's forests. Barred owls, which are better adapted to second growth forests, have displaced many spotted owls from younger forests to older forests, contributing to spotted owls' dependence on old growth forests. A spotted owl can be observed between the Family Farm and "Bug" World — Adventures with Arthropods at Woodland Park Zoo.

Goshawks are raptors that are superbly adapted to forest life with their short wings for powerful flight and long tails for maneuverability among trees. Goshawks prey on a variety of small mammals and birds. They primarily inhabit dense forest, often perching on downed logs when cleaning fur or feathers off prey.

Small Mammals

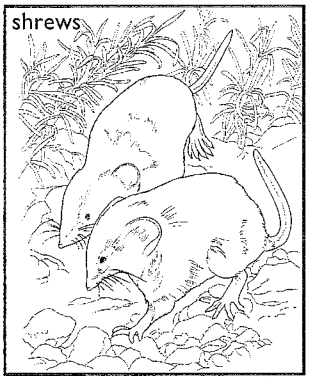
One complex web of interactions that involves small mammals is also important for the giant trees of the forest. This web is based in the soil of the rain forest. Certain species of fungi develop hair-like filaments called **hyphae** that form white mats, called **mycelia**, throughout the soil on the forest floor. The hyphae grow into and around the surfaces of tree roots, forming an association of fungus and root called a **mycorrhiza**. This relationship benefits both the fungi and the trees. The extensive mycelia of the fungi absorb water, nutrients and nitrogen which are conducted into the tree through its roots. In return, the fungi receive carbohydrates made by the trees through photosynthesis. Pacific Northwest trees that are grown without a mycorrhizal association do not fare as well as trees with mycorrhizal help. Some mycorrhizal fungi produce above-ground mushrooms, others produce below-ground truffles. It has been discovered that many small mammals regularly search for and eat truffles. Truffle-eaters include flying squirrels (also the only lichen-eating rodent), red-backed voles, deer mice, chickaree squirrels, chipmunks and hares. The spores of the truffles survive their passage through small mammal digestive systems and are dispersed when the animals move throughout the forest. The dispersed spores will grow their own mycelia and create new mycorrhizal relationships with the trees. Thus, small mammals are vital to the overall health of a forest.


deer mouse

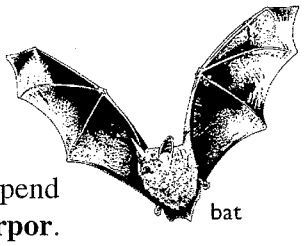

flying squirrel

Unlike some squirrels and chipmunks, chickaree squirrels, flying squirrels, and voles do not **hibernate**. Chickaree squirrels store large amounts of food, such as conifer seeds and truffles, for the winter. Flying squirrels depend on truffles in the summer but obtain most of their nourishment from lichens in the winter. Flying squirrels cannot actually fly. They have a well-developed gliding ability aided by flaps of skin

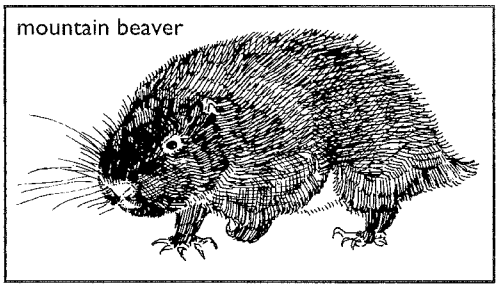
that stretch between their fore and hind legs on each side of the body. Gapper's red-backed voles, which also feed heavily on truffles, are highly dependent on dense forest, preferring little ground vegetation and a lot of rotting logs.



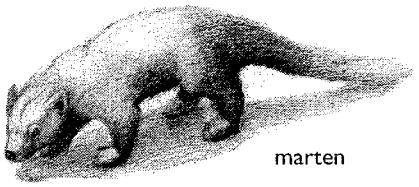
Shrews have extremely high energy needs and search nonstop for food. Shrews are active, in cycles of greater and lesser degrees of activity, 24 hours a day and do not hibernate in the winter. Terrestrial species of shrews burrow in the leaf litter of the forest floor looking for insects, while water shrews often prey on amphibians and other aquatic animals. Water shrews even eat salamanders, which most other animals find unpalatable. Water shrews have short, stiff hairs on the margins of their feet that trap air bubbles. These hairs not only help them to swim but enable them to actually run on the surface of water for several seconds. Shrew-moles, though resembling shrews, are actually the world's smallest mole. Like water shrews, shrew-moles are excellent swimmers.


bat

Due to their appetite for insects, bats of temperate forests are essentially the shrews of the air! Unlike shrews, however, bats are generally active only at night and spend their days in a deep sleep called **torpor**. Temperate forest bats hunt insects using their sense of hearing. Bats emit high-pitched sounds that reflect off surrounding objects giving them a "sound map" of their environment. This technique is called echolocation. Bats may catch insects directly with their mouths or scoop them up into a space inside their bent wings and pick them out with their mouths while momentarily free-falling. Some bats, including little brown bats and long-eared bats common in temperate forests of Washington, use membranes on either side of the tail to scoop up insects so that they can eat on the fly. Silver-haired bats are migratory bats that occur in Washington's forests in spring and fall. Silver-haired bats typically roost during the daytime in the spaces created when loose bark separates from the trunks of trees.



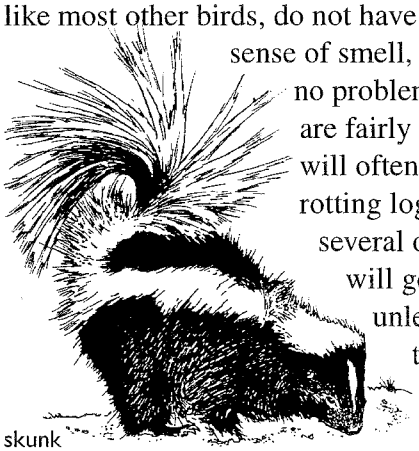
Mountain beavers, the oldest known living rodents, are often referred to as "living fossils." Inappropriately named, mountain beavers are not actually beavers and they most commonly inhabit lowlands, not mountains. Other names for mountain beavers include sewellels and boomers. Mountain beavers are found mainly in western Washington but also inhabit the Okanogan Highlands. Mountain beavers are burrowing, voracious herbivores and prefer damp openings, such as ravines and deciduous tree groves, within coniferous lowland forests. Here, they harvest plants, mainly ferns and small flowering plants, to store over the winter. Plants to be stored are often laid out in neatly arranged piles next to burrows and on top of or under logs, with the cut ends of the stems aligned together, resembling a bouquet of flowers and greens lying on the forest floor. The plants are left to wilt slightly before being carried into feeding chambers of their burrows. These orderly piles are sometimes encountered in the forest and mistaken for the work of humans! Mountain beavers host the largest flea in North America (*Hystrichopsylla schefferi*) within their fur.


marten

Martens, members of the weasel family, are small but vicious predators. In the Olympics, martens frequent cedar swamps near the coast. Martens are very **arboreal** and can hunt as adeptly in tree branches as on the ground, eating small mammals, insects and birds. Martens can easily run down squirrels and red tree voles in the forest canopy. It has been proposed that the gliding ability of flying squirrels is an adaptation for escaping from arboreal predators such as martens. Martens also eat berries when they are available, and during winter they hunt on the ground for voles and hares. Cavities high up in trees are important to martens as nesting sites, though they may also find winter refuge in downed logs on the forest floor. Martens are quite solitary except during their breeding season in the summer months.

Fishers are close relatives of martens but are larger and heavier with darker fur. In all of Washington state, fishers are probably most numerous in the Olympics. Though fishers are not as arboreal as martens, they are good climbers and swimmers. Despite their name, fishers rarely fish. In most of their range, fishers prey primarily on porcupines. The fisher will run in circles around a porcupine, biting at its face for up to half an hour until the porcupine is worn down. In the Olympics, however, while fishers are native, porcupines are not. There, fishers eat hares, other small mammals, birds from nuthatches to owls, and carrion of deer and elk. Fishers often make dens in brush piles, under logs, and under the roots of blown-down trees. Due to their vulnerability to predators, such as raptors and bobcats, fishers and martens are wary of crossing open areas. Thus, they are restricted to dense forests and are easily isolated when clearings are created by logging. Fishers can be observed in the Northern Trail at Woodland Park Zoo. They reside next to their favorite prey, porcupines. Because they are well-fed, the fishers at the zoo probably do not feel the urge to go hunt the porcupines, and the porcupines can most likely sense this.

Spotted and striped skunks are also members of the weasel family that inhabit temperate forests. Skunks prefer damp lowland **riparian** areas with deciduous trees. They also frequent cleared areas. In the winter and spring, skunks prey mainly on small mammals, such as cottontail rabbits and mice, while in summer and fall they primarily eat insects (especially beetles), berries and other parts of plants in addition to mammals. Skunks will also eat carrion when available. Skunks may be preyed on by great horned owls. It has been noted that great horned owls sometimes have a slightly skunky smell about them! Great horned owls, like most other birds, do not have a well-developed sense of smell, so eating skunks is no problem for them. Skunks are fairly sociable animals and will often share their dens in rotting logs or stumps with several other skunks. Skunks will generally not spray unless persistently threatened.


skunk

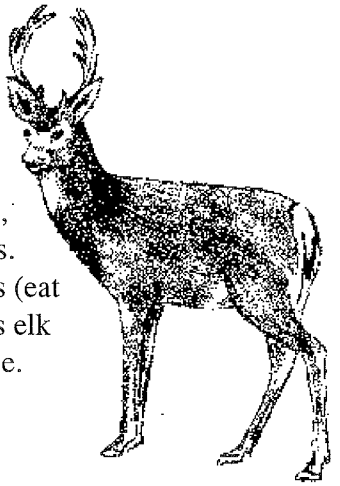
Large Mammals

Many large mammals inhabiting temperate forests, due to the extent of their ranges, rely on dense forest, open areas and second growth forests.

The mammal with perhaps the greatest impact on the Olympic rain forest landscape is the Roosevelt elk. Through **grazing**, **browsing** and trampling, elk often influence the composition of understory and forest floor vegetation. For example, the growth of ferns and shrubs is limited by elk, thus creating a more open understory and encouraging the vigorous growth of herbaceous plants on the forest floor which in turn provide good grazing for the elk. As referred to earlier, seedlings growing on large logs or snags have a better chance of surviving because they are out of reach of the elk. This is especially important for hemlock seedlings which elk find tastier and less prickly than spruce seedlings. Elk live in **matriarchal** societies. Adult males only associate with the herds of females during breeding season. Herds depend on an older, lead female to find the best forage and lead the herd over rough terrain and across rivers. Elk can often be seen in the lowland forests of the Olympic Peninsula. In spring some Roosevelt elk graze in meadows and clearings at low elevations, while other herds move to higher elevations. A small herd of Roosevelt elk inhabits the Northern Trail at Woodland Park Zoo. (See "Montane Wildlife" for more information on elk.)


mule deer

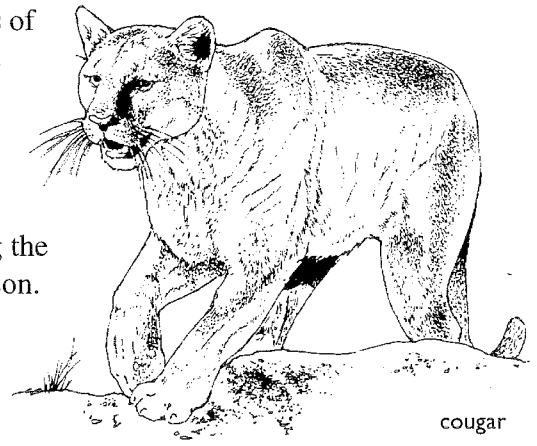
Black-tailed deer, due to their smaller size, have far less impact on forest vegetation than do elk, but are an important food source for several predators, such as cougars and coyotes. Deer are primarily browsers (eat woody vegetation), whereas elk graze more than they browse.


deer

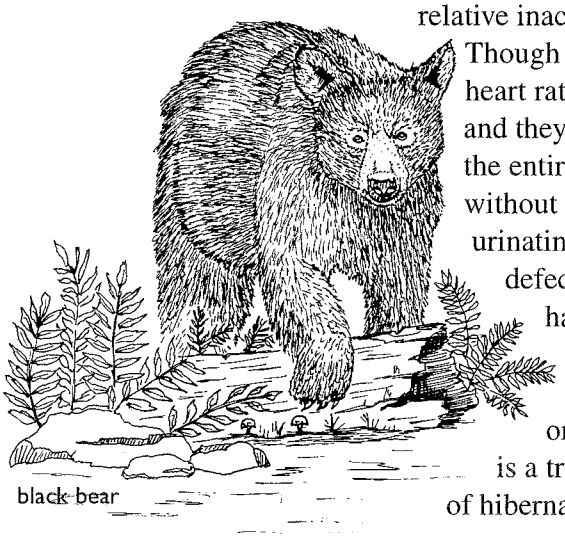
Coyotes, **omnivorous** members of the dog family, have become more widely distributed throughout their habitat since the **extirpation** (elimination from a certain area) of wolves from Washington state by the early 1900s. The diet of coyotes includes mammals as large as young deer, carrion and seasonal fruits, such as blackberries and salal berries. Coyotes will hunt in forest thickets and forested riparian areas but they prefer running down their prey in open areas. For this reason, coyotes have actually benefited from the increase of open areas due to logging. Coyotes in western Washington generally hunt at night. When they are not hunting, coyotes may find shelter among fallen logs and other logging debris in clear-cut or in underground dens. (See "Urban Wildlife" for more information on coyotes.)

Bobcats are one of the few strictly **carnivorous** animals found in the Olympic rain forest. Bobcats also range across Washington state and utilize a variety of habitats at various elevations. A small-sized cat with thick, light gray fur, the bobcat may have been named for its extremely short tail. Mainly active at night, bobcats hunt their prey by ambush, the "sit-and-wait" technique. Bobcats prey on hares, birds and rodents such as mountain beavers and mice. In winter, bobcats will eat carrion of deer and elk, though they may occasionally hunt and kill young deer and elk. In the forest, marks of bobcats can be seen on trees where they sharpen their claws about two to five feet (60 to 150 cm) up the trunks. Bobcats often travel in brushy areas, but they are fairly adaptable, utilizing logged land and second growth. During the day, when they are not hunting, bobcats rest out in open areas or in brush, but in bad weather they may use dens in hollow trees, stumps or logs for shelter.

Cougars, also known as mountain lions, pumas or catamounts, are also carnivores of the Olympic rain forest and other forest regions of Washington. By stalking and then pouncing, cougars prey mainly on deer and elk. Cougars occasionally eat other animals from insects to hares to coyotes and will also **scavenge**. Marks of cougars sharpening their claws can be seen five to eight feet (150 to 240 cm) up on tree trunks. Cougars inhabit regions that are more forested than those inhabited by bobcats. Cougars are very solitary animals. They will tolerate overlapping **home ranges** of other cougars but will actively avoid contact with one another, except during the breeding season. The winter home range of a male cougar is a minimum of 16 square miles (40 km^2). Their home ranges in summer are larger and, in general, females' home ranges are smaller than those of males. Cougars are beneficial to forest ecosystems because they cause redistribution of elk and deer, preventing damaging overgrazing, overbrowsing, and trampling of any particular region. Cougars can be observed in the Trail of Adaptations at Woodland Park Zoo.


cougar

Black bears are the largest predator found in low-elevation forests of Washington, but they have an extremely varied omnivorous diet. Bears eat lots of plants in spring, berries found in forest edges to fatten up in fall, and insects, fish and small mammals whenever they can be found. Bears often rip open rotting logs to find beetles and other insects, thus aiding in the decomposition process. Though they are mostly ground-dwelling, black bears are good climbers. They climb trees to find bee hives and to take refuge when in danger. Bears' markings on trees differ from cats' in that larger sections of bark are removed as they scrape at the trunk. Using dens in hollow trees, rotting logs or underground, black bears spend the winter in a state of relative inactivity. Though their heart rate slows and they often go the entire winter without eating, urinating or defecating, it has been debated whether or not this is a true state of hibernation.


black bear

Their body heat lowers to only 88° F (31° C) as compared to 40° F (4.5° C) for hibernating squirrels. Bears generally remain in their dens without any activity until spring, but they may stir and leave the den for short periods of time. Female bears give birth to their cubs in the middle of winter while sleeping in their dens.

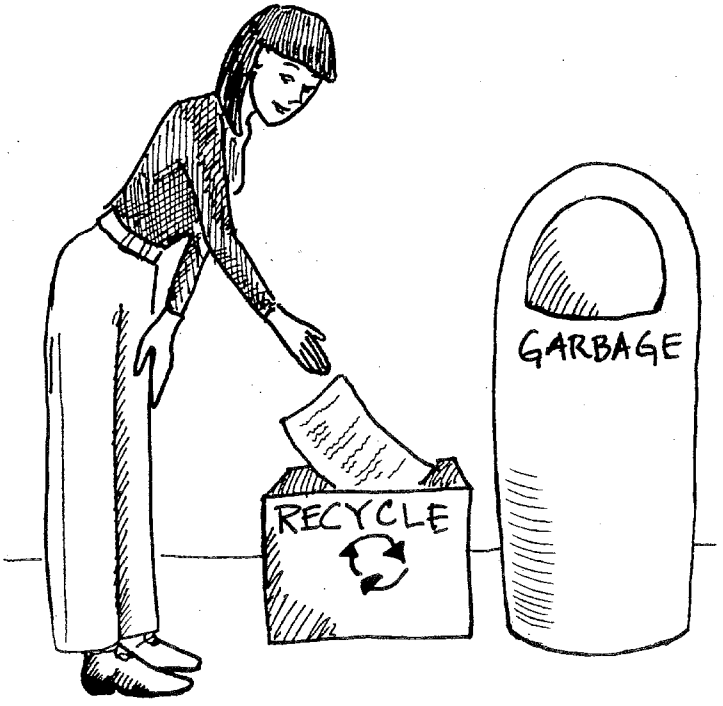
Temperate Forest Conservation Projects

Temperate forests have been the focus of many of research projects over the years. In 1995, the only temperate forest canopy crane was established in Washington state, giving researchers new insights into this hard-to-reach forest level. Other canopy research cranes are located in tropical forests. Washington's crane is located in stands of old growth at the Wind River Experimental Forest, between Mt. St. Helens and the Columbia River. The crane, which is 285 feet (86 m) tall and is similar to those used for city construction, is owned by the University of Washington and jointly managed by the university and the U.S. Forest Service. The crane is used by a myriad of researchers exploring such topics as the use of different forest levels by bats, life cycles of insects that breed in the canopy, the important role of needle "scuzz" in the food chain, the role of lichens in fixing nitrogen and improving air quality, canopy photosynthetic rates under varying environmental conditions, and weekly counts of songbirds inhabiting this layer of the forest. These studies have turned up large amounts of new information, adding to our knowledge of the complexity of old growth forests and aiding in designing new forest management and conservation practices.

Temperate forests are easily explored in areas across the state, including parks and recreation sites not far from urban areas. Old growth forests are the best places to enjoy the diversity of temperate forest plants and animals. Areas of old growth forests are found in the Olympic, Mt. Baker-Snoqualmie and Wenatchee National Forests as well as lowlands of Olympic and Mt. Rainier National Parks. Small stands of old growth forest have also been preserved in many urban parks around Puget Sound.

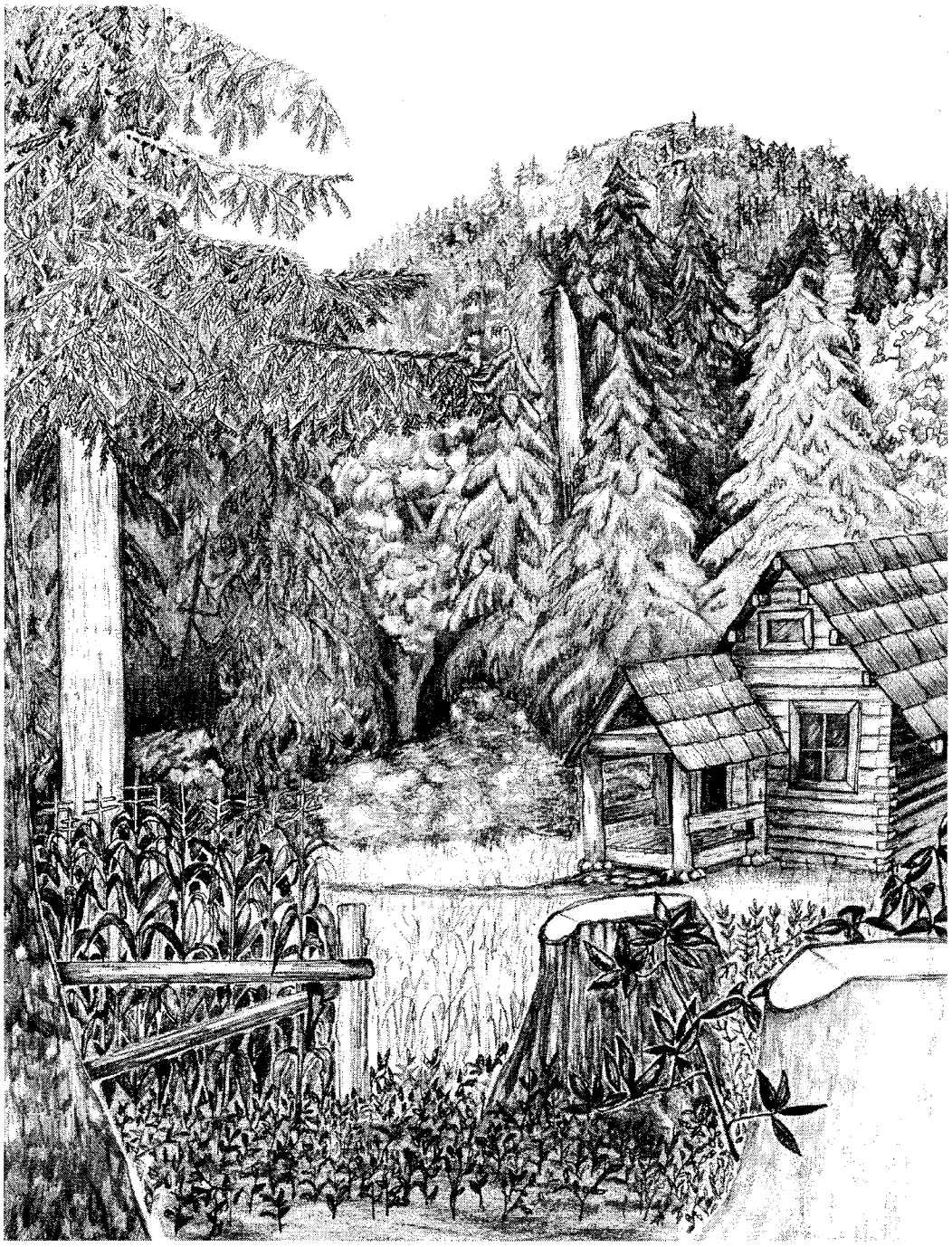
Caring About Temperate Forests

Some species of animals benefit from the presence of logged-over clearings or second growth, but most temperate forest animals depend to some extent on well-developed forests with trees at a variety of growth stages. Remaining old growth forests exist only in strips and patches across Washington state. Logging and road building break up forest habitats and create abrupt forest edges, reducing the overall quality of habitat available for wildlife. Some animals utilize forest edges and even logging roads as parts of their habitat. The exposed edges, however, have negative effects on the health of the remaining forest. Trees at edges are more prone to wind damage and the increased exposure reduces a forest's ability to provide shelter and moderate the interior climate. Many species of animals will not cross open areas, such as roads or logged land, and are thus restricted to small patches of remaining forest. These patches may not adequately provide for an animal's habitat needs or may isolate a population, limiting genetic diversity. This said, we all rely on forest products everyday. Forests shape our lifestyles and the economy of the Pacific Northwest. We can, however, be continually aware of the natural resources we are using and make efforts to use them more wisely. Remember the three R's: reduce, reuse and recycle.



When visiting the forest to take in the natural wonders, it is important to remember to tread lightly, respecting the plants, animals and other organisms that call the forest their home. Refrain from collecting or disturbing plants, animals, and nonliving things of the forest and take out everything that you brought with you to the forest. In addition, remember that we share our habitat with predators and we must use caution when traveling in areas inhabited by them. Research the area you plan to travel in and take appropriate precautions.

When learning about temperate forests, keep in mind that there is always more to this exciting story. Many previously-held beliefs about forest inhabitants have been disproved by careful observation and research. And as the story continues to unfold, new information and new species of plants and animals are discovered in Washington's habitats every year. There is much more to be learned!



WETLANDS HABITATS

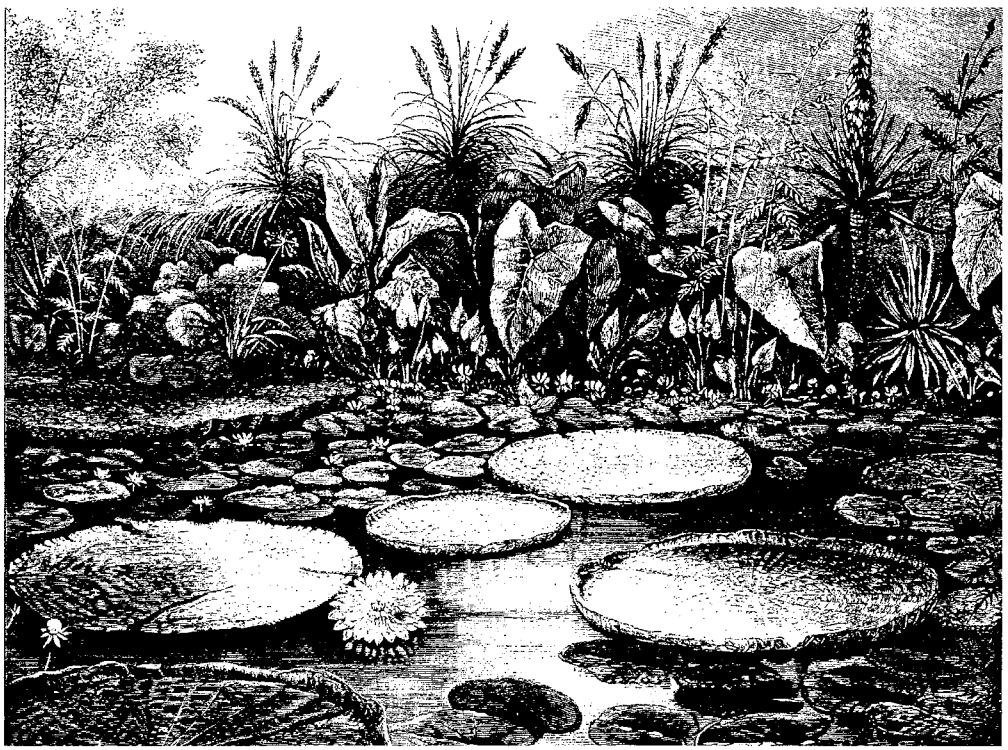
Wetlands are a dynamic part of Washington state's natural environment. They perform a variety of important functions and provide **habitat** for a great diversity of plants and animals.

Wetlands are generally identified by three defining characteristics that are closely associated with each other. The first, and most significant, of these characteristics is the presence of a high **water table**. This means that water is continually present either at or near the surface of the land. Because wetlands soils are constantly saturated, they contain very little oxygen. These soils are called **hydric soils** and are the second defining feature of wetlands. Plants take in carbon dioxide and give off oxygen through their leaves. But through their roots, the exchange of gases is opposite: plants take in oxygen and give off carbon dioxide through their roots. Due to the conditions posed by a high water table and hydric soils, namely the low levels of oxygen in the soils, wetlands support unique communities of specially adapted plants. The presence of these types of plants, called **hydrophytes**, is the third defining characteristic of wetlands.

Formation of Wetlands

One might expect Washington state to have an abundance of expansive wetlands areas, especially considering the moist climate in the western part of the state. However, the terrain west of the Cascade mountains, where yearly **precipitation** is high, is not conducive to the formation of large wetlands. Due to many steep slopes, water in western Washington is generally moving and not collecting or standing. East of the Cascades, the topography of Washington is generally flat and more likely to collect water. However, the amount of annual precipitation in the eastern region is very low. Wetlands are numerous in Washington, but they are small in comparison to wetlands in other areas of the world. Washington does have a rich variety of wetlands types.

Washington's wetlands are mainly found in glacial valleys and lake basins, along river **floodplains**, and at mouths of rivers. During the last ice age, about 15,000 years ago, a large ice sheet extended down into the Puget Sound region. As it slowly moved, the ice sheet scoured out basins and valleys, in both lowlands and mountains, where large and small lakes formed after the ice retreated. In eastern Washington the Columbia Basin was scoured by enormous floods that created depressions in which lakes formed (see "Formation of the Columbia Basin" in the Steppe section). As organic material and **sediments** accumulated in lakes, **freshwater marshes** formed along the lakes' edges. **Swamps** developed where shrubs and trees grew in shallow lakes. **Bogs** formed as organic material gradually built up over thousands of years, filling in smaller lakes west of the Cascades. **Riparian woodlands** grew on river floodplains where sediments were deposited during periods of flooding. **Salt marshes** developed where rivers reached the end of their journeys and flowed slowly into salt waters.



Wetland Types

FRESHWATER MARSH

- water above soil surface with seasonal fluctuations of water level
- vegetation consists of herbaceous plants (grasses, sedges, cattails)

SWAMP

- water at or above soil surface with seasonal fluctuations of water level
- trees usually dominant vegetation, shrubs present

BOG

- water above soil surface, water level unchanging with no inflow or outflow of water
- thick layers of peat mosses in the water, with shrubs and trees present

RIPARIAN WOODLAND

- subject to periodic flooding, soils temporarily saturated deciduous trees and shrubs along river margins

SALT MARSH

- mixture of fresh and salt water subject to tidal fluctuations
- vegetation is largely herbaceous

Functions of Wetlands

Wetlands perform several important ecological functions in our environment. When storms suddenly increase the amount of water moving across the surface of the land as runoff, wetlands, particularly those associated with rivers, decrease the rate of this runoff. Like a sponge, river floodplains can quickly absorb and slowly release large volumes of water. This slowing down of storm water helps to prevent floods. Just east of Seattle, wetlands associated with the Snoqualmie River have been drained, filled and paved over as suburban areas expand. The effects of losing these wetlands have been demonstrated by floods of greater force and regularity in recent years. Just north of Seattle, a successful effort was made to restore and preserve Ronald Bog. One of the important reasons for the restoration of Ronald Bog was to provide a natural storage area for seasonal storm water runoff.

Coastal salt marshes have the ability to absorb the energy of ocean storms. Salt marsh plants have adapted to withstand constant tidal forces and are not easily swept away. The stability of the plants prevents the brunt of the storm from damaging inland ecosystems or developed areas. This is especially important for Washington state with its extensive coastline.

Freshwater marshes play an important role in **aquifer** recharge. Aquifers are layers of underground rock that store large amounts of water. We rely on aquifers as sources of fresh water. They are "recharged" when water trickles down through soil layers and is stored in the layers of rock. Small wetlands help to recharge the aquifers which underlie much of Washington state. The largest aquifer in Washington state lies underneath the entire Columbia Basin.

Wetlands also improve water quality by acting as huge filters. When water flowing into wetlands areas slows down due to the flat land and thick vegetation, sediments, which may contain pollutants, settle out of the water. The settling process removes the sediments and pollutants from the water and leaves clearer, cleaner water for plants and animals living in the wetlands. These sediments along with **detritus**, decaying matter from dead plants and animals, remain at the bottom of wetlands. A variety of **decomposers** and decomposing processes are active in wetlands sediments. These decomposing organisms and processes act to recycle

nutrients from sediments back into forms usable by living plants and animals. Other processes promote nitrogen fixing, chemical precipitation, and other reactions that remove pollutants from water. Nitrogen fixing is important because it converts atmospheric nitrogen into a usable form of nitrogen that is required for plant growth.

The exact fate of pollutants removed from water by wetlands is under debate. They may be trapped in sediments or broken down into less toxic forms and absorbed into plants through their roots. If sediments are disturbed or plants die, however, it is possible that these pollutants may re-enter the ecosystem.

Wetlands are extremely valuable as habitat for a great diversity of plant and animal life. Because wetlands are unique transition zones, or **ecotones**, where aquatic and terrestrial habitats meet and overlap, wetlands provide important resources for many organisms. A great number of animal species depend on wetlands as breeding grounds as well as rest stops during migration. In fact, over one third of all the plants and animals listed as threatened or endangered in the United States live in, or depend in some way, on wetlands! People also spend a great deal of recreation time in wetlands hunting, fishing or simply taking in the beauty and diversity of wetlands ecosystems.

Types of Wetlands in Washington

There are several types of wetlands found throughout Washington state. Different types of wetlands are distinguished by the soils, frequency of flooding, and the communities of plants and animals they support. The following kinds of wetlands significantly impact our region's natural environment. Plant and animal species that inhabit these wetlands types can be observed in different exhibits at Woodland Park Zoo.

Freshwater Marshes

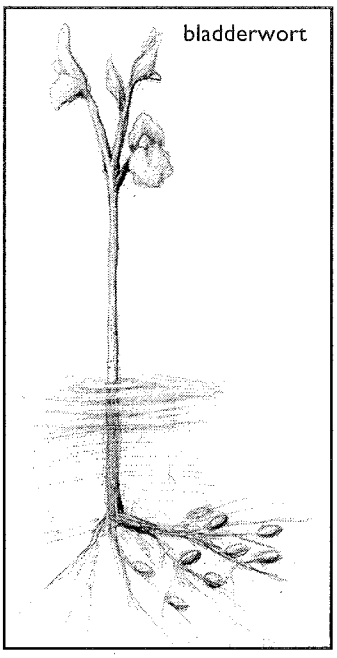
Freshwater marshes are often found at edges of larger bodies of water, such as rivers and lakes. They have a water table above the soil surface, but seasonal fluctuations of the water level can occur. Movement of water in a freshwater marsh is slow in contrast to the fast-moving water in the streams or rivers feeding into the marsh. Freshwater marsh vegetation consists mainly of **herbaceous** plants (plants with soft tissues, unlike woody trees and shrubs).

Freshwater marshes are often dominated by cattails or bulrushes. These are **emergent** plants, rooted in soils underwater with stems growing up above the water surface. Many emergent plants have long empty spaces in their stems. These spaces make it possible for oxygen to travel from the leaves all the way down to the roots. Cattails, growing 5 to 6 feet (1.5 to 1.8 m) tall, will often form exclusive colonies, as will bulrushes. Cattails can be distinguished from bulrushes by the cattails' familiar brown flower spikes resembling hot dogs on sticks. Bulrushes, often called "tule," can grow from 3 to 10 feet (1 to 3 m) tall and resemble cattails but lack the brown flower spikes. Tule stems were used by Native Americans of the region to make mats and baskets. The mats were used as walls and roofs of temporary shelters or floor mats for permanent residences.


cattails

Other emergent plants in freshwater marshes include sedges, rushes, grasses and broadleaf plants. Of the grasses, reed canary grass is most prominent because it grows vigorously in areas disturbed by human habitation or agriculture. It is unclear whether reed canary grass was **introduced** throughout Washington state or was **native** to parts of the coast and spread due to human activity. Wapato, also called "arrowhead," is an emergent, broadleaf marsh plant with large, arrow-shaped leaves. The starchy tubers of wapato were an important food source to local Native American tribes.

In addition to emergents, deeper marshes, with water 2 to 3 feet (60 to 90 cm) deep, are inhabited by floating and **submergent** plants. Many floating plants, such as pond lilies, are actually rooted in the soil under the water, while others, such as duckweed, are not. Pond lilies have **stomata**, pores through which oxygen and carbon dioxide are exchanged, on the upper surfaces of their leaves, which is the only side of their leaves exposed to air. This is unique because most plants have stomata only on the lower surfaces of their leaves.



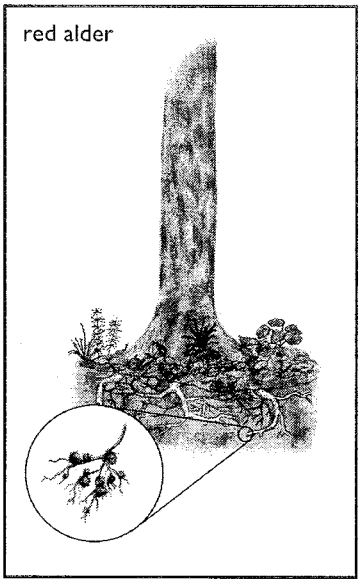
Plants growing entirely underwater are called submergents. Submergents, including water-milfoils and bladderworts, have weak stems because they are supported by water. They also have slender, flexible, feather-like leaves that move with water currents and provide a larger surface area to carry out photosynthesis and gas exchange underwater. You can often feel water milfoil tickling your feet when swimming in shallow areas of Washington's lakes. The most common species of water milfoil in Washington is an introduced species. Bladderworts are **carnivorous** submergent plants with thread-like leaves bearing tiny bladders at the tips. The bladders have valve-like lids with bristles. If a crustacean or other small aquatic animal touches the bristles, the valves open and the animal is sucked into the bladder where it decays and is absorbed by the plant.

A freshwater marsh can be explored in the north end of Washington Park Arboretum near the University of Washington in Seattle. The Foster Point and Waterfront trails lead through stands of native (and nonnative) freshwater marsh vegetation. In eastern Washington, near Cheney, a large area of freshwater wetlands can be visited at Turnbull National Wildlife Refuge. Freshwater marsh plants can also be observed in the Marsh at Woodland Park Zoo.

Swamps

In Washington, swamps are found in lowlands of the Puget Sound region and the coast. The ground is saturated most of the year, often by overflow from nearby streams or rivers. Swamps are forested wetlands usually dominated by trees, but they may be dominated by shrubs.

Coniferous trees are abundant in swamps of the northwest. Western red cedar is the most common of these. Northwest coastal Native American tribes depended heavily on red cedar bark and wood for shelter, clothing, tools and transportation (dugout canoes). The availability of water in swamps also encourages the growth of various **deciduous** trees, including red alder, black cottonwood, Oregon ash and bigleaf maple. Red alder is the most common, and often dominant, deciduous tree. Red alder enhances the growth of other plants in the area because it has bacteria-filled root nodules that help transform atmospheric nitrogen into a form utilized by plants. Willows and skunk cabbage are strong indicators of swamps.



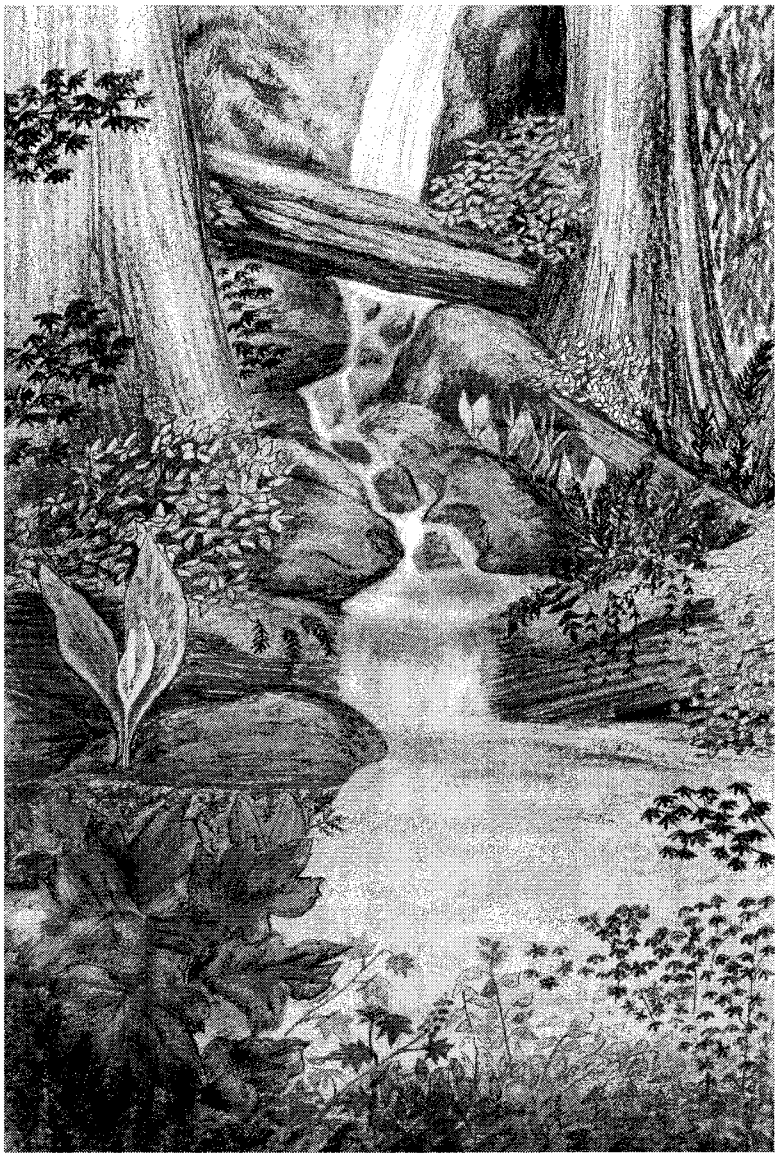
The Cape Alava and Sand Point Trails between Lake Ozette and the coast pass through forested swamps in the northwestern coastal part of Olympic National Park. Sitka spruce and red cedar trees reach up overhead, while skunk cabbage and sedges on the forest floor indicate the presence of water. A forested swamp similar to those of the eastern United States can be explored in the Swamp at Woodland Park Zoo.

Bogs

In bogs, the water table is usually above the soil surface and the level of the water does not change. Bogs, unlike other wetlands covered here, do not have inflow and outflow of water. Rather, all of the moisture comes from precipitation. Bogs are characterized by abundant **peat mosses** and shrubs, though trees are often present.

Peat mosses tend to grow in cool, stagnant water, forming thick mats. These mosses gradually use most of the available nutrients, including nitrogen. Peat mosses and stagnant water together create a highly acidic and oxygen-poor environment. The lack of oxygen inhibits decomposition and the thick layer of dead mosses and plants that collect in a bog remains relatively undecomposed. This layer of material is called **peat.** Though the water table is above the soil surface, peat and peat mosses in the water may be so thick you can walk on them. Most plants cannot grow where there is little oxygen and nitrogen and high acidity, but plants that grow in bogs have adapted to tolerate these conditions.

Sweet gale, a bog shrub, has a special adaptation for living in a nitrogen-poor environment. Sweet gale, like red alder, has root nodules that help to supply the local environment with usable nitrogen. Bogs have a few interesting herbaceous plant species, notably carnivorous plants. Due to the lack of available nitrogen, carnivorous plants, such as sundews, supplement their nitrogen intake by digesting insects. Insects are attracted to sundews by a sticky secretion on hairs of the leaves. When an insect gets stuck to the hairs, the leaf rolls up around the insect which is then digested by special enzymes. Buckbean, a smelly bog plant with white flowers, attracts a variety of flies and beetles, which help pollinate its flowers. Bog cranberry is a shrub that can be found growing in natural bogs of western Washington. Bog cranberries were eaten by coastal Native Americans, but commercial cranberries, though they are locally cultivated, are not native to the state.



The Cape Alava trail mentioned previously also travels through an old, rather dry bog. The bog, two miles from the trail head, lies in Ahlstrom's prairie, part of which is an ancient lake bed. In this bog, sphagnum moss grows along with Labrador tea, swamp gentian, sedges, rushes and a few sundews.

Riparian Woodlands

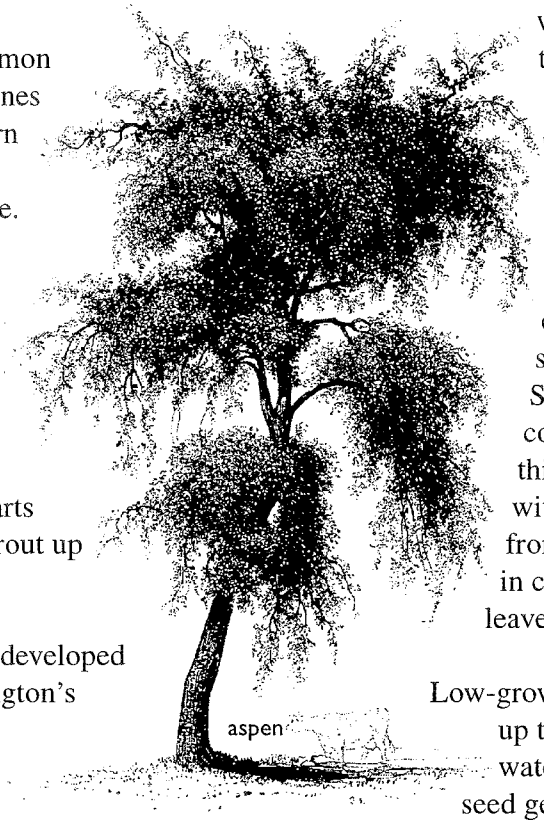
Deciduous trees and shrubs growing along wet riverbanks make up riparian woodlands. These woodlands may be periodically flooded by the seasonal rising of rivers.

Black cottonwood trees grow to great heights along rivers. These trees provide shade, keeping the water at an ideal temperature for fish, insects and amphibians that live in and around the water. This is important because when water becomes too warm it cannot hold as much oxygen, thus limiting the amount of oxygen available to animals in the water. Black cottonwoods also hold great volumes of water in their trunks and increase the humidity of an area by releasing large amounts of water vapor through their leaves.

Trees that are no longer standing are also important in riparian areas. When trees fall across streams, the logs can trap organic debris, which adds nutrients to the stream. Pools created by

logs serve as rest and refuge spots for fish, amphibians and aquatic invertebrates. Fallen logs can also cut the flow rate of the water, allowing coarse sediments, called gravels, to settle out. These gravels collect in stream beds just downstream from the logs, creating ideal places for fish to lay their eggs.

Black hawthorn shrubs are common along rivers, streams and in ravines of eastern Washington. Hawthorn and quaking aspen trees often grow together in a periodic cycle. When aspens dominate and shade the understory, hawthorn growth is reduced. Aspens, however, tend to develop heart rot and die after growing for approximately 50 years. When the aspens die back, hawthorns become dominant. The cycle starts anew when aspens gradually sprout up and take over again.



Riparian woodlands occur in undeveloped lowlands along many of Washington's rivers. A riparian woodland can be explored along the Little Spokane River, a tributary of the Spokane River just north of Spokane. Here, freshwater marsh vegetation merges with riparian woodlands typical of eastern Washington. Sections of the Dosewallips River, which empties into Hood Canal, in the eastern-central part of Olympic National Park, host riparian woodlands typical of western Washington. The Nature Center at Snake Lake in Tacoma, is an excellent example of how a riparian woodland and freshwater marsh have been preserved in an urban area.

Salt Marshes

In Washington state, salt marshes occur along Puget Sound and the coast. Salt marshes are associated with **estuaries**, where fresh water from rivers or streams dilutes salt water as a result of tidal action. Salt marshes form on gently sloped land where river mouths are protected from strong waves by bars of sand, gravel or rock.

Salt marshes, like freshwater marshes, form as **silts** (loose sedimentary material with small rock particles), detritus, pollutants and any other particles settle out as flowing water slows upon reaching the river's mouth. In fact, the word "silt" originates from an old Scandinavian word meaning "salt marsh." Salt marsh vegetation, which is predominantly herbaceous, thrives on these silts.

Salt marshes are inhabited by many **halophytes**, plants that are adapted to live in areas of high salt concentration. One danger for plants living in a zone of high **salinity** is the possibility of water loss by **osmosis**. Many salt marsh plants, like some steppe plants (see "Adaptations of Steppe Plants" in the Steppe section), concentrate salt in their roots to prevent this water loss. Other ways halophytes cope with high salinity include excreting salt from glands on their leaves and storing salt in certain parts of their tissues, such as leaves, which may later be shed.

Low-growing, **perennial** herbaceous plants make up the majority of salt marsh vegetation. Salt water and tidal action are not conducive to seed germination or establishment of seedlings, making **annual** plants, which produce seeds then die, scarce in salt marshes. The species of plants present depends on the degree of salinity in the marsh. Marshes with higher salt concentrations are often dominated by slough sedge and soft-stemmed bulrush. **Brackish** salt marshes have lower salinity and are often dominated by sea arrow grass or American bulrush, glasswort and fleshy jaumea. Salt marsh dodder is a native, parasitic salt marsh plant that wraps itself around the stems of other salt marsh plants, especially those of the goosefoot and sunflower families. Dodder seedlings develop suckers which penetrate the tissue of the host plant and then take up nutrients from the plant.

Salt marshes are highly productive ecosystems. High productivity in salt marshes is due to a combination of factors:

- the great amount of nutrients deposited both by runoff from the land and by tidal upwellings
- the maximum amounts of solar radiation captured due to the openness of the area

- high oxygen levels in the water, necessary for plant growth, are maintained by incoming tides
- the abundance of water that aids plant growth

In most regions, salt marshes are more productive than forests. In the Pacific Northwest, however, our coastal forests produce more plant material than do our salt marshes. This is probably due to the frequent cloudiness near the coast, which reduces the amount of solar energy reaching salt marshes, but at the same time provides the forests with necessary moisture for growth.

The Nisqually Wildlife Refuge, between Tacoma and Olympia, is a good place to experience a salt marsh environment. Here, the Nisqually River meets Puget Sound and a variety of salt marsh plants, mammals, birds and other inhabitants can be seen. Theler Wetlands, near Belfair, host a salt marsh where the Union River flows into Hood Canal. Sedges and other salt-tolerant plants grow in abundance here, and salt marsh invertebrates and birds can be observed. A coastal salt marsh can be explored at Grays Harbor National Wildlife Refuge, where the Chehalis River meets the Pacific Ocean.

Human Uses of Wetlands

Native American peoples of Washington relied on wetlands for a variety of items. Giant horsetail, black cottonwood, red alder, bog cranberry and wapato were important food sources. Other plants, such as western red cedar, cattail, tule and skunk cabbage, provided raw materials for construction and other crafts. Yellow pond lily is one wetlands plant that had numerous medicinal uses and was revered for its curative effects.

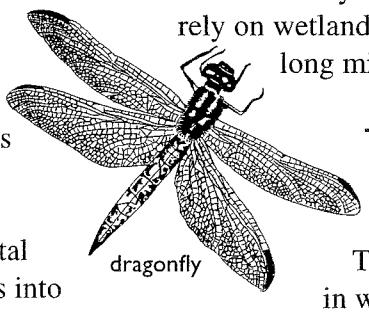
One wetlands animal, the beaver, played a pivotal role in the movement of Euro-American settlers into the northwest. In the early 1800s, beaver hats were a fashionable item for men. The desire for beaver pelts provided economic incentive for the exploration of the west. Fur-trapping explorers blazed the trails for subsequent settlers. When beaver hats went out of fashion, beaver hunters found new careers as guides as more people began moving into the west. Beaver populations have recovered from the drastic drop that occurred during the height of fur trapping, though they presently suffer from habitat loss.

Plants and animals introduced, accidentally or intentionally, by humans from one area of the world to another can cause great changes in their new ecosystem. Two emergent freshwater marsh plants, purple loosestrife and yellow-flag iris, are widespread introduced species. Introduced species may aggressively compete with native species for nutrients and space and often displace native species. Purple loosestrife, for example, often takes over large areas of wetlands, choking out native vegetation. The absence of native vegetation reduces the quality of habitat for native wildlife that have come to depend on the native plants.

Until recently, the important functions of wetlands were not fully understood. Wetlands were seen as undesirable, waste places and were altered to accommodate development. Washington state has lost 31% of its wetlands to draining, filling, and other methods of wetlands destruction (Jackson and Kimerling, 1993). Currently, development at wetlands sites is regulated by government agencies to ensure that overall wetlands functions are not compromised. In addition, many efforts have been made to preserve, restore, and even create wetlands areas for the benefit of humans and wildlife.

Wetlands Wildlife

Wetlands provide habitat for a wide range of animals. Some animals establish permanent residences in wetlands while others depend on them for certain parts of their life cycles, particularly breeding. Many species rely on wetlands as places to rest and fuel up during long migrations.


dragonfly

Tiny Creatures

Much of the wildlife inhabiting wetlands may not be easily visible. Tiny fungi and bacteria feed on detritus in wetlands. These organisms help to break down the detritus, providing nutrients for plant growth. Small invertebrates, such as nematodes and annelids, and larvae of larger invertebrates feed on the fungi and bacteria. Larger invertebrates, including mollusks, crustaceans and insects, also feed on detritus as well as eating the smaller invertebrates, fungi and bacteria. All of these creatures form the basis of food webs in wetlands habitats. Because bogs are not as productive as other wetlands due to the slow rate of decomposition, these smaller life forms are not as abundant in

bogs as they are in other wetlands types. Some common insects of wetlands include mayflies, stoneflies, leafhoppers, damselflies, dragonflies, beetles, ants, wasps, caddis flies, true flies, butterflies and moths. Backswimmers and giant water bugs are two wetlands insects of Washington that can be seen in "Bug" World — Adventures with Arthropods at Woodland Park Zoo. Giant water bugs are voracious **predators**. By using their front legs for capturing their **prey** and their piercing and sucking mouthparts for eating, giant water bugs can attack and consume other insects, crustaceans, tadpoles, frogs and fish much larger than themselves. The giant water bugs of eastern Washington are a different species than those housed in "Bug" World. Those of eastern Washington are larger and the females lay their eggs in clumps on leaves and other vegetation rather than on the backs of the males, as do the giant water bugs in "Bug" World. Arachnids, such as spiders and mites, are also common inhabitants of wetlands.

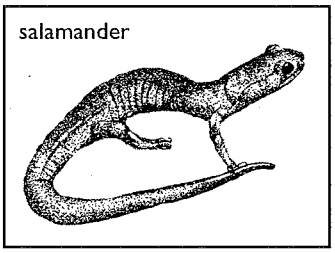
Fish

A variety of fish species inhabit Washington's wetlands and associated bodies of water. Especially important in the Pacific Northwest are salt marshes and the **anadromous** fish that depend on them. Anadromous fish hatch from eggs in freshwater environments but soon migrate downstream to salt water, often traveling through salt marshes. After reaching adulthood, anadromous fish return upstream to **spawn**, to lay and fertilize numerous eggs. With still waters and abundant food sources, salt marshes provide vital temporary habitats for young anadromous fish migrating out to sea or for adult fish beginning their journeys upstream to spawn. After spawning, most species of adult anadromous fish die. "[T]he salmon's death is one of nature's principal ways of bringing nutrients from the sea to the land of the Northwest" (Egan, 1990).

Anadromous fish, such as Pacific salmon and trout, have a wide distribution in Washington state, reaching all but the northeastern quarter. Populations of many of these species have decreased greatly, however, due to many factors including dams; destruction of river habitat through logging, agriculture and urbanization; and overfishing. Salmon have been and are currently central to Washington state Native American tribes as a source of food, economic benefit and a spiritual symbol. It is speculated that early populations of Native Americans began expanding greatly when anadromous fish vastly increased their runs throughout the northwest region about 8,000 years ago (Robbins, Frank and Ross, 1983). Salmon continue to be of great importance, particularly economically, to many people of Washington state.

Amphibians

Many amphibians utilize wetlands habitats for parts of their life cycles, especially for breeding. The word "amphibian" means "dual life." This name may refer to the different body structures at the two life stages of amphibians, or to the fact that many amphibians live part of their lives in the water and part of their lives on land. Many amphibians require still water in which to lay their eggs. Usually, after hatching from eggs, **larval** amphibians live in water and depend on gills to obtain oxygen. In the adult stage, after losing their gills, most amphibians are terrestrial but still depend on water. In order for amphibians to obtain oxygen through their skin, the skin must remain moist, therefore moist areas, such as wetlands, are vital habitats for amphibians.

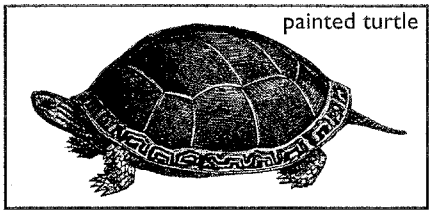


Washington's amphibians include salamanders, newts, toads and frogs, all of which are primarily found in western Washington. Some species of frogs and toads are found in both western and eastern Washington, but the Woodhouse's toad and northern leopard frog are both found almost exclusively in eastern Washington. Salamanders and newts are carnivorous in both larval and adult stages. Frogs and toads, on the other hand, are not generally carnivorous as tadpoles, usually eating algae and bacteria and occasionally scavenging **carrion**. Adult frogs and toads are carnivorous.

Amphibians introduced to Washington state have greatly affected populations of native species mainly by overtaking **niches** or eating the young and adults of native species. For example, bullfrogs were introduced to Washington from eastern North America. They now inhabit shorelines of our lakes, ponds, sloughs and reservoirs, eating almost anything they can swallow from insects to birds as large as robins. Bullfrogs have affected populations and distributions of spotted frogs,

northern leopard frogs, some reptiles such as the western pond turtle and even waterfowl. Fifty years ago spotted frogs inhabited both western and eastern Washington, but they are now mainly limited to the eastern part of the state due in part to predation by bullfrogs.

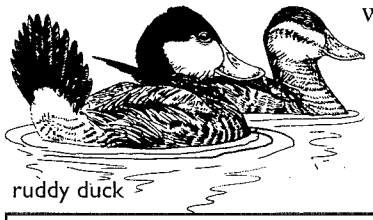
Reptiles


painted turtle

Reptiles inhabiting wetlands include turtles and garter snakes. Painted turtles and western pond turtles are found where there is abundant aquatic vegetation in marshes, slow-moving rivers, lakes and ponds. These turtles are **omnivorous**, eating arthropods, tadpoles and aquatic vegetation. Western pond turtles also favor algae, lily pods, and tule and cattail roots. Western pond turtles are currently listed as an endangered species in Washington state. Projects aimed at helping their populations to recover are addressed later in this section. (See "Wetlands Conservation Projects.")

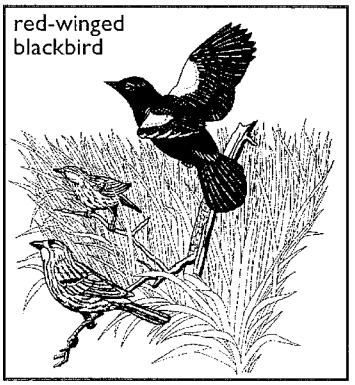
Birds

A great variety of birds rely on wetlands habitats, either as permanent homes or as temporary stopovers along migration routes. Wetlands not only provide water and an abundance of food; wetlands vegetation provides cover for hiding from predators and for nesting. At Woodland Park Zoo, many examples of native wetlands waterfowl, birds that live in or utilize water habitats, can be found in the Marsh and Swamp.


ruddy duck

Waterfowl use different techniques for finding food. Some waterfowl are divers; their feet are located toward the back end of their bodies so they can easily dive under the surface of the water. Other waterfowl have their legs near the middle of their bodies. These birds, called dabbling ducks, feed closer to the surface of the water, sometimes tipping up their back ends to reach a short way down into the water. Waterfowl with skinny legs and beaks usually stalk their prey in mud and shallow water. Grazers nibble at vegetation at or near the surface of the water.

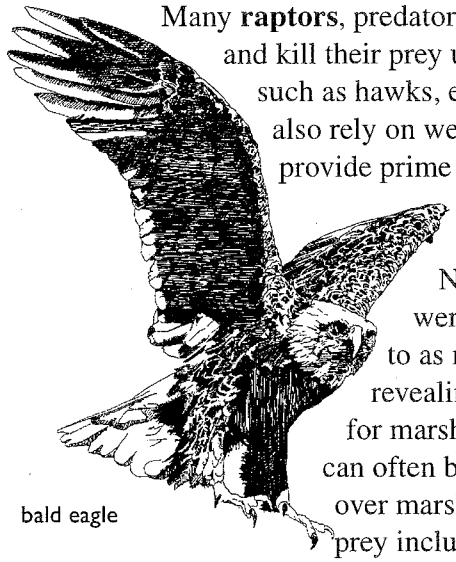
The species in the chart are all native, or migratory visitors, to Washington state. These birds can be seen in wetlands, particularly freshwater marshes, across the state. Great blue herons, though not residents of Woodland Park Zoo, are characteristic wetlands stalking birds and can commonly be seen around the state or visiting wet areas in zoo exhibits. In the Swamp at Woodland Park Zoo, many wild mallards and dabbling ducks have taken up residence.


red-winged blackbird

One highly visible (and audible) resident of Washington's marshes is the red-winged blackbird. Female redwings build their nests among cattails, bulrushes, sedges or other marsh plants. The nests, made of sedges, iris leaves or other fibers from marsh plants, are woven in and out of the leaves of the supporting plants. When singing, male redwings ruffle up their feathers and display the red patches on their shoulders. Their call sounds somewhat like "ko-kla-reeee" (the notes ascending from low, middle, to high).

Divers at Woodland Park Zoo (Marsh)	buffleheads, canvasbacks, common goldeneyes, hooded mergansers, lesser scaups, redheads, ring-necked ducks, ruddy ducks
Dabblers at Woodland Park Zoo (Marsh)	American wigeons, cinnamon teals, green-winged teals, northern pintails, northern shovelers
Stalkers at Woodland Park Zoo (Marsh)	black-crowned night heron, green-backed heron
Grazers at Woodland Park Zoo (Swamp)	tundra swans, snow geese, Canada geese

Birds of Prey


bald eagle

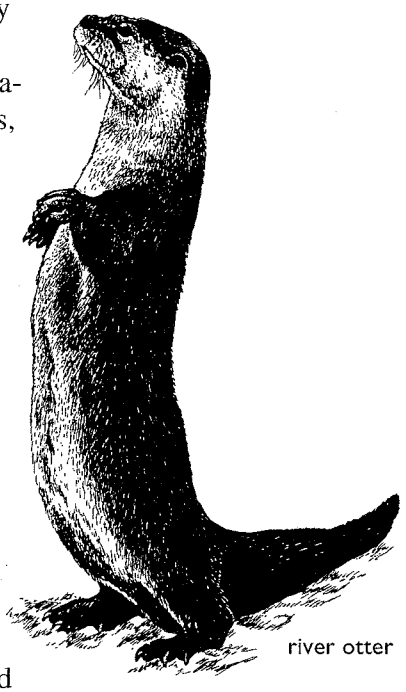
Many **raptors**, predatory birds that catch and kill their prey using their feet, such as hawks, eagles and falcons, also rely on wetlands. Wetlands provide prime habitat for many prey species favored by raptors. Northern harriers were formerly referred to as marsh hawks, revealing their preference for marshy habitat. Harriers can often be seen flying low over marshes in search of prey including rodents, amphibians, reptiles, waterfowl and many insects. Harriers commonly nest in swamps and marshes among the shrubs or grasses. Bald eagles can be found around marshes and riparian corridors **scavenging** and hunting for the anadromous fish that make up most of their diets. Bald eagles may also hunt in wetlands for waterfowl. Merlins and American kestrels, North America's smallest falcons, eat large quantities of insects and may hunt in wetlands areas. Bald eagles and an American kestrel can be seen at the Raptor Center at Woodland Park Zoo.

Mammals

Small mammals are frequently found around wetlands habitats. One of Washington's most common bats, the little brown bat, is usually seen near water in the late evenings. These bats feed exclusively on insects, catching as many as 500 (Larrison, 1976) to 1,200 (Bat Conservation International pamphlet, 1996) small insects an hour! Western pipistrelles, the smallest bat of the Northwest at 3 inches (7.5 cm) long with an 8 1/2 inche (21 cm) wingspan, frequent riparian woodlands of eastern Washington. Shrews also eat many insects, feeding almost continuously to fuel their high metabolism. (See "Temperate Forest Wildlife" for more information on shrews.) Raccoons often visit wetlands habitats, using their front feet to feel around for crayfish, frogs and other tasty wetlands treats. (See "Urban Wildlife" for more information on raccoons.) Black-tailed deer and mule deer, the subspecies found east of the Cascades, find cover from predators and plants to forage on in wetlands areas. (See "Montane Wildlife" for more information on deer.)

Beavers, the largest rodents in the Northwest, play an important role in forming and sustaining wetlands. Beavers prefer still ponds where they can harvest small trees growing along the margins. If no pond exists, beavers will create one by felling trees to dam a stream. In this way, beavers provide habitat for themselves as well as other creatures that prefer slow-moving waters, such as muskrats, mink and river otters. Beavers build their lodges in the ponds and stockpile them with food, the inner bark of trees such as alders, aspens and cottonwoods, in preparation for winter when the ponds could freeze and make foraging impossible.

Muskrats make deep burrows in the banks of streams or lakes, though they may also build lodges similar to those of beavers. Muskrats are omnivorous and eat many wetlands plants, including cattails and water lilies, and animals, such as frogs, turtles and crayfish. Minks, relatives of weasels, spend most of their time swimming, though they may forage on land in winter. Minks are predators and favor muskrats, but they also feed on fish, frogs and other animals available in wetlands. River otters, residents of lakes, rivers and streams, find adequate cover in wetlands vegetation but may use dens, especially for breeding. River otters are carnivorous. Their diet consists mainly of fish but amphibians, crayfish, birds and mammals (mostly muskrats) are also eaten. Well-developed webs on all four feet and a strong tail make river otters excellent swimmers. River otters have extremely dense fur which helps to keep them warm and dry while in water. In an area of fur the size of a quarter, a river otter has more hairs than a person has on his or her whole head! River otters can be observed in the Northern Trail at Woodland Park Zoo.


river otter

Wetlands Conservation Projects

Projects aimed at studying the functions of wetlands, learning about wetlands plants and animals, and restoring wetlands are conducted across the state. Woodland Park Zoo is involved in boosting populations of the endangered western pond turtle. As mentioned previously, populations of western pond turtles have been decreasing due in part to predation by bullfrogs. Loss of wetlands habitat has also caused pond turtles to be in greater competition with other wetlands inhabitants, including the introduced bullfrogs. At Woodland Park Zoo baby pond turtles are getting a "headstart" on life. Female pond turtles are tracked by radio-transmitter and the locations of their nests are recorded. Small shelters are built to protect the eggs from predators. The baby turtles are taken from the wild just after hatching and are raised at Woodland Park Zoo for a year. By the time the young turtles are a year old, they are large enough to avoid being eaten by bullfrogs or other predators and are therefore released back into the wild. Thus far, 200 yearling turtles have been released into wetlands in Klickitat and Skamania counties and near Tacoma. Pond turtles have survived successfully in wetlands created or restored by people! In order for released pond turtles to continue to survive, it is important that we take care of wetlands.

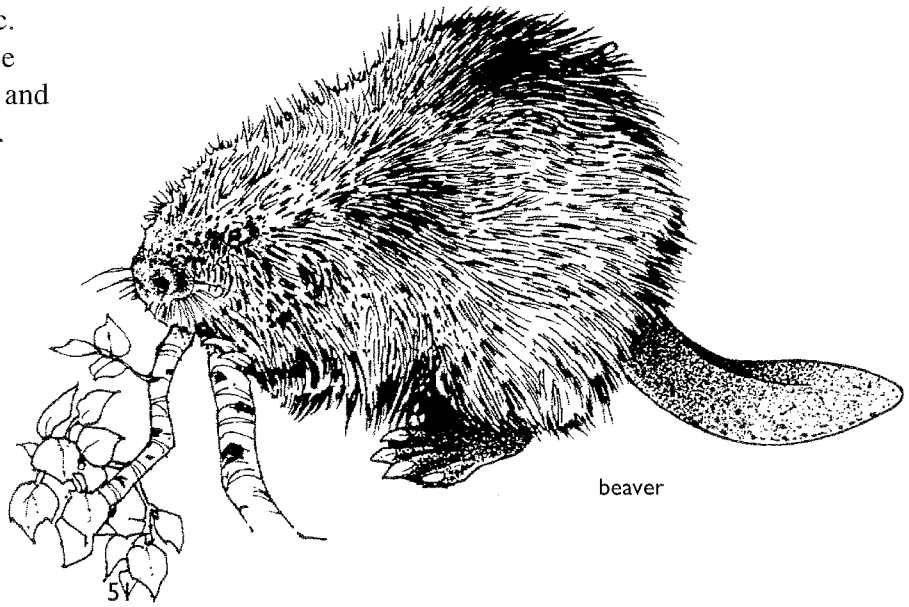
Wetlands provide important habitat for birds that migrate between North America and Central and South America. A wide variety of these neotropical migrants rely on Washington's wetlands ecosystems, such as riparian woodlands. Woodland Park Zoo, as a participant in the Partners In Flight project, serves as a resource for educational materials on migratory birds for other conservation organizations and the general public. Through this project the zoo is helping to increase awareness of the importance of healthy wetlands and other ecosystems for neotropical migratory birds.

Caring About Wetlands

Wetlands are important ecosystems throughout Washington state. Along with protecting areas from floods and ocean storms, wetlands replenish supplies of fresh water for the use of all living things. Wetlands also help to keep water clean. Many animals would not be able to survive without the food and shelter provided by wetlands. If too much wetlands area is drained, filled in, paved over or polluted, animals will not have sufficient habitat for survival. Humans will also suffer from these losses.

Throughout the state and around the world, people are working to preserve and restore wetlands ecosystems. However, it is important that we all participate in wetlands conservation, not only to prevent further destruction of wetlands, but, where possible, to restore what has already been altered. Simple efforts, such as conserving water and reducing the use of toxins in your home can make significant differences in the quality of water draining into wetlands. It is important to remember that reptile and amphibian pets, such as turtles and frogs, may not be native to our state and should not be released into local wetlands. As previously described, nonnative species can significantly alter the natural balance of native plants and animals.

For those who want to get more involved, there are many opportunities to participate in local wetlands reconstruction projects. These efforts will ensure that humans and wildlife will benefit from wetlands in your community for a long time to come.



beaver

raccoon

URBAN AND SUBURBAN HABITATS

Across Washington state humans have had a greater impact and influence on the environment than any other species. Land in Washington has been altered in many ways to satisfy human needs. Some areas of high human concentration, such as Seattle, Spokane or the Tri-Cities, are **urban** regions and are surrounded by **suburban** areas. Even in places away from cities and suburbs, such as rural farms, humans control many aspects of the environment.

Wild plants and animals inhabited Washington state long before humans ever did. However, plants and animals have had to adapt to share the environment with humans. If species are unable to survive in proximity to human habitation, their ranges are restricted to places where human influence is not as great. Other plants and animals that did not originally live in Washington were brought here by people coming from Europe or from other parts of the United States. Some of these **introduced** species have adapted very well to living in Washington's urban and suburban areas. In some cases, introduced species have out-competed **native** species. As other sections of this packet cover plants and animals that live in more natural environments, this section will cover plants and animals that thrive in primarily human environments, or urban **habitats**.

Formation and Population of Urban Habitats

In Washington state, the highest densities of human inhabitants occur in the lowlands surrounding Puget Sound (including Seattle, Tacoma, Olympia and Bellingham) and the metropolitan areas of Spokane, the Tri-Cities (Richland, Pasco and Kennewick), Yakima and Wenatchee. The populations of these areas have been continually increasing over the last two decades. These areas are favorable for human habitation for many reasons including environmental factors, such as a relatively moderate climate, and geographic proximity to transportation by water, road and/or rail. The geologic and climatic characteristics of these urban areas are similar to those found in their surrounding natural environments (see "Formation of Temperate Forest Lands" in the Temperate Forest section and "Formation of the Columbia Basin" in the Steppe section).

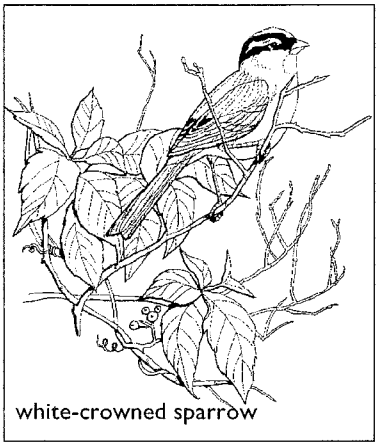
Types of Urban Habitats

Urban and suburban landscapes are mostly dominated by human-created structures, from parking lots to skyscrapers. Urban areas are highly developed with buildings and streets, while suburban areas may have relatively more green spaces such as parks, backyards and undeveloped lots. Buildings come in different shapes and sizes. Cities have closely spaced buildings, many of them large and tall. In suburbs, buildings are generally spaced further apart and are not as large or tall. Likewise, human populations in suburbs are less dense than in cities. Many cities and suburbs have trees or ornamental shrubs planted along streets. For **urban wildlife**, these variations in structures, space and vegetation create a diverse habitat in which to survive.

In some cases, urban structures emulate natural habitats. Many species have adapted to using human-created structures in place of similar structures found in their natural environments. Tall buildings resemble rocky cliffs preferred by peregrine falcons, and dark places underneath bridges are similar to rock overhangs used for shelter by rock doves (pigeons). Large expanses of grass surrounding airport landing strips resemble arctic tundra, attracting migrating snowy owls. In addition, the temperature within cities is often warmer than that of surrounding areas due to reflection of heat by concrete and buildings. This allows some plants and animals to inhabit cities that lie further north of the species' usual range. Vacant lots,

overgrown with urban-adapted plants, and backyards both large and small provide refuge for urban wildlife. Animals, such as raccoons and skunks, that use natural burrows or holes for shelter often inhabit openings underneath houses or other buildings. Where humans have abandoned land or buildings, plants and animals have the opportunity to establish themselves. Birds can roost in abandoned buildings and other animals can take shelter inside or underneath them.

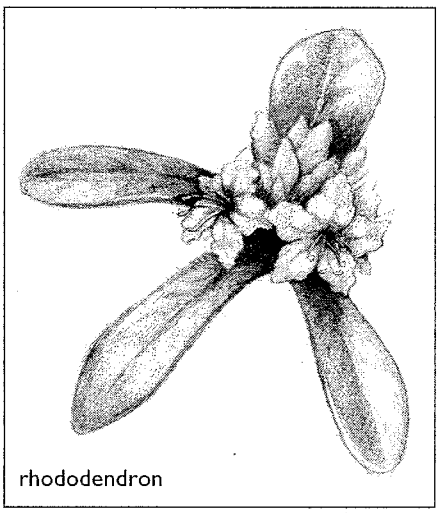
In addition to human-made structures, cities and suburbs often have systems of parks which provide more natural habitats for wildlife. These are sometimes left in very natural states, such as Seattle's forested Discovery and Seward parks, or they may be intensively manicured. Heavily manicured parks, consisting of short grass and a few trees, do not generally host as wide a variety of species as do more natural parks. As in most habitats, the greater the vertical diversity of plant life (short and tall grasses, shrubs and trees), the greater the diversity of animal life. For example, the diversity of bird species increases with a wider variety of canopy layers and a greater total coverage of the canopy. In addition, the diversity of mammal species in urban habitats increases with a well-developed layer of **herbaceous** vegetation around 8 to 20 inches (20 to 50 cm) high. But parks are small, isolated habitats. Although some animals can satisfy all of their survival needs within the area of one small park, others must travel between parks, or even between urban and more natural habitats in order to fulfill their basic needs (food, water, shelter, air and space). Birds, bats and flying insects are best able to travel from place to place. Other animals benefit from **corridors** which connect one habitat to another. Urban corridors can consist of parks, backyards, schoolyards and vacant lots. Corridors, such as the forested Mountains to Sound Greenway along Interstate 90 from Cle Elum west to Puget Sound, allow animals to move between habitats under the cover of vegetation and with minimal contact with humans. In 1981, a cougar showed up in Discovery Park, just northwest of downtown Seattle. It is believed that the cougar traveled to the park from the north via the vegetated corridor along the train tracks paralleling Puget Sound.


white-crowned sparrow

Urban Vegetation

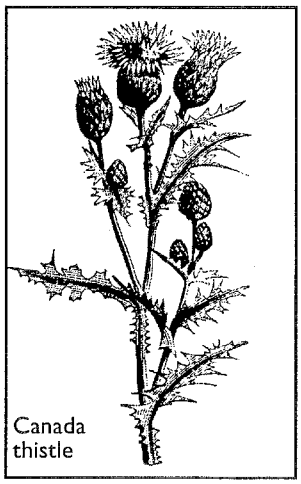
To a large extent, the vegetation that existed where urban habitats now lie, whether it be low-elevation temperate forest or steppe vegetation, has been eradicated or extremely altered. Where plants in urban and suburban environments have been left to grow naturally, the vegetation primarily resembles what the natural habitat used to look like. In the Puget lowlands, for example, many parks support **coniferous** forests with the same understory species found in temperate forests of surrounding non-urban areas. Across the state, parks that include streams may have natural **riparian** forests of native **deciduous** trees.

Some species of native plants are common throughout urban environments. Pineapple weed, a native member of the sunflower family with pineapple-scented flowers, grows very commonly in playfields and cracks in sidewalks. Fireweed, a tall plant with bright pink to purple flowers, can be seen growing along roadsides, especially when flowering in spring. Fireweed produces large amounts of nectar, attracting many insects. The insects then pollinate the flowers while sipping nectar. Large trees such as Douglas fir, western hemlock and ponderosa pine protect buildings from wind and sun in open urban areas. Rhododendrons are a very popular garden species. Most rhododendrons used in landscaping, however, are derived from Asian species of rhododendrons, but are adapted to a climate similar to that of western Washington. By gardening with native plants, which are adapted to our climate and so need less care and watering, suitable habitat for native wildlife can be created.

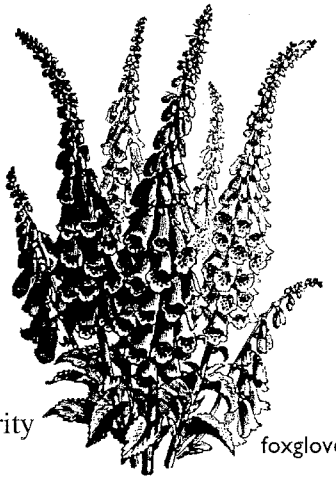

rhododendron

The vast majority of urban plant life consists of introduced species. Some plants were intentionally brought here by European settlers as garden ornamentals or as flowers or fruits that were familiar to them from their native lands. Other plants established themselves when seeds were accidentally transported from one place to another. Introduced species generally take over roadsides, playfields, pastures, cracks in the sidewalk and other areas that are highly and/or regularly disturbed. Some urban plants have adaptations well-suited to their arid native lands. These adaptations also aid their survival in urban habitats where higher temperatures, compacted soil and concrete result in less water available for their roots. For example, great mullein, an introduced plant now common along roadsides, has long taproots and hairy leaves. Urban plants face threats not generally found in more natural habitats such as herbicides and intense pollution. Because species introduced from other parts of the world, particularly Eurasia, have existed together with large populations of people longer than any plants native to Washington state, introduced species are often better adapted to cope with challenges posed by human activity. Many of our native plants succumb more easily to pressures placed on them by human populations.

Some **nonnative** species aggressively invade urban habitats and shade or choke out native plant species. English ivy, an **invasive** plant, can grow so thick and heavy on a tree, the tree will fall over! Purple loosestrife is an invasive plant that has completely taken over many wetlands, choking out other plants, limiting diversity and degrading the quality of the habitat (see "Freshwater Marshes" in the Wetlands section). Canada thistle is another invasive plant that was accidentally introduced from Eurasia to Canada in the 1700s. Mixing cheap seeds in with crop seeds was a common practice prior to the 1900s and many plants, such as Canada thistle, were introduced this way. Like many other introduced plants, Canada thistle grows aggressively and reproduces very rapidly. One flower stem can produce as many as 40,000 seeds in one season. The seeds then lie dormant in the ground and are able to germinate after as long as 20 years. Thistle stems can grow up from spreading horizontal roots. Exasperated workers attempting to remove Canada thistle have found that even a root fragment less than an inch long can produce new stems!


Canada thistle

There are both positive and negative aspects of introduced species. As has been described, some introduced plants can out-compete native plants, reducing the quality of the habitat for animals that rely on the native plants. In other instances, animals may be able to adapt to nonnative plant species, such as weeping willows, trees introduced from Eurasia, that provide shelter for many bird species. Humans also benefit from some urban introduced species. Himalayan blackberry, an invasive Eurasian species, has completely taken over many urban open spaces. These tasty blackberries are collected and eaten by many urban dwellers. Common ground cover weeds, all introduced members of the pea family, include red and white clover, common vetch and perennial peavine. Many plants in the pea family have nodules on their roots containing bacterias which take nitrogen from the air and incorporate it into the soil. This enriches the soil and stimulates the growth of other plants. Gardeners and farmers sometimes grow clover as ground cover to naturally enrich the soil and then turn it under before planting crops.


foxglove

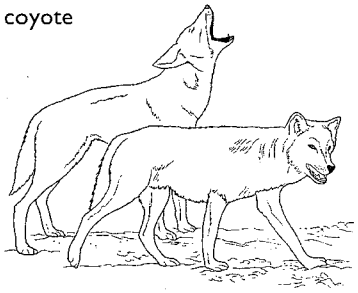
Many of the very common introduced **weeds** (plants that grow vigorously and take over areas where they are not wanted) of urban and suburban areas have been important as medicine in the past, both for Europeans and Native Americans. The majority of these plants were native to Eurasia. Self heal, a plant in the mint family, had a variety of medicinal uses, as implied by the name. Native Americans of the Pacific Northwest coast placed leaves of self heal on cuts and bruises. Foxglove, a common roadside plant, contains poisons which, in their natural state, affect muscle tissue and circulation. The modern pharmaceutical drug for heart disease, digitalis, is derived from foxglove. Common

St. John's wort, or Klamath weed, a relative of the western St. John's wort often used in landscaping, was historically used in Europe to treat nervous disorders. In North America, however, common St. John's wort is considered an aggressive weed in fields and pastures and can be poisonous to domestic animals. The crushed seeds of Queen Anne's lace, the wild ancestor of the cultivated carrot, have been used for at least 2,000 years as a contraceptive. The seeds have shown some success as a contraceptive in modern laboratory testing.

Despite the success of introduced species and the ability of some native animals to adapt to the presence of nonnative plants, the existence of native plants in our urban environment is still very important. Because native species of animals have existed with, and utilized only, native plant species for thousands of years, many species of animals cannot find suitable habitat or adequate food where introduced plant species have invaded.

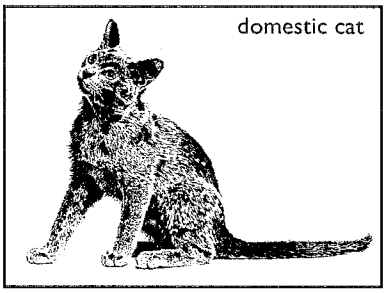
Urban Wildlife

Many animals native to Washington have been able to adapt to life in proximity to people. Introduced animals, like introduced plants, are also successful in urban habitats because they are highly adaptable. Urban wildlife can be defined as native and nonnative, non-domesticated animals that live in or spend time in urban habitats.


coyote

Most often, animals that successfully inhabit urban environments are able to eat a greatly varied diet. Many of them are **scavengers**, consuming almost any food item they can find. Although constant change is a basic characteristic of all habitats, change can happen more often and very quickly in human-influenced habitats. Thus, the most successful urban animals are those that can adapt to change quickly and find new alternatives to fulfill their basic needs in urban environments. For example, coyotes roam the fringes of urban and suburban habitat and readily change their diet according to what is available, such as food discarded by humans and the rodents it attracts.

Urban animals must face dangers not prevalent in more natural habitats. Many urban animals are **nocturnal,** which helps them avoid disturbance by the daytime activities of most humans. But nocturnal activity makes animals more vulnerable to the most voracious "**predators**" of urban habitats — cars. One natural instinct of many animals when faced with a predator is to freeze and try not to be seen. This is why deer and other animals may freeze when caught in the headlights of cars. Unfortunately, this instinct makes animals even more likely to be struck by cars. Other species, particularly amphibians and insects, are just too slow to escape moving vehicles.


domestic cat

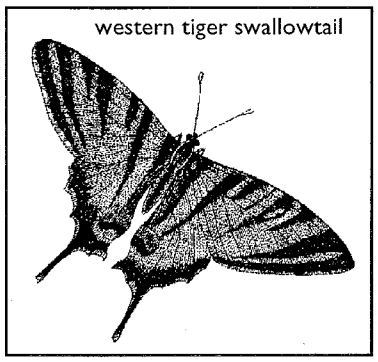
Domestic cats and dogs are also unnatural predators in urban habitats. In more natural ecosystems, populations of predators respond to fluctuations in populations of **prey** animals. If for any reason prey animal populations decline, predators may move to different areas, prey on different species, or their reproduction rates may even slow in response to the reduction of available food. Cats and dogs, on the other hand, are regularly fed by humans. So even if populations of urban animals decline, cat and dog populations do not naturally fluctuate. If anything, cat and dog populations tend to increase with increasing human populations. Thus, regardless of population sizes of urban prey species, domestic cats and dogs will continue to harass and prey on them. In this way, cats and dogs can seriously affect the existence of urban wildlife.

Humans also pose significant threats to urban animals by persecuting those that are considered to be pests. Many methods of "control" are used, including pesticides and traps. In some cases, prevention may be a more effective and less environmentally damaging control, such as keeping kitchens clean, keeping lids tight on garbage cans, and using covered composting bins to avoid attracting unwanted animals. Pollution of air and water caused by various human activities also affects the survival of urban animals. In order for species of urban animals to survive, it is important that people learn to share the environment.

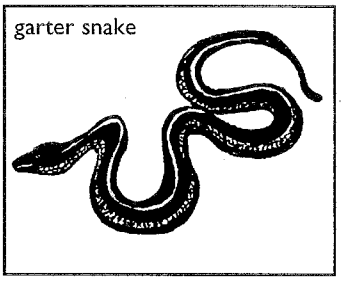
Tiny Creatures

Some of the more familiar urban animals are the smaller residents of backyards, parks and vacant lots. These include earthworms, terrestrial mollusks (slugs and snails), and a variety of arthropods (animals, including insects and spiders, that have hard exoskeletons and jointed appendages). Many of these animals are scavengers, feeding on dead plant and animal material. These scavengers are the **decomposers** in urban environments. Earthworms digest plant **detritus** in the soil. This helps to loosen the soil which they also enrich with their droppings, called castings. Earthworms are an important food source for many animals including moles and birds. Millipedes, sowbugs and pillbugs are all common arthropod scavengers. All these tiny decomposers form the base of the food chain, providing energy for other animals.

Slugs, snails and crickets, among others, are **primary consumers**, meaning they feed on live plant material (**producers**). Most slugs that are considered garden pests in Washington are introduced species, and therefore may not have as many natural predators here as in their native Europe. The large, native banana slug is not common in gardens, but may be found in western Washington's forested urban areas munching on forest floor mushrooms or plants. Mourning cloaks and western tiger swallowtails are butterflies commonly seen in urban areas. Their **larvae** (caterpillars) feed on the leaves of willows, alders and cottonwoods. Centipedes and some ground beetles are **carnivorous**, serving as **secondary consumers** in the food chain. Centipedes feed on insects, spiders and other small animals, using venom from specialized claws to immobilize their prey. A close look at their body segments and legs can help differentiate centipedes and millipedes. Centipedes have only one pair of legs on each body segment, while millipedes have two pairs on each segment. Some centipedes, unlike millipedes, can be poisonous to humans when handled; thus, handling them should be avoided. Predatory ground beetles prey on the larvae and adults of other insects. Some, such as beetles in the genus *Scaphinotus*, have mouth parts that are adapted to eat snails and slugs. Due to their slug-eating habits, *Scaphinotus* beetles are gardeners' friends. Earwigs eat live and dead plant material as well as preying on other insects, such as aphids. Ladybird beetles (ladybugs) also feed heavily on aphids and can be used as an effective natural control for garden pests.


western tiger swallowtail

Amphibians and Reptiles

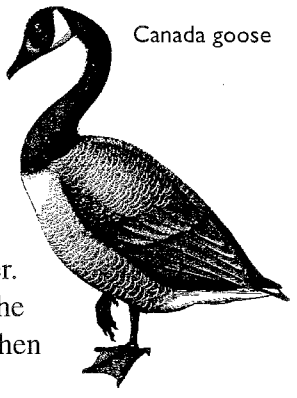

garter snake

Wet urban places host amphibians likely to be found in surrounding natural areas. Western toads and Pacific tree frogs can inhabit and breed in urban environments, as can the introduced bullfrog. (See "Amphibians" in the Wetlands section for more information on amphibians.) Garter snakes are common urban residents and prey on slugs, worms, amphibians and small mammals. In fact, because they are often found in people's gardens, garter snakes are often erroneously referred to as "gardener snakes."

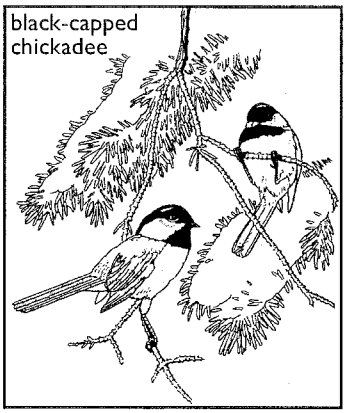
Birds

Birds are probably the most easily observed of all urban animals. In Seattle's parks alone, 225 species of birds have been recorded. Because they are able to move between fragments of habitat, birds can satisfy all their habitat needs by flying to many different areas within urban environments. Birds can also fly between urban and natural habitats, making use of the best of both environments. European starlings, for example, nest during spring and summer in urban areas, where natural predators are few, but travel to rural agricultural areas to feed on seeds in crop fields in fall and winter.

Humans often provide food for urban birds. But sporadic feeding of foods poor in nutrition, such as bread, can lead to their dependence on humans for food. Feeding may also encourage birds to change their natural habits and congregate in urban areas throughout the year. Birds, particularly ducks, then suffer when handouts subside in winter. Canada geese were brought to the Seattle area in the mid-1960s when


Canada goose

McNary Dam on the Columbia River was completed, flooding islands used by Canada geese for nesting. Since then, numbers of Canada geese, which are generally not migratory in this region, have increased greatly in urban areas around Puget Sound. Urban lawns are heavily grazed by geese throughout the year. The large numbers of geese are a cause for concern due to overgrazing and the large amounts of feces left behind, averaging 5.2 to 18.8 poops per goose per hour! This can affect the quality of recreational activity areas as well as creating water quality problems in nearby streams, lakes and reservoirs.



Urban development has removed natural vegetation which provided food for native seed-eating birds through all seasons. Regularly providing nutritious seeds throughout the year for these birds can help to supplement the natural food sources that are left. Providing liquid water during the winter also helps birds when other water sources may be frozen. Bird feeders attract not only many seed-eating birds, such as dark-eyed juncos and chestnut-backed and black-capped chickadees, but the presence of these prey species may eventually attract birds of prey such as Cooper's and sharp-shinned hawks. This is a good opportunity to observe bird behavior and an important food chain in action: the seeds are the producers, the songbirds the primary consumers, and the hawks the secondary consumers.

Urban environments are suitable for several birds of prey. Red-tailed hawks can often be seen perching on utility poles along roadways. The poles provide good lookout sites over the forest edges. Forest animals preyed on by hawks may venture from the forest into the open, making easy targets. American kestrels, North America's smallest falcon, can be seen in open suburban and rural areas of Washington state hunting large insects and sometimes small birds. Kestrels, like many other urban birds, nest in holes or cavities. Urban habitats provide a variety of cavities suitable for nesting, such as holes in trees, abandoned buildings and under eaves. But, both native and introduced cavity nesters require good nesting sites. Introduced cavity nesters, such as starlings, often take over available nesting sites, reducing the reproductive success of native species.

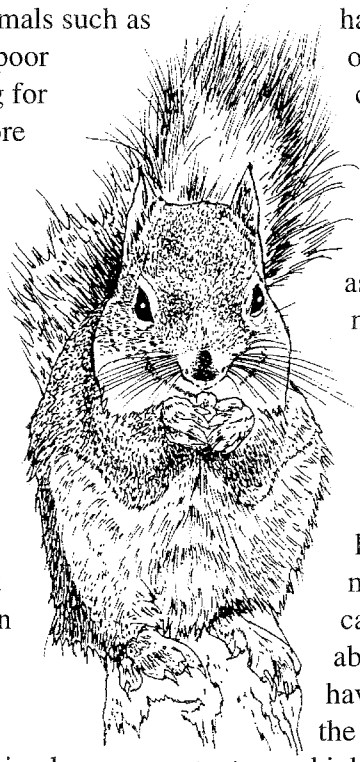
Peregrine falcons were one of the many species that suffered from the abundance of DDT, a pesticide used on crops, from the early 1940s to the early 1970s. Peregrine numbers had declined drastically due to eggshell thinning caused by eating DDT-contaminated prey. Use of DDT was banned in the United States by 1972, and a program for breeding peregrines in captivity was successfully developed. Since then, approximately 4,500 peregrines have been released across the United States in both developed and natural areas. In natural habitats, peregrines nest on rocky ledges. In cities, window ledges of skyscrapers make good substitutes and prey species, particularly pigeons, are abundant. Urban areas provide an advantage for the survival of young peregrines due to the absence of their natural predators, especially great-horned owls. One pair of peregrines has nested on a building in Seattle for the past several years.

Bald eagles, another species recovering from population decreases due to DDT, are also present in urban areas of Washington. Bald eagles have also had help from humans in re-establishing their numbers. Since 1971, more than 50 bald eagles that were injured in the wild, due to accidents or intentionally by humans, have been taken in, rehabilitated and released along the Skagit River by Woodland Park Zoo staff. Bald eagles prey on fish, but they also capture and eat waterfowl, especially mallards. Mallards and other species of waterfowl, including great blue herons, frequent ponds in urban parks and rural farmlands. (See "Birds" in the Wetlands section for information on common waterfowl.) In western Washington, several species of gulls have taken to scavenging in urban areas close to their saltwater habitats.

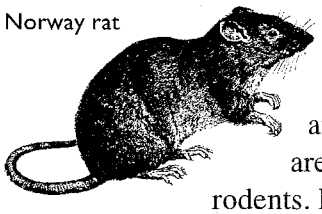
Small Mammals

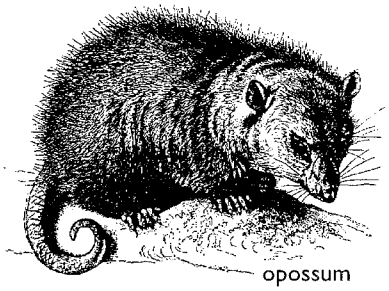
Many small mammals are able to satisfy all of their basic needs within the confines of urban habitats. Decomposers, such as earthworms and arthropods,

are important food sources for small mammals such as moles and shrews. Moles have extremely poor eyesight and depend more on their hearing for hunting earthworms. Moles sometimes store live earthworms for later use by giving them a disabling bite which does not kill the earthworms but keeps them from leaving the burrow. Shrews are constantly active in their search for insects to fuel their high metabolism. Some shrews have concentrations of poisonous compounds in their salivary glands and are among the very few mammals that can deliver a poisonous (but not fatal) bite! Shrews are not eaten by many animals except owls and Steller's jays. Shrews are often caught but not eaten, perhaps due to the poisons in their glands, by domestic cats.


squirrel

Squirrels are abundant in urban areas and provide interesting subjects for amateur animal behaviorists. The most common squirrel that shares habitats with people in Washington is the eastern gray squirrel, a species introduced from the eastern United States. The native western gray squirrel is now listed as a threatened species in Washington, due to hunting and loss of its preferred habitat. The western gray squirrel relies primarily on acorns found in oak woods of western Washington lowlands from Tacoma southward, but is not often seen in urban areas. Deer mice, introduced house mice and introduced Norway rats are other common urban rodents. Deer mice, native to Washington, are most often inhabitants of grassy areas where they find seeds, nuts and fruits to eat. House mice and Norway rats have found their **niches** living close to humans by scavenging accessible human food in addition to natural seeds and fruits. All of these small rodents are preyed on by urban predators such as owls and snakes.


Norway rat


opossum

Raccoons, opossums and skunks successfully inhabit urban environments. These animals, with their widely varied diets and nocturnal habits, exemplify the advantageous adaptations of many urban animals. Raccoons are good climbers and swimmers and are very adept at obtaining food using the excellent sense of touch in their front paws. Raccoons are omnivorous and eat frogs, fish, small mammals, birds, seeds and fruits of plants as well as food scavenged from humans. If people are not careful with their garbage, raccoons and other urban animals can come to depend on garbage as a food source, leading to undesirable interactions with humans or their pets. Opossums eat fruits, nuts, berries, cat and dog food, and other foods discarded by humans. Opossums are marsupials (mammals that carry their young in abdominal pouches) that have been introduced from the eastern United States. A high reproductive rate has helped opossums to populate urban environments, even though they often fall victim to cars at night. Skunks are omnivores and travel through urban areas relatively undisturbed due to their stinky defense, which is rarely used but serves its purpose by keeping people and other animals at a respectable distance. Skunks cannot climb so they take shelter in dens on the ground, either in burrows of other animals or under buildings.


opossum

In western Washington, mountain beavers often venture into suburban gardens collecting plants, such as rhododendrons, vegetables, roses and fern sprouts, and storing them in their burrows to be eaten later. These primitive, medium-sized rodents excavate large burrows in which they take shelter and store large quantities of plants.

Large Mammals

Most large mammals have responded to the spread of human populations by limiting their ranges to less populated habitats. Urban and suburban habitats do not usually provide sufficient resources to fulfill the habitat needs of larger animals. A few large mammals, however, have been able to adapt to and thrive in urban areas.

Deer use natural corridors and come to edges between forests and urban areas to eat desirable foods such as fruits and other common garden plants. This may occur particularly during winter when available food in the forest is limited. Free-running dogs will chase, harass and kill many deer in urban and suburban habitats and are significant predators of deer in these areas. Unlike natural predators of deer, however, dogs will kill more than they can eat.

Coyotes are able to live close to humans because they can readily change their habits to fit the situation. Coyotes in natural areas not populated by humans may be nocturnal or diurnal depending on the prey available at different times of the year. Coyotes living close to humans, however, are generally nocturnal in order to avoid confrontation with humans. Coyotes are predators of all urban wildlife and can survive on a variety of foods, from rabbits to human food scraps, changing their diet accordingly. In 1997, a coyote managed to make its way into an elevator of the Federal Building in downtown Seattle. The coyote may have entered the elevator because it looked like a small, dark place to hide. Red foxes have also been seen close to urban and suburban areas. These foxes descended from foxes that escaped from captive fur farms in western Washington.

Occasionally large mammals, like the cougar mentioned previously, come into urban and suburban areas. This happens more frequently as human development encroaches further into wildlife habitat. Cougars and bears may be encountered by humans who live in or visit forests near cities and towns. In these situations, it is important to be aware that we share habitats with predators and to take necessary precautions to protect yourself without disturbing them.

cougar

If you do see a cougar or bear the most important thing to remember is not to run, as this makes you seem like prey! Cougars may be intimidated if you maintain eye contact with them and appear as large as possible by waving your arms or your coat above your head. If you come across a bear, on the other hand, back away slowly without holding eye contact. If you see an animal that looks like it may have been killed by a predator, it is best to leave the area in order to avoid any confrontation.

In some areas of Washington where human habitations are spreading into low-elevation temperate forests, black bears sometimes wander into backyards. Most often bears will leave on their own. Occasionally, however, if they begin to rely on urban areas as an easy source of food, they may come to be considered a problem. In western Washington in 1997, a backyard bear climbed into a tree after being chased by a dog. Animal control officers darted the bear with a tranquilizer and quickly put the neighbor's trampoline underneath the animal so he wouldn't be injured when he fell from the tree. It was a bouncy but safe landing!

Urban Habitat Conservation Projects

Many projects aimed at studying urban vegetation and wildlife offer opportunities for students and other community members to get involved. In recent years, scientists have been calling upon watchers of backyard wildlife to assist in gathering information about species found in urban habitats. Through a project called Nature Mapping, the University of Washington and the Washington Department of Fish and Wildlife are enlisting the help of students and community volunteers to collect baseline data on species of fish and other wildlife in their area. This data will provide useful information for future resource management planning. Nature Mapping offers students the opportunity to be involved in important research and become stewards of their local environments. (See Contact Information list for Nature Mapping contacts.)

Caring About Urban Habitats

Urban and suburban habitats of Washington allow us an exciting opportunity to watch and learn about wildlife. By opening our senses to wildlife in our urban habitats, we can learn about important ecological concepts and improve our connections with nature in all habitats. Ecological processes such as the natural food chain, interdependence and **biodiversity** are all functioning in our own backyards and when we try to manipulate one factor we often don't realize the long-reaching effects of our actions on the environment as a whole. For the sake of maintaining biodiversity within our urban habitats, we must learn to share the environment with urban animals. There are often natural alternatives that can be used to deter unwanted animals instead of trying to kill them. For instance, slugs will not move across strips of copper wider than a few inches. Strips of copper can be placed around areas of gardens that are often attacked by slugs in order to keep them out without killing this important member of the food chain.

To facilitate urban ecological experiences we can enhance urban habitats for wildlife. There are a variety of programs that are making efforts to improve urban resources for wildlife, from removing introduced plants and planting native ones, to caring for watersheds that provide habitat for fish and other animals. Our own backyards can even become wildlife habitat when we increase the diversity of layers using native vegetation. (See the Contact Information list for additional information on creating a backyard habitat.)