PREFACE

This guide was originally written in 1976 to serve the first volunteers in the Nature Conservancy's environmental education program on the Fairfield Osborn Preserve. It has been revised each fall in response to the experiences and needs of the program participants. The original encyclopedic format has been replaced with a community based organization intended to better represent the tremendous interrelationship of all the components of the natural environment.

However, nature's organization is much too complex to easily lend itself to the two dimensional restrictions of ink on paper and linear sequence. Obviously many, if not most organisms, are found at one time or another, in communities other than those in which they are mentioned in this guide. Keep an open mind and a sharp eye (and ear, and nose), and you will gain a much more intimate understanding of the diverse components of the mountain's ecosystem.

Another necessary disadvantage of the community format which we have chosen to use is that, even once you have read it, you will have to work a little harder to get back and use it as a reference. You have been provided with a comprehensive index. Do use it. Look up an animal and read about what it eats, where it lives, what it needs to breed. what eats it, etc.; all the myriad conditions and constraints which make up-its niche and its position in the complex food web.
LIST OF DRAWINGS AND CONTRIBUTORS

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Soap Plant - Jacque Giuffre
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Scorpion and Young - Lynn Lozier
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AN INTRODUCTION TO BIOTIC COMMUNITIES

Our local star - the sun - constantly radiates an inconceivable amount of energy into space. It is emitted in the form of electromagnetic radiation, and travels in all directions away from the star. Approximately eight minutes and ninety-three million miles later, a very small fraction of this is intercepted by our planet. Over a third of the extraterrestrial energy which does reach Earth is reflected back into the void of space by clouds, atmospheric dust, and reflecting objects on the planet's surface. Another fourteen percent is absorbed by the atmosphere. It is here that the ozone layer acts to shield the life below from the harmful effects of ultraviolet radiation. Less than one percent of the light energy which reaches the surface of our planet is used in photosynthesis: the biological process in green plants that converts solar energy into the chemical energy that can be used by earthly life forms. However, the energy that was captured by the atmosphere and the Earth's surface was not wasted. Reradiated as heat, the resulting energy maintains the narrow band of temperatures that makes life possible. It also evaporates water, melts ice, and generates the winds and ocean currents.

The world's organisms are not distributed at random. In order to survive, they must be well adapted to the habitat in which they are found. This results in the formation of the recognizable groupings of organisms called biotic communities. It would be relatively easy for most people to break up the Fairfield Osborn Preserve's total acreage into its component oak woodland, grassland, riparian, Douglas-fir, freshwater marsh, chaparral and pond communities. Although they might not be aware of their method, they probably would have done this by looking at the dominant plant species in the areas under consideration. These are the ones that are most conspicuous and seem to have the greatest influence over the other species. In the oak woodland community the oak trees are dominant. They intercept a good portion of the available solar energy and wind coming into the area, and so modify the physical characteristics of the community. Only shade tolerant plants adapted to the resulting moist, temperature stable environment can exist beneath the oak canopy. The oaks also provide major resources to other members of the community in the form of acorns, leaves, and wood. Much of this organic litter is high in toxic tannins; further restricting the types of plants which can grow there. If you eliminated most of the oaks, the community species composition would change drastically because of the altered environmental conditions. On the other hand, the removal of some of the non-dominant low growing species would only result in minor changes in the oak woodland community.

However, it is important to realize that all the species within a biotic community are valuable and contribute to its stability. The individuals of each species compose a population, and there are many different animal (faunal) and plant (floral) populations within any community. In the oak woodland there are populations of tree squirrels, deer mice, oak worm moths, millipedes,
lichens, poison oak, and thousands of other species. All of these interact with one another. The connection is not necessarily direct, but it definitely exists. Falling oak leaves form part of the detritus on the forest floor that millipedes and earthworms feed upon, and their activities help release the vital nutrients that are trapped within the confines of the leaves. The nutrients are then available to the roots of oak trees and other plants, which enables the floral species to produce new leaves. In direct contrast to the short sighted communities of man, those of nature recycle everything as much as possible.

OAK WOODLAND COMMUNITY

The oak woodland is the largest community on the preserve. Wherever they are able to grow in the open, the oaks spread their gnarled branches almost directly out from their trunks. Each of these limbs then forks again and again, finally terminating in the multitude of tiny twigs that support the leaves. When viewed as a whole, this dendritic branching pattern often results in the formation of a graceful dome shaped tree. Under the more crowded conditions of forest growth, the same species of oaks grow their branches much more vertically, allowing their leaves to compete with those of the other trees for the limited light. There are three main types of oaks in this community. Coast Live Oak has small, sharp pointed, boat shaped leaves. Oregon Oak has larger and flatter leaves, the margins of which have rounded finger-like lobes. California Black Oak leaves are similar to those of Oregon Oak, but are even larger and have lobes that end in points. California Bay is also a dominant in the oak woodland community. It has long elliptical leaves that are aromatic, releasing a pleasant fragrance when crushed.

The main function of any leaf is photosynthesis. During this complex process, carbon dioxide and water are converted into sugar and oxygen by the green chlorophyll molecules inside the leaf. A large amount of energy is needed to power the required chemical reactions, and it is obtained from sunlight. Photosynthesis cannot occur underground or in any completely dark area. The sugar that is manufactured is stored as starch in the plant, and is also used as an energy source in the construction of other plant materials. All of these substances contain some amount of energy; that is why plants are worth eating. Only green plants can make their own food. The rest of the life forms on the planet must obtain their energy from plants, even though they may get it in a rather roundabout way. The predaceous hawk is just as dependent upon green plants as the herbivorous grasshopper that feeds directly on vegetation.
In order for photosynthesis to occur, the green chlorophyll containing cells in the leaf must be exposed to light and carbon dioxide in a moist environment. This presents a dilemma. The leaf has to be thin and have openings in it, or the important gases will not be able to travel in and out of its cells fast enough. At the same time, the requirement for a moist environment inside the leaf means that any such openings will be detrimental, because precious water will leak out the same holes in the form of water vapor. The problem is compounded by the absolute necessity of exposing the leaf to the heat of the sun, since this will speed up the rate at which water evaporates from the plant tissues. It turns out that the thin flat leaves of higher plants contain evolutionary solutions to this apparent paradox. First of all, a thin layer of a transparent waxy substance coats the upper surface of the leaves. This prevents water from evaporating out of the part of the leaf that is exposed directly to the sun's radiation, while allowing the light to penetrate through to the interior where it is needed for photosynthesis. Tiny pores are located on the undersurface of the leaf where there is less light energy. These enable oxygen to leave the leaf and carbon dioxide to enter. The openings are surrounded by special guard cells that can completely close off the pores during times of moisture stress. When conditions become more favorable, the guard cells automatically separate. Gas exchange between the interior of the leaf and the external environment is then possible with a minimum of water loss. Finally, there is often a mat of hairs on the undersurface of the leaf which further restricts the loss of water vapor. It does this by breaking up the air currents that move over the pores. The hairs on Oregon Oak leaves are easy to see with a ten power magnifying glass.

Sooner or later, all leaves fall from the plant to which they were attached. Species that lose their leaves at the same rate at which they are replaced are called evergreens, while those that lose them all at once are said to be deciduous. In the oak woodland community, Coast Live Oak and California Bay are evergreen, and California Black Oak and Oregon Oak fall into the deciduous category. One of the reasons for leaf drop is that the cells within the old leaves have no way to replace themselves. Unlike animals, only a few specialized regions within plants are capable of cell division and renewed growth. It is beneficial to discard the aged leaves before they become infected with fungi and other disease organisms. Another factor is that many broad leaved plants are found in areas with very cold winters. In places like this, the thin water-filled leaves would freeze if retained on the plants. Even in areas without snow, water loss through the leaves would occur when absorption of water by the roots was minimal. Roots cannot absorb well when they are cold. In these situations the pores in the leaves would have to be closed as tightly as possible. Photosynthesis could no longer occur, so the leaves would then be a liability instead of an asset.

By choosing when to initiate leaf fall, the plant can seal off the region between the leaf stem and the main tree tissues before the leaf drops off. This greatly reduces the chance of infection. It also allows the plant to withdraw vital nutrients from the leaves before they are discarded. As
soon as the chlorophyll molecules are broken down and taken back within the main body of the plant, all the remaining pigments in the leaves become visible. The beautiful yellows, oranges, and reds of fall were always present, but they had been masked during the growing season by the dominant green of the chlorophyll molecules.

The living leaves of the oaks are protected from most herbivores by toxic chemicals called tannins, but some animals have evolved the capability to feed upon them without harm. The messy silken webs of the Tent Moth caterpillars are common among many different species of trees during the spring, and the caterpillars consume large quantities of leaves. Another insect, though, has more of an impact upon the equilibrium of the oak woodland community. California Oakworm Moth larvae are much more numerous than those of the Tent Moth, but they are seen less frequently because they hide underneath the oak leaves. At first the tiny caterpillars merely graze the lower layers of the leaves. Before long, the growing larvae begin to chew completely through the leaves, making large irregular holes that can be seen from some distance. When their first leaves are mostly consumed, the caterpillars move on to adjacent ones and continue their feeding. The larvae are so abundant in some regions of California that they can actually strip all the leaves from the trees.

Such total defoliation is unlikely in our area, due to the natural biological control of the insect's population by insectivorous birds. These feathered carnivores obtain their food by gleaning insects off plants. They move over bark, leaves, stems, and twigs in their constant search for prey; with many of the birds becoming specialists. The Plain Titmouse, Chestnut-Backed Chickadee and Common Bushtit are all agile animals with-pointed beaks, and they constantly look over and under vegetation for their insect food. Occasionally, one of these birds will tumble down to a lower bough before resuming the scrutiny of the foliage and twigs. The chickadees and bushtits are gregarious birds, and move through the forest in combined flocks. They call to one another as they feed, a behavioral device that serves to keep the group together. The titmice will often tag along during these woodland, forays.

Brown Creepers have a different feeding technique. They fly to the base of a tree and then walk up the trunk, bracing themselves with their stiff tail feathers as they climb. Creepers have a slender down-curved bill that is ideally suited for prying under bark in search of insects and their eggs. When they reach the top of the tree they are at an impasse, and must drop down to the base of another tree before they can continue their hunt, White-breasted Nuthatches are
larger birds with stronger feet, and their hold is so firm that they can walk down a tree trunk head first. These insectivores will also walk upside down along branches, but they are more likely to work their way around in a spiral fashion. Like the creepers, they seem to apply most of their efforts to bark, extracting the insects and spiders that had taken refuge in the cracks.

While watching the birds moving about in the trees, it becomes obvious that the trunks and branches are almost completely covered with a fuzzy type of plant growth. Closer examination will reveal that this is mostly a cloak of lichens, composite plants that consist of the intimate association of an alga and a fungus. Most of the, bulk of the lichen is formed by the fungus, with the cells of the algae located deep within the fungal framework. The algae and fungi of the lichens look like normal species of their kind when experimenters grow them separately. Oddly enough, hardly any of the species which compose lichens ever manage to grow alone in nature. The relationship has become obligatory.

Lichens can be quite colorful, revealing an array of reds, oranges, yellows, greens, tans, greys and blacks to anyone who opens their eyes in the outdoor environment. They also come in a variety of shapes. Crustose lichens are most common on the rocks exposed to the full force of the sun, and resemble thin crusts of splashed paint. Leaf-like (foliose) lichens have more body to them, with distinctly different top and bottom sides. Shrubby (fruticose) lichens grow out from one attachment point, and have flattened or cylindrical extensions. These last two types are found on both rocks and wood, and are very common sights on the branches of oaks. It is one of the fruticose lichens that many people confuse with the southern Spanish Moss, as they both hang freely from the trees in a similar manner. Spanish Moss is actually a flowering plant, and does not look like either a lichen or a moss on close inspection.
The peculiar cup shaped structures protruding from the bodies of the lichens are the reproductive organs of the fungus part. These release thousands of spores into the wind, and each spore can develop into a fungus filament - but if it does not locate the proper kind of alga
soon it will die. This haphazard technique is probably a carryover from the fungus's past when it was still a free living fungus species. Powdery white areas on the surface of the lichens represent a much more practical method of dispersal, because they release masses of
intertwined algal and fungal filaments into the air. These can grow directly into a new lichen if they reach a suitable attachment site. Lichens may also get started when small pieces break off and are transported to new areas by winds or animals. The combination of all these methods must make for dependable dispersal, since bare spots on rocks or trees are uncommon in mature communities.

This does not mean that lichens are rapid growers. In fact, they grow extremely slowly and should be treated with the utmost care and respect. Crustose forms hardly ever grow more than a millimeter a year, and the other two types rarely grow more than a centimeter in the same time interval. That means that a crustose lichen two inches across is at least fifty years old. Of course, as a lichen grows it bumps into adjacent lichens and its growth will be greatly retarded, so a given specimen on a stable site may easily be a couple of hundred years old.

One of the factors responsible for this slow development is the inability of lichens to store water. They dry out very quickly, and so even dew and fog can be important to their survival. A lichen can stay alive with a water content that is only two to fifteen percent of its completely dried out weight, whereas a typical leaf of a higher plant will shrivel and die if its water content drops below fifty percent of its oven dried weight. This is why lichens can tolerate very dry habitats. They cannot compete with the plants in more shaded areas, probably because the quicker growing mosses would overgrow them. It is also possible that the lichens require the bright sun of the more exposed regions. This could explain why the deciduous trees like Oregon Oak have a denser lichen crop. The lichens are fully exposed to the sun's energy during their main growth period in the winter and early spring. Lichens do not parasitize trees in any way, they merely use them as convenient supports to get them off the ground. The algal component of the lichens produces all the food that the composite plants require, releasing about half of its manufactured sugars to the fungus. Contrary to popular opinion, there is no evidence that anything moves from the fungus to the algae. The fungus does not supply the algae with nutrients or keep it from drying out. It appears that the relationship is actually one of controlled parasitism, with the fungus component holding the upper hand. The fungus does not even allow the algae to have sex.

Oak galls are also found in the oak canopy. Some of them grow from the twigs, while most sprout directly out of the leaves. These bizarre structures come in many different shapes and colors, and are produced by the tree in response to an irritant supplied by small insects. Sometimes this chemical is injected by the adult insect when it lays its eggs, and in other cases the substance is manufactured by the developing larvae. Whichever occurs, the resulting galls become the secluded habitats of the larvae; which feed upon the plant tissues within the galls. The insects even manage to cause the oaks to produce galls that have a very high protein and carbohydrate content. This means the young insects can obtain a rich and balanced diet while
remaining inside the galls at all times. Both gall wasps and gall flies are capable of inducing gall formation, and each species of insect is responsible for the creation of a different type of gall. Some of the wasps even have two adult stages in their life cycles, with a separate type of gall produced by each kind of adult. The galls do not represent total security. Some birds have learned how to break them apart to get at the soft bodied immature insects residing within. Mistletoe is also found on the trees, often growing in massive green clumps among the branches. Unlike the lichens, it is partially parasitic on the trees it grows upon. Heavy infestations can even kill the host trees.

Mistletoe is a flowering plant, and the seeds are protected within fleshy berries. These are avidly consumed by many different species of birds, which flock to the afflicted trees when the berries become ripe. The fruits are very sticky, and so the birds will often wipe their bills off on the closest branch whenever they land. The seeds that had been adhering to their bills will then sprout and begin to send roots into the tissues of the tree. Even the seeds which pass through the birds' digestive tracts are not harmed, and these can also start to grow if defecated upon a suitable branch. It is a beneficial relationship to both species. The birds obtain the nutritious flesh of the berries, and the mistletoe achieves a spectacular method of dispersal for its seeds.

Black-tailed Deer are often seen in the oak woodland community, but they also roam throughout the rest of the preserve. The males grow forked antlers and weigh 125 - 200 pounds, while the smaller females always lack antlers and are only 100 - 150 pounds. They are most active around dawn and dusk. During the remainder of the day they rest in secluded areas. An average doe has a home range of about one half mile, but a buck might travel an area of three quarters of a mile diameter during its search for food. Every day, a deer has to obtain about two pounds of solid food and two and a half quarts of water for each hundred pounds of its weight.

The ideal diet appears to be grass and herbaceous plants in late winter and early spring; brush sprouts in late spring brush sprouts and succulent herbs in summer; and acorns in fall. They prefer to forage along the outskirts of brushy areas. It is because of this that communities with widely spaced shrubs provide the best deer habitat. They bite the new green growth close to the ground, but by February or March the grasses and other herbaceous vegetation have become too mature for them. Acorns have a high fat and carbohydrate content, making them a rich food source whenever they are available. Since deer can only reach about four feet high, they usually can only eat acorns after they have fallen to the ground. Another highly favored plant is the California Bay. In our region, frequent browsing may prevent young trees from developing into anything more than a well pruned shrub. Oak saplings are also hit hard, and it is a rare seedling that manages to grow above the deer browse level.
The bucks' necks begin to swell in the middle of September, a signal that the rutting season has begun. Actual mating does not occur for another four to six weeks. It is during the period from mid September to the end of November that the bucks are more active during the day. They are searching for does. Mule deer do not form harems, and a receptive doe may run with several males. The fights between males only serve to increase the general breeding condition of the herd. Other bucks may gather around to watch the clash of antlers. There is no real winner in the encounters, and injuries are rare.

Toward the end of May, pregnant does fight off fawns of previous years and retire to thick cover to give birth. The older does become antagonistic toward other females at this time, which tends· to spread the does fairly evenly through the brush. Suitable cover is always limited, and one third or more of the younger does will be forced to emigrate to other areas. It is normal for a mature doe to give birth to two young. The fawns retain their spots for around three and a half months, and do not seem to have any detectable odor at first. Hunting dogs have been seen to pass right by hidden fawns without noticing them.

The bucks shed their antlers each year during January. Representing an important source of calcium, fallen antlers are gnawed by wild mice and rats. New antlers begin to grow in early spring. During the growth period, they are covered by a delicate tissue that contains nerves and blood vessels. This serves to supply the maturing antlers with oxygen and growth substances. The final shape and size of the head ornaments is reached by July. The covering, called velvet, is rubbed off in the autumn after it dries up. Unfortunately, a male's age cannot be determined by the number of points on his antlers.

It is true that mountain lions prey on deer, and a single lion may kill fifty of them during the course of a year. An impediment to man's desire to totally exploit the deer population himself, hunting and bounty campaigns were initiated to exterminate the cats. After the resulting drastic decrease in their· numbers, it is doubtful that they can appreciably affect the deer population in today's world. It was all a fallacy anyway. Large predators do not substantially alter the abundance of the animals they feed upon. Still, many hunters and ranchers-continue to shout for the total extinction of the mountain lion. The lions which roam this area do so in the dark of night, seemingly aware ·of the malicious inclinations of the humans who have usurped their land. These powerful carnivores are not permanent residents of Sonoma Mountain, since each must travel up to fifty square miles to obtain the young, old and weak deer which are its normal food. Only man, armed with his arsenal of weapons, is capable of killing healthy deer in the prime of their life.

The deer are also beset with other problems, suffering from the attacks of many different parasites. Ticks are particularly abundant during the fall. At this time, Scrub Jays may be seen foraging on the deer for ticks. Deer are also host to bot flies and liver flukes. It is a rare
individual that lives longer than ten years, and in areas managed for a high deer population the life span is even shorter.

The oak woodland floor is littered with fallen leaves, twigs, and branches. Interspersed among all this organic matter and the protruding rocks are numerous moderate sized holes, many of which point out the entrances to Deer Mouse burrows. The three to four inch bodies of these mice are set off beautifully by the contrast of the cinnamon brown dorsal fur with the white underfur. Their tails add another two to five inches to the overall length, and continue the coloration pattern of a dark upper surface and a lighter ventral surface. This is an example of countershading, a common phenomenon throughout the animal kingdom. If an animal was uniformly colored it would stand out from its surroundings, because the part closest to the ground would not receive as much light as the upper surface. The evolution of countershading has solved this problem, because the lighter ventral surface has an increased reflectance, countering the effect of the shadows and so flattening out the animal's form. There is also the possibility that in vertebrate animals with color vision, their eye will tend to fill in the whiteness with the color of the surrounding habitat, providing a much better color match than mere pigment could ever achieve. In this latter case, the potential predator’s own visual system would be providing the camouflage that the prey animal requires.

Deer Mice are nocturnal animals, only feeling safe after the sun has set. Then they emerge from their burrows or hollowed trees, hurriedly searching for the food they need to sustain them. Seeds, nuts, acorns, berries and insects are all part of the fare of this omnivorous mammal. In the spring, a large part of their diet is made up of butterfly and moth larvae. Fall is the time to prepare for the coming winter, and large quantities of seeds, acorns, and baynuts are gathered and stored in the burrows. The mice do not know why they collect these objects in such abundance. The required behavior was naturally selected for through the course of their evolution, because the mice which did hoard food were the ones which survived the winter and had offspring the following year.

These rodents are found throughout the entire United States, and inhabit every type of dry land habitat within their range. There may be as many as ten to fifteen of these mice per acre. It is not surprising to find that almost every type of mammalian carnivore includes them as part of its diet. Deer Mice are not even safe from shrews, which are even smaller than they are. Owls and snakes are other predators that sample the abundant mouse population. As with other heavily preyed upon species, they can sustain the pressure because of a high reproductive rate. A female has two to four litters a year, with an average of four young in each litter. More importantly, they breed when only five to six weeks old. The individual Deer Mouse appears aware of the odds against it, moving rapidly and nervously. Even after finding a food item it is likely to run or jump away before finishing with the item of interest. Lacking defensive
The Long-Tailed Weasel is a common predator on the preserve. Although active both day and night, they are rarely seen, a tribute to their small size and alertness. If you are lucky enough to catch a glimpse of a weasel, the long slender eight to ten inch body and black tipped tail is highly distinctive. Once again, countershading is used as a camouflage aid: in this case, the ventral surface is yellowish-white and the upper surface covered with short brown fur. In the Sierra they molt to pure white during the winter to blend with the snow, but on Sonoma Mountain they retain their normal coloration throughout the entire year.

They are extremely active and agile animals, and will sometimes climb trees when looking for prey. The slender shape allows them to run through gopher burrows or squirm through brush and rock piles, all the while in hot pursuit of rapidly fleeing animals. When they finally apprehend the prey item, they pierce the back of its skull with their canine teeth; destroying its brain functions and bringing about a quick death. Many a deer mouse has died under the teeth of a weasel. Rodents form the bulk of the diet, but a few birds are also eaten. There may be as many as fifteen to twenty weasels per square mile. Voracious predators, they have been known to eat up to forty percent of their weight each day. Observations made at one nest showed that in just thirty-seven days a weasel brought her young seventy-eight mice, thirty four chipmunks, twenty-seven pocket gophers, four ground squirrels, three wood rats and two moles. Finding it easy to evict the previous occupant, they choose to live in the burrows of their prey. They are so powerful and ferocious that very few animals even attempt to capture them.

Grass spiders spread their webs across the forest floor. They prefer to let their prey come to them, and wait patiently in the funnel shaped retreat along one side of the web. When one of these ground level webs is disturbed by the struggles of an insect, the spider rushes out and seizes the animal in its fangs. The silken strands of these webs are not sticky. Haste is essential, or the stumbling insect will regain its footing and escape. On the other hand, if the vibrations transmitted by the strands are too strong the spider remains in its retreat. A larger predator than itself could be lurking outside the funnel orifice, and many animals find spiders edible. Although these grass spiders produce thousands of webs in the oak woodland and grassland communities, they are seldom seen because of the transparent nature of spider silk. A foggy morning will completely alter the picture, transforming each of the myriad webs into a glistening cluster of multihued water droplets.

Western Skinks feed upon the same types of prey as the grass spiders, but the lizards can have a three inch body, a size advantage that allows them to prey on much larger organisms. Spiders form part of their diet. They also eat beetles, grasshoppers, crickets, leafhoppers, caterpillars,
moths, and sow bugs. Skinks are clothed in minute shiny scales, and our local species has brown and white longitudinal stripes along its body. The color pattern is more intense in the juveniles, differing entirely from the adults in the possession of a bright blue tail. This appendage is extremely fragile, and will break off at the slightest touch. Once it is separated from the main body, the tail goes into convulsions and thrashes about. The hungry predator is attracted by the writhing tail, and while it is busy consuming it the rest of the lizard makes its escape. A young skink’s distinctive tail increases the likelihood that the aggressor will make its first strike at this expendable appendage.

Many species of lizards share this type of escape mechanism. The whole procedure is possible because of cartilage fracture zones in most of the tail vertebrae. These are planes of weakness, where sufficient stress can separate the tail from the main body. The force for the separation is supplied by the brief tug of war between the predator and the lizard. Afterwards, the tail will be slowly regenerated. The previously bone vertebral column will be replaced by a cartilaginous rod, and the new tail will not be a perfect texture or color match of the original. It is still as functional as the first tail, breaking off from the body whenever it becomes necessary. The caudal vertebrae closest to the body lack fracture planes. This part of the tail contains important structures such as fat bodies and hemipenes and cannot be discarded.

Skinks walk with a typically plodding lizard gait when there is no need to hurry, but if hard pressed they can move rapidly with snakelike undulations of their body. Although active during the day, they usually remain out of sight. Most skinks are discovered by the rustling sound they make as they move through dried grass or leaves. A dedicated search through rotten logs, under bark, and beneath stones is also likely to turn up at least one specimen. The female lays her eggs in such secluded areas. Unlike most lizards, the female may stay with the eggs until they hatch.

Rufous-sided Towhees are common birds in the woods, displaying a white belly, rufous sides, and a black back speckled with white. Towhees kick up the detritus on the ground, examining it with their bright red eyes for any insects or seeds that were exposed by the foot work. If anything edible does come into view, it is promptly grabbed in the bill and then swallowed.

Slender Salamanders must occasionally suffer this fate, as they are abundant among the fallen oak leaves during the wetter portion of the year. These amphibians frequent both grassland and woodland habitats, with sufficient moisture being the primary limiting factor. They completely lack lungs, depending on a moist skin to transfer enough oxygen to their working cells. When the dry season arrives, Slender Salamanders retreat into worm burrows and other subterranean refuges. It is here that the eggs are probably laid, because only a few egg sets have ever been found. The eggs hatch into small salamanders that are miniature copies of the adults. These are peculiar animals, with wormlike bodies and short legs. If they are touched,
they will often undergo violent contractions that cause them to bounce about the ground. Small insects and mites make up the bulk of their food, and these abound in the moist litter the salamanders inhabit. They capture organisms by walking up to them and shooting out a sticky tongue at the prey.

Ringneck Snakes are one of the main predators of Slender Salamanders, but they will also take other salamanders, frogs, slugs, and worms. These snakes will be found wherever their prey is numerous. They are slender animals, and only reach a length of twelve to thirty inches. A distinct orange or red neckring stands out sharply from the olive or blackish dorsal surface. The bellyside (ventral) is orange to red, with the color becoming more intensely red as you progress toward the tail. When startled, a Ringneck Snake will often coil the tip of its tail into a tight spiral, revealing the reddish underparts to the animal which disturbed its normal routine. This is a warning that the snake is toxic or distasteful. Bright colors are often used as warnings in nature, since harmless animals usually stand a better chance of surviving if they blend with the surrounding habitat. Primarily nocturnal, this species is usually discovered when curious people overturn rocks to see what lies beneath.

Earwigs are frequently found underneath rocks in the oak woodland and grassland communities. It is not uncommon to find a female brooding eggs. She will even stay with the young for awhile after they hatch, which is very unusual behavior for nonsocial insects. The abdomen of these animals terminates in a pair of tweezer-like structures. They are pushed menacingly toward a potential predator, an action which has earned them the nickname "pincher bugs". Nevertheless, it is mainly bluff, with extremely few documented cases of successful pinches on record. The tweezer's primary purpose is the manipulation of the delicate hind wings. First, the wings are pleated and folded like a fan; then, they are folded twice more and tucked securely underneath the short leathery forewings. Earwigs are omnivorous animals, although they do have a preference for animal matter. Gardeners become upset when these insects add small quantities of flower petals to their diet. Fortunately, unless you sleep on the floor of a thatched hut, there is no danger of them crawling into your ear.

Scorpions are also found under the rocks in the woods, and they have a much more effective pinch. At night they emerge from their hiding places, holding a pair of powerful appendages out before them as they walk across the forest floor. Each of these limbs ends in a huge claw, and they are used to grasp any small insect or spider that comes within reach. The stinger at the apex of the abdomen is then brought down to pierce the body of the prey, injecting a poison that quickly finishes the captive's struggles. Luckily, our local species are only mildly venomous to humans, with a sting that is about as toxic as that of a bee or wasp. Scorpions are easy to locate at night, even though their bodies are inconspicuously colored. An ultraviolet light will
cause their exoskeletons to fluoresce brilliant greens or violets, which causes them to stand out sharply from the surrounding habitat.

The young are born live, and spend their first one or two weeks in the outside world riding upon the back of their mother. Possibly to avoid a mishap, they lack functional stingers at this time.

Western Gray Squirrels have a white underbelly, gray body, and bushy tail. They are often sighted as they race about the ground in search of acorns. The nuts drop in the fall, which means the squirrels have to come down from the safety of the trees to collect them. Each individual acorn is buried in a separate hole three to four inches deep. Later, when hunger stirs it, the squirrel will relocate the food with its acute sense of smell. These rodents also use their noses to locate truffles, a type of fungi found growing underneath oak trees. Truffles grow completely underground, and are only exposed to view when they are dug up by an animal. The squirrels also eat other types of fungi.

The ground is a dangerous place for these animals. It is here that most of their predators capture them. Large hawks, owls, coyotes and bobcats all prefer to apprehend this rodent when it is grounded. If you surprise one of these squirrels when it is on the forest floor it will usually rush up the nearest tall tree, pausing halfway up to scold you with a rapid series of barks. Their dens are also located in the sanctuary of the treetops; either consisting of an enlarged woodpecker hole or an original structure constructed from shredded bark and twigs.

They are well adapted to the oak woodland community, but sometimes manage to extend their range into the higher mountains; a habitat where survival is much less likely for animals like themselves. Snow carpets the ground during the winter, making it difficult for them to locate the single conifer seeds they had previously buried. The agile martin can also capture them after they have reached the upper branches of the trees, and it can even follow them into their dens. Douglas Squirrels and Red Squirrels have evolved in this coniferous habitat. They bury their conifer cones in large caches, which means that a single tunnel through the snow will make all the cones available. These squirrels are also nimble enough to elude the martins during the chases through the branches, and their woodpecker hole dens are too small for the predators to force entry. Every species is best adapted to the habitat in which it evolved.

Many other species besides rodents and deer feed upon the acorn crop. The best known is the Acorn Woodpecker, an overall black bird that has a red cap and white facial markings. It is a gregarious species, and several may be seen working the same tree. Their raucous calls are voiced much of the time they are in the area. Although hazelnuts and other nuts are taken
when they are available, acorns provide the staple diet. The acorns are stored in the bark of
trees, in individual holes which have been drilled especially for this purpose. Each nut is
pounded into the tree point first, a process which does not hurt the tree. The acorn does not
penetrate all the way through the bark, but it must be driven in flush or a passing jay or squirrel will remove it. Barring this type
of loss, the acorn will remain embedded until the woodpecker
 takes it out. It is carried to the top of a branch; where it is
placed in a crack and hammered to pieces by the steady actions
of its strong bill. The bite sized fragments are eaten on the spot
or taken to the nest and fed to the young. In the spring and
summer months, this vegetarian diet is supplemented with
insects such as grasshoppers, beetles, and flies.

Much of the acorn crop is attacked before the nuts ever fall
from the trees. Female acorn weevils are attracted by these
fruits and fly to them in great numbers. After landing upon an
acorn, one of these beetles will use its long proboscis to chew a
tunnel into the interior of the fruit. Instinctual behavior insures
that the weevil selects an excavation site close to the cup of the
acorn, where predators will be less prone to notice the passageway. Once the pathway is
completed, the beetle will turn around and oviposit in the hole. It will then fly off and repeat
the process at other acorns. When the eggs hatch the immature white grubs will consume the
nut from within. A single acorn may contain several of these small larvae. They eat until they
are fully grown, and then transform into a resting stage or pupa. After several months of
development within the pupa, a mature weevil will emerge and dig its way out of the acorn. It
then flies off and seeks out its own kind. After mating, the females will lay their eggs in the new
crop of acorns; completing one full circle of the life cycle.

During the spring, an amazing number of eggs and young birds are eaten by Stellers' and Scrub
Jays. Although both are found in our region, the Stellers' can be told at some distance by its
black crest. They are opportunistic at all times; feeding on acorns, fruit, seeds, and insects
whenever they become available. Jays are noisy and aggressive birds, often following and
scolding larger predators that have come to their attention. It is worth investigating whenever
these birds are exceptionally noisy; you might be lucky enough to see a weasel or a bobcat.

Along the forest edges, small birds are often seen perched on barren limbs. If one of these is a
flycatcher, it will soon dart out into the air, returning to its favorite perch after it captures the
insect which had been flying past. An elusive prey item sometimes results in an exciting display
of aerial acrobatics, because the flycatcher will follow the erratic flight path of the fleeing
morsel. A large prey item may be rapped on the perch a few times before it is swallowed. There are several species of these brown to greenish birds, and they vary in length from four to seven inches (tip of bill to end of tail). It is very difficult to tell them apart. Collectively known as flycatchers, these birds tend to sit up relatively straight as they survey their world for approaching food. The success of their hunting is improved by their possession of flattened bills, which act to increase the size of their gape. The odds are improved still further by the tiny, stiff, bristlelike feathers in the corners of their bill. These direct an insect in toward the middle of the mouth.

Accipiters scan the forest for any small bird they can catch unawares. These are powerful hawks, with streamlined bodies and long narrow tails. This allows them to fly fast and maneuver well, but it makes them very poor at soaring. This is no loss, since they work within the forest cover where soaring flight would be impossible. They will often pursue their prey, instead of relying exclusively upon surprise. The Cooper's Hawk is our largest accipiter, but the closely related and smaller Sharp'-Shinned Hawk is also common on the preserve. Both of these species will feed upon birds such as flickers, quail, flycatchers and jays. The menu is not just restricted to birds. They will also eat squirrels, mice, rats and large insects. Whatever the animal, once a victim is sighted it is doomed unless it can rapidly obtain dense cover. A dramatic chase often occurs. When an accipiter captures a bird it, will pluck the feathers off before eating it. Therefore, when piles of bitten off feathers are found on the ground, the observer knows that an accipiter has eaten a bird at a nearby perch. Like other hawks, they might rip open the abdomen of the prey, feeding on the entrails of the carcass first. They do this to satisfy their thirst, since they do not drink water like other birds. This is a really peculiar trait; even owls and vultures will drink free water.

At night, the ecological role or niche of the hawks is taken over by the owls. One common species on the preserve is the Screech Owl. It looks like a miniature copy of the larger Great Horned Owl. Screech Owls have a wingspread of about two feet, and feed upon birds, mice, shrews, moles, salamanders, frogs and insects. Because of its small size, this owl is vulnerable to predators such as its larger relative. Consequently, they nest in tree holes instead of using a more vulnerable open nest. Any suitable natural cavity or old woodpecker excavation will appeal to them.

Bobcats are heavy set animals with small ear tufts and a short five inch tail. They den in rock crevices, hollow logs, or beneath downfalls, and can be found in any of the terrestrial habitats. The home range has a diameter of about four miles, but they will occasionally wander as much as fifty miles. Although they are very powerful animals, these cats only weigh about twenty pounds. Prey consists of squirrels, gophers, rats, meadow mice, deer mice, harvest mice, rabbits and hares. Now and then a small or weakened deer is added to the list, and they will
eat carrion. In refutation to the arguments of some hunters, Bobcats seldom eat birds. The ones that they do manage to catch are probably diseased, and so the avian population is actually aided; because the sick animals are removed from contact with healthy birds. Much faulty data comes from the trappers' practice of baiting: their traps with the heads, wings, and viscera of game birds. The result is that stomach analysis of the captured cats appears to show that they have been preying on these animals, whereas all it really demonstrates is that they were feeding on carrion. The Bobcat and the local avian population have coexisted for thousands of years. It is extremely unlikely that the feline will cause any bird species to go extinct in the immediate future.

POND COMMUNITY

A pond is any body of water that is shallow enough for rooted vegetation to grow all the way across the bottom. It also has to be relatively permanent, retaining water through all the year's seasons. Although they were originally man made, the two ponds on the preserve have developed a natural appearance. They are now surrounded by an almost impenetrable growth of cattails and tules, with the water column itself supporting a great diversity of plant and animal species. This change is an example of ecological succession.

The biotic communities within a region exist there because of a combination of factors: soil type; available nutrients; accumulation of organic matter; amount of moisture, wind and rain; frequency of fire; length of growing season; available light; interactions between the species; and other variables. It is not a static situation, and if the controlling factors change there will be a corresponding alteration in the structure of the biotic community. Any such unidirectional change in species composition and abundance within a community is referred to as succession. Eventually, ecological succession will lead to a relatively stable community that is capable of maintaining itself. This "stable" community is called the climax. It can exist as long as the general climate of the region remains constant.

In Cattail Pond, the cattails are moving inwards toward the center of the pond; removing some open water with each season of growth. The band of cattails is now ten to twenty feet wide, leaving a one hundred by fifty foot region still clear of emergent vegetation. This central area is also choked with dense growths of submerged aquatic vegetation. The serrated, whorled leaves of the Hornwort are jammed tightly against the soft translucent ones of Elodea. Together, they occlude almost all views below the surface. Occasionally a rare open area is found, and you can
peer down and see the clustered growths billowing up all the way from the bottom. This represents a full ten foot wall of plants, all striving to obtain the solar light at the surface. This pond is fed by seepage and is free of the suspended particle load a stream would bring in, but the masses of aquatic plants contribute a tremendous amount of organic matter each year when they die.

Tule Pond is fed by a stream, which is probably why a central island of vegetation has already developed. It then the fast moving stream waters enter the pond they slow down considerably, and most of their load of suspended material is dropped to the pond bottom. This has tended to fill in the pond faster, allowing plants to become established in the shallow zone in the middle of the pond. Curiously, the island and perimeter of the pond supports a dense growth of tules, with cattails being uncommon. Even more interesting is the absence of any submerged vegetation, can result of the solid sheet of duckweed that grows upon the water surface. Very little light can penetrate through this living barrier. Duckweed is a tiny flowering plant, but it rarely flowers; choosing instead to propagate by asexual budding. A handful of duckweed will contain hundreds of the tiny plants. Numerous amphipods will also be represented in the haul. These small crustaceans feed upon the duckweed mass. Flatworms are also common here. Two dimensional animals, they glide along the objects in the pond in search of the decaying matter that is their food.

Since there is more available light at Cattail Pond, it has many more species of algae. These are microscopic plants, but they often become visible to the naked eye when hundreds of individual cells become connected in long filaments; the filaments then intertwining to be seen as greenish scum growing upon the surface or other plants. Other species form smaller chains or remain unicellular. These are only revealed when a sample of water is viewed through the powerful lenses of a microscope.

Algae are actually found in many different habitats. They only become physiologically active where there is enough moisture. Algal cells have little means to prevent water loss. However, because of their microscopic nature, they can thrive in the moistened mud surrounding the ponds. During the rainy season, every bare spot of soil will literally be alive with algae. A few species also live on the comparatively dry surfaces of fence posts and buildings, while others are even reputed to breed high up in clouds. Aquatic situations, though, are the habitats where algae do best. Any lake, pond, hot spring, drainage ditch or creek will have its share of these minute plants.

They frequently appear quickly after water is applied to a dried up habitat. This is because they can resist dry conditions in an inactive state for a very long time, multiplying rapidly when conditions again become favorable. Even the normal vegetative cells have been known to germinate after fifty years of dried storage, and the specialized resistant spores must remain
viable for considerably longer. Dispersal to new regions is not difficult. The spores are so tiny that some are borne to distant places in dust clouds. Dust clouds originating in Arizona have been known to travel east of the Mississippi before coming to earth. Pieces of algae and resistant spores could also lodge between the feathers of aquatic birds, or even upon the body parts of water living insects. When the animals land in a different water body the algae have a new place to grow and multiply. Dispersal is so easy for algae that many species are found throughout the world.

Although tiny, it is a mistake to consider these plants unimportant. A good portion of the earth's oxygen exists because of the activities of algae. It is a mere byproduct of their photosynthetic reactions. The food they produce through this process also forms the base of most of the world's aquatic food webs. The oceans, where most of the algae are found, cannot be used as an indiscriminate dumping ground for toxic wastes if future generations are to be assured the right to breathe.

A silent approach to the ponds will sometimes reward the stealthy hiker with the sight of a flock of ducks upon the water surface. Once aware of your presence, they will probably start to take off. They face into the wind, and then flap their wings while running on top of the water; a combination of actions that provides enough lift to get their heavy bodies into the air. It is a seemingly laborious process, a possible side effect of their high adaption to the aquatic environment. Three of their toes are webbed, an arrangement that provides more surface area against the water during each swimming kick. Since they spend such a large amount of time eating in the water, they highly waterproof their feathers with oil from tail glands at each preening session. The bills have a row of fine partitions along the inner edge. This allows them to strain mouthfuls of mud or plant material through their bills, leaving small food items like insect larvae within their mouths.

During the spring of 1978, a flock of ducks ate almost all the duckweed cover from Tule Pond, and it was several months before it returned to its former abundance. Dabbling ducks are most likely to be found in this pond, since the water of Cattail Pond is too deep to allow the birds to dabble. This is the process in which they reach underwater with their heads, tipping their bodies so just the rump and tail remain above the water. Mud from the bottom can then be strained through their bills. Mallards are common ducks of this type, and over ninety percent of their diet is composed of vegetable matter such as duckweed and seeds. The seeds are from sedges, grasses, tules, cattails and willows. A large number of mosquito larvae and pupae are also included in the diet.

Wood Ducks also feed on a lot of vegetable material, but most of it is collected from above the water. They will also eat on land, which results in a varied animal fare of mayflies, beetles, minnows, tadpoles, and even some snails and salamanders. Since they must be able to see
what they will be feeding upon, their bill is narrower than that of a Mallard's. This adaption facilitates the capture of wary prey.

These beautiful animals get their common name from their choice of nest sites. They generally nest in abandoned flicker holes, and these are often fairly high up in trees. After the young hatch, they flutter down to the ground and are led to the water by the female. If there is a lot of debris near the nest or it is located too far from the water, the female may choose to carry the ducklings to the water one by one in her bill.

Most birds are altricial, which means they are born blind and helpless. Ducks (and quail) have precocial young. This type hatches with a full covering of down. They are also able to scurry about the ground, swim, and even capture the majority of their food. This is an effective method for ducks, because the young can obtain most of their normal type of food without having to fly. There is a lot of available prey in the size range which they can capture. There is some liability in that the eggs take longer to hatch, because they need the extra time to pass through the naked blind stage at which other birds are born.

Another type of bird common to both ponds is the rail, and both Sora and Virginia Rails are present. They are highly secretive birds that are hardly ever seen. By clapping their hands rapidly, some people can get the elusive rails to voice their characteristic calls. Even if rarely visible to humans, they still provide important functions in the pond community. The long pointed bills of both species are ideally suited to apprehending the insects that are common at the ponds. Sora rails will also swallow the filamentous algae, possibly obtaining extra nutrition from the aquatic animals trapped within the network of filaments. Although relatively large birds, they have long toes which allow them to walk upon the floating vegetation of Cattail Pond. You are most likely to actually see one of the rails during early morning hours or when it is raining.

Pacific Pond Turtles are common in both ponds, but are more easily seen in Cattail Pond where they bask upon floating boards. The five to six inch carapace and body parts are olive to blackish, with black spots or lines on the head. You must approach carefully or they will slip off their floating islands, splash through the surface tension barrier and swim to the safety of the bottom. The female turtles have to leave the water entirely to lay their eggs. They dig earthen cavities for these precious objects, and completely cover them with soil after the entire clutch is laid. This reduces the chance that the eggs will be discovered by a hungry raccoon. Pacific Pond Turtles are omnivorous, sating themselves upon carrion, aquatic vegetation, and insect life. In the northern part of their range they hibernate through the winter in the bottom mud, but our local turtles apparently just become more sluggish.
In early spring, Rough Skinned Newts can be seen migrating overland. The orange ventral surface contrasts strongly with the brown dorsal surface. A set of bright warning colors is used by many different toxic animals to train potential predators to leave them alone. The newts are no exception. Their skin is highly poisonous. When confronted with a possible predator, many of the newts will arch their bodies strongly upward, revealing the orange color pattern to the larger animal. On the other hand, a completely orange animal might attract too much attention. The newts blend with the environment most of the time, hiding the warning colors until it is absolutely necessary to display them.

The newts travel to ponds or pools, often the same one they emerged from after metamorphosis. They fold their legs against their bodies and swim with powerful motions of their tails. Their graceful swimming ability is all the more beautiful when compared to the awkward ungainly gait they have to resort to on land. Pairs of newts are often seen swimming around in an apparent copulatory process. This is actually just stimulation behavior. After a while, the male will sink downwards and deposit a packet of sperm on the bottom. The female soon follows. She locates the sperm cluster by scent and walks over it, pressing it into her cloaca. Her eggs are soon fertilized by the swimming sperm, and each one will be attached to aquatic vegetation individually. The related California Newt deposits its eggs in globular masses, but it is much less common in our area. Newts are not very agile or quick animals when after food, and depend on long waits or slow approaches to get them their insect prey.

The ponds are also the best place to see the greatest numbers of dragonflies and damselflies. Damselflies are delicate in general appearance and size, and fold their wings above their bodies when at rest. Dragonflies are of stocky build and better fliers, holding their wings straight out from the sides of their bodies when alighted. Both types are fascinating animals to watch. They capture aerial insects in flight by folding their spiny legs into a loose basket, quickly transferring the startled prey to the powerful chewing mandibles before it can escape. Although they may travel far from water while searching for food, they are concentrated near ponds and streams. This is where they must come to perpetuate their kind. After a complicated copulation process, a pair of these insects will often fly about for some time in tandem. Most species lay their eggs directly into the water. Others attach them to aquatic vegetation or even insert them within the tissues of the plants.

The larvae which hatch from the eggs are equally predaceous, shooting out their hinged lower jaws to capture any suitable animals that pass before them. Soft bodied mayfly nymphs and tadpoles must take the bulk of the assault, but beetle larvae, water bugs, and even small fish are also taken. Dragonfly larvae are stout, with anal gills located within the rectum. They can make a rapid escape by ejecting a stream of water from their anus, and so make use of jet propulsion; just like the oceanic squids. Once again, the damselflies are more delicate. Their
larvae are slender and have three paddle like gills at the posterior end of the body. Both types of larvae show gradual development into the adult form, with the wing buds becoming a little larger with each successive molt. Finally, the nymphs crawl up pieces of vegetation and climb out of the water. After a quiescent period of several hours, the larval skirts split for the last time and adult insects emerge. In this state these winged acrobats are at the mercy of any predator: they cannot fly until their wings harden. The cold of night also immobilizes them, and they must wait for the sunlight to warm their frigid bodies before they can become airborne.

Our planet abounds with insect species. They dominate all biotic communities except those of arctic or marine nature. Insects have hard exoskeletons and a three-art body plan; possessing head, thorax and abdomen. There are always three pairs of walking legs on the thorax, and it usually also bears two pairs of wings, A pair of antennae are mounted on the head. These small animals range in size from one hundredth of an inch to over six inches in length, and they are the most successful type of life on this planet. There are probably two to four million species of insects existent at this time, while there are a mere 1500 species of mammals and 8600 species of birds. Each of the insect species is incredibly numerous. They also represent a very stable group, with a genealogy that extends back 100,000 years in the fossil record. During their evolution they have diversified tremendously, and now capture most of the energy in the world's food webs.

The insect's body is surrounded by an external skeleton which protects it from the rigors of the environment. This exoskeleton also provides attachment sites for the powerful muscles. It is hardened to various degrees, and is the site of most insect coloration. A thin coat of wax on its outermost portion greatly reduces water loss. One of the main disadvantages of the system is that the external skeleton is too rigid to allow much growth of the animal trapped within it. The growing insect must periodically shed this restrictive armor, an action which leaves it in a soft and highly vulnerable state. When an insect begins to discard its exoskeleton it may gulp in air or water. This has the dual function of splitting the old skin and stretching the new one underneath before it hardens. The insect can then gradually grow into its new covering. With the exception of mayflies, flying insects do not molt. This means that they are incapable of further growth. Size differences in adults of the same species result from sexual dimorphism (differences between the sexes) or nutritional deficiencies in some of the immature stages.

In insects, oxygen is not transported by the circulatory system. It is carried to the tissues by a complicated system of branching tubules called trachea. This respiratory network opens to the outside through holes called spiracles; structures that can be opened or closed at will. Diffusion alone is usually enough to account for the movement of oxygen into the tissues and waste carbon dioxide out. Some insects also have air sacs in the tracheal system, and these act as bellows when the abdomen changes shape. Very active insects such as bees and flower flies can
be seen vigorously telescoping the abdomen in and out to increase the flow of air in the tracheal system. You can also look for this in large insects like grasshoppers; simple diffusion is not quick enough to supply the cells of animals with their mass. The tracheal system is so efficient that air can be channeled through the body without ever having to retrace its path through the trachea, which means that air flow is continuous. Insects can inhale and exhale at the same time! Closing the spiracles also decreases the amount of water lost from the system, a big problem in vertebrate lungs. Further water retention is achieved by eliminating nitrogenous wastes in the paste-like form of uric acid, a technique of water conservation also utilized by birds and reptiles. Mammals excrete such wastes in the much more toxic form of urea. This makes it necessary to dilute it to a safe level with lots of water before it can be voided to the environment.

The sensory system of the insect is highly developed. The numerous tiny hairs seen projecting from the body of a captured insect are all sense organs. When one of these hairs is moved in its socket the insect perceives the sensation of touch. Extremely sensitive, the hairs are even able to detect changes in air currents. They are specialized in various regions to enable the insect to taste and smell. Many butterflies, moths, flies and bees taste with their feet, automatically extending their proboscis when their feet touch something sweet. More careful taste analysis is done with the mouthparts before the potential food is actually ingested. The sense of smell is mainly confined to the antennae. Most insects possess simple light sensitive cells called ocelli. More complex compound eyes are formed when many ocelli-like visual cells are packed together. There may be 4,000 of these hexagonal facets in the eye of a housefly, and a dragonfly may have as many as 28,000. Every one of these visual units has a lens and a retina. A special pigment around each cell keeps the images from overlapping. There is no way to really tell how good an image is perceived by the insect compound eye, although it is generally assumed that a greater number of visual cells means better visual acuity. Anyone who has ever tried to capture an active dragonfly knows that the resolution is certainly good enough.

The developmental process of insects also contributes to their success. More primitive insects exhibit gradual metamorphosis. Grasshoppers, dragonflies, true bugs, earwigs and bristletails fall into this group. With this type of development, each successive stage is somewhat closer to the adult’s form. The wingbuds on the young stages are very evident. More recent kinds of insects have complete metamorphosis. It is exhibited by bees, beetles, flies and butterflies. This is where the larvae does not look at all like the adult, and transforms to the adult form in a resting stage between the last larval stage and the adult. A caterpillar does not gradually change into a butterfly, but does it entirely while within the resting (or pupal) stage. This allows the young and adults to obtain energy in two separate ecological niches, eliminating the usual competition between the young and adults for food.
Finally, their tremendous numbers give insects a huge buffer against environmental change. There are enough different combinations of genes in the populations that some will be able to adapt to almost any new situation. This is true whether it is the age old chemical warfare between plants and insects or the newer one launched against them by humans. There will always be some individuals that are immune to the attack, and they are the ones which will survive and multiply. This is why pesticides such as DDT are highly successful at first, but soon become less potent as the insect populations select for immunity to the chemicals.

At the ponds, a portion of these insect legions can be seen flying over the surface of the water. If you view this scene toward twilight, the oblique angle of the sunlight will illuminate the wings of these tiny animals, revealing the air to be filled with their flying forms. It is at these times of the day that the swallows fly over the ponds. These agile birds are specialized insect eaters, depending on their long narrow wings to provide the maneuverability necessary to overtake their prey in flight. In addition, they have a wide flattened bill to increase the gape of their mouths. Swallows are rapid flyers and frequently change the direction of their flight, demonstrating superb coordination and balance at all times. They capture small insects such as midges, mosquitoes, flies, bugs and leafhoppers.

The Black Phoebe is a flycatcher. It is not built to expend much energy in the pursuit of a meal. This species sits on a perch until an insect is plainly in sight, and then flies out to make the capture before returning to its perch. Sometimes they will take aquatic insects when the small animals surface to obtain air. The Black Phoebe is a handsome species, with an all black upper body and a pure white underbody. This conspicuous plumage has tempted many authors, including this one, to mention that it looks like the bird is wearing a tuxedo.

The pond is also the residence of other insect feeders. Red-legged Frogs are common sights on top of the aquatic vegetation, sometimes coming out on land along protected shores. If you approach Tule Pond carefully, and look underneath the large willow tree, you might see them before they become alarmed. Most people only become aware of them by the splash they create when they jump into the water. Although they are pond frogs, they are occasionally seen traveling overland during the rainy season. Red-legged Frogs are our largest native frog (2-5"), and have a distinct reddish coloration underneath their legs. Bullfrogs are also common in the ponds, but they never venture far from permanent bodies of water. They have very conspicuous eardrums, and range in length from three to eight inches. It is claimed that their catholic diet is going to lead to the elimination of the Redlegged Frog, since they will eat anything that they can jam into their mouths. On the preserve, it seems there is enough aquatic vegetation in the water to allow the smaller frogs to hide. Otherwise, management steps would probably be required to reduce the population of introduced Bullfrogs.
The final pond used in this program has a completely different character from the two that are on the preserve. It is also man made, but has suffered severely from the impact of the cattle which graze the surrounding countryside. These beasts trample or eat any vegetation that attempts to sprout around the pond perimeter, because the cattle come to the pond to satisfy their huge thirsts. Fortunately, an island of willows and other plants has managed to survive. It is in the center of the pond and beyond the effective reach of the herbivores. The water itself is grossly polluted from the nitrogenous wastes of the cattle, which urinate and defecate in the pond and along its shores. This over enrichment with nutrients has eliminated the normal shortage of available nutrients and resulted in the eutrophication of the pond. A tremendous algal bloom has been encouraged, making the water appear green. The accumulation of organic matter from the dying algae will shorten the life of the pond. The production of plant matter is so great that hardly any of it manages to decompose, and a layer of mud several feet thick has already developed. Just like the other two ponds, ecological succession will eventually lead to a freshwater marsh, but here the actions of the cows have greatly speeded up the process.

Few turtles are found here, and Red-legged Frogs are absent. Bullfrogs are quite abundant. There is also still a large population of stocked fish in the pond, with both Bluegill and Largemouth Bass represented. This is what mainly attracts the kingfishers. Belted Kingfishers have a large head with a ragged crest, and a long straight bill that seems oversized for a bird that is scarcely twelve inches long. The result is that the bird appears top heavy on its small legs and weak feet. As usual, the feeding behavior of this strange predator reveals that the peculiar body is actually beautifully designed. It hunts over the water, either from a perch or by hovering, and dives down below the surface to capture fish or tadpoles. The heavy head serves to absorb the shock of impact when the bird hits the water. Food is captured with the bill, so the feet do not have to be large or strong like those of hawks or owls. The prey is subsequently swallowed head first, and indigestible bones and fish scales are later disgorged. When fishing is bad, these birds have been known to eat frogs, mice, or even large insects.

Kingfishers dig burrows in banks above the water, loosening the soil with their heavy bills and then pushing it out with their feet. The toes of this bird are arranged two forward and two backward, and the two front ones are fused somewhat near their base. This helps to reinforce them for the digging activities. Since there are not any suitable banks in this area, Belted Kingfishers do not nest on this mountain. They are sometimes chased by Cooper's Hawks, but it is usually easy for them to avoid the raptors' talons. They are never far from water, and a quick dive beneath the surface will shake off the most persistent pursuer.

Herons are also seen at this pond. Their diet is similar to that of the Belted Kingfisher, but they will tackle larger animals. They are wading birds well over three feet high, with most of this length being contributed by the long legs and neck. The legs hold the heron above the water
while it slowly stalks through the shallows. When something edible is felt or sighted, it pulls back its long neck and suddenly strikes down beneath the water's surface. There is often a fish or tadpole visible in the bill when it is withdrawn from the water. If the prey is large, the heron may fly to land with deep beats of its wings, legs dangling, and then whack it a few times on the ground before swallowing it whole.

Great Blue Herons also spend a considerable amount of time feeding on land. Their legs hold them far enough above the surface that they can easily see down into the grass of meadows and marshes. Their high vantage point reveals prey such as frogs, mice, shrews, rats, frogs, and large insects like grasshoppers and dragonflies. This dual method of feeding allows the herons to exploit two separate biotic communities, as they gather food from both aquatic and terrestrial habitats.

Due to the stress on this pond from the cattle, it is a much simpler community than the other two ponds. A general ecological principle states that the more species there are in a community the greater its stability. Undisturbed communities usually have a very high species diversity. In this community, the fish and frogs are supporting many other populations of animals. If the pond became more polluted they might die off, creating violent oscillations in the size of all the other floral and faunal populations in the pond.

In the other ponds there are many more different types of producers, herbivores, and carnivores; only a few of which have been mentioned in these pages. The producers are the green plants which manufacture their own food through photosynthesis. Herbivores feed directly on the plants, and carnivores feed on other animals. In a stable community the interactions between all the various populations can be extremely complex, and this increases the stability of the community. If something happens to one herbivore species it does not matter that much; there are many other herbivore species to eat the plants and be food for the carnivores. Increased species diversity will always lead to greater overall stability. Any outside stress will decrease the species diversity and so make the community less stable.

FRESHWATER MARSH COMMUNITY

The freshwater marsh community surrounds the two ponds on the preserve, and is also found in several other scattered locations. It occurs wherever the ground is saturated with water, often appearing next to springs that bubble water up from underground sources. For the most part, little surface water is visible most of the year. It is only during the period of winter storms that a layer of water flows overland through the marsh. However, even in the dry season the ground is always wetter than in the surrounding terrestrial communities, which restricts the type of vegetation which can grow there. Triangular stemmed bushy sedge plants are common
in this community, as are the round stemmed rushes. Several grasses, such as Slim Head Manna Grass, Deschampsia, and Creeping Wildrye are only found in the freshwater marsh.

This is also the preferred habitat for Stinging Nettle. It is a serrated leaved plant that may grow up to five feet tall. The name comes from the numerous stinging hairs on the stems and foliage. Each has a spherical ball at the tip, and when you brush against it, the ball is broken off, leaving a thin, jagged structure which easily penetrates mammalian skin. A supply of formic acid at the base of each broken hair is then injected into your skin by the impact of your touch. The resulting burning sensation is only temporary. If you do not scratch, it will only last about thirty minutes. However, the discomfort is sufficient to make you understand why most herbivores leave Stinging Nettle alone.

Giant Horsetails, found throughout the marsh, thrive in soggy soils. The vegetative green growth is most familiar. It consists of a main stalk up to two and a half feet high, with numerous whorls of side branches most people confuse with leaves. The actual leaves are the small scale structures closely appressed to the stern. Heavy glass content in the tissues also makes this plant unpalatable to the average herbivore. It is the green stem and branches, not the leaves, that carry on photosynthesis; A portion of the sugars produced are conducted to the underground stem and roots. The saturated soil does not allow enough oxygen flow to these underground parts of the plant, and so all the stems contain large continuous air canals.

Actually, the first Giant Horsetails to become visible in the spring do not look like horsetails at all. These white nonphotosynthetic stems push their way up through the earth and continue to elongate, eventually producing a two inch long spore cluster at the top. When ripe, tapping this elongate, cone-like structure will produce a dense cloud of millions of spores. Carried by the winds in an unpredictable fashion, they travel outward from the parent plant and must reach a suitable habitat within fifteen days or they will die.

Another plant of interest in the marsh is Cow Parsnip, a modern flowering plant. It grows up to eight feet tall. A huge flat topped inflorescence is found at the top of each branch of the stem. One of these floral units consists of hundreds of tiny green-white flowers. Each of the flowers manufactures both pollen and nectar, and a host of insect pollinators is attracted. Unlike many plant species, Cow Parsnip’s strategy is not to select for a particular type of insect pollinator. It maintains the fidelity of all its visitors by offering a huge amount of nectar. Various flies are the most abundant visitors, with flower flies, dung flies, and soldier flies all being common in the Cow Parsnip patches. Only animals with copious saliva can redissolve the nectar and obtain the sugars, because it is fully exposed to the sun and soon becomes thick and crystalizes.

Wasps also come to the flowers. Most bees ignore the plant; it does not produce enough pollen for them and their larvae. Beetles do not require such large quantities of the yellow substance,
which is why Long-horned Beetles are so plentiful here. Many of these pollinators share the need for a flower with a large landing platform. Since each individual flower is tiny, they are clustered into a huge inflorescence composed of hundreds of blooms. These particular pollinators also tend to be fairly unimaginative, so the food rewards have to be directly in view and easy to find.

Pacific Treefrogs are frequently encountered during a walk through this community. They are readily recognized by their small ¾ -2 inch size and the black line running along the side of the head and up through the eye. Delicate suction cups at the tips of their toes are a device that evolved to allow them to climb up any natural object, but they also happen to be good enough to enable the frogs to ascend up a pane of smooth glass. Their coloration is exciting; you never know what hue the next treefrog you find will be wearing. They can be green, brown, tan, gray, bronze, black or any combination of the above.

Treefrogs are amphibians, as are other frogs, toads, and salamanders. They are usually all found in aquatic habitats, since their moist skin is too permeable to water to allow them to travel very far from it. The atmosphere is almost always drier than the amphibians themselves, and so water will constantly diffuse through the amphibian skin and into the air. This is a fundamental principle of chemistry. Free molecules will always travel from an area of higher concentration to one of lower concentration. For the amphibian, this means that the drier the environment the quicker the moisture loss. They will die if they cannot periodically return to wet areas to renew their normal water content.

Although apparently a liability, the wet skin is essential to amphibians because~ they all breathe, to some degree at least, through their skin. Amphibian lungs are poorly developed, and some salamanders do not even have lungs. All that is required for respiration to occur is the possession of a highly vascularized (full of blood vessels) moist surface that is permeable to gases such as oxygen and carbon dioxide. This is a description of the mammalian lung, amphibian skin, the gill of a fish, and the tracheal system of an insect. Amphibians keep their skin moist with mucus secretions from the numerous glands smattered throughout their outer skin. If it dried up they would not be able to breathe.

Another factor that bonds amphibians to moist habitats is that their eggs can only develop in such places. Many species lay them directly in the water. During the breeding season, frogs, toads and newts are compelled to travel to our local streams and ponds. The territorial chorus of the vocal males is often audible for considerable distances. Fertilized eggs hatch larvae that do not resemble the adults at all. Those of toads and frogs are called tadpoles. Even then they are distinguishable, with frog tadpoles brownish and those of toads black. A gradual metamorphosis is required before the animals are suited for life on land. The gills are slowly reabsorbed and replaced by lungs, while limb buds push through the tadpole body and grow
into legs. The tail is the last vestige of larval life to go, and it is common to see miniature toads and frogs hopping around which still have a tiny tail.

Toads are able to tolerate drier habitats than frogs, but they still lose water just as fast as all other amphibians. Their secret is simply that they can remain alive in a much more dehydrated state. Western Toads are abundant in the freshwater marsh. They travel with a slow undramatic hopping motion. There is none of the agility and long distance leaping shown by the treefrogs. An explanation for this carefree manner of locomotion can be found in the bumpy skin of the toad. It is packed with poison glands, and so most predators find them totally inedible and leave them alone. Some raccoons do manage to eat them, discarding only the head and the very large poison glands situated close to it.

Amphibians are carnivorous as adults. They will eat almost anything they can overcome; and can manage to swallow surprisingly large food items. The short adhesive tongue of toads and the longer one of frogs is shot out of the mouth and swings around the intended prey, bringing the victim back with it when it returns to the open mouth of the amphibian. All sorts of insects, small mammals, and even other amphibians suffer this fate. The food items are swallowed alive and kicking, often with large organisms being jammed into the predator's mouth with quick motions of its forelegs. Salamanders and newts are less dramatic, usually merely walking up to an animal and grasping it in their jaws.

Distinctly striped garter snakes crawl through the marsh at all times of the day and night, but the rustling sound of their rapid retreat is all most people notice. If water is close by they may head toward it when disturbed. Garter snakes are excellent swimmers, propelling themselves through the water with rapid lateral undulations of their bodies. Depending on circumstances, they may chose to keep their head elevated or swim totally submerged. They are even rapid enough swimmers to catch fish, frogs, toads, tadpoles, salamanders, earthworms and lizards are also selected as suitable food whenever they are available. Just as in the case with the raccoons, toads can only make up a very small part of the dietary fare. A wild animal cannot afford to be ill, and even small amounts of the potent toad toxins are bound to make a predator
nauseous. All their food is swallowed whole, with the numerous pointed teeth serving to prevent the prey from squirming out of the mouth. In snakes, the jaws are hinged in five places and independently moveable, an anatomical marvel that allows them to swallow animals larger than their heads.

When accosted, garter snakes may bite. They are more likely to release foul smelling substances from their anal glands, mixing it with excrement before smearing it all over the aggressor. It is a tenacious smell, and is even difficult to remove with soap and water. These lasting qualities might make it a good base for a perfume, but in its present raw state most humans find it highly objectionable. Another interesting behavior of theirs is that they are live bearing animals. The eggs are retained within the body of the female until they hatch. In early spring, each fertilized female will give birth to up to seventy young.

Because they have a dry scaly skin, reptiles can stand more exposure to the sun than amphibians. Their outer layer is essentially waterproofed, very little water is lost through it. Periodically, the skin is shed to allow further growth. Most lizards and turtles shed it in small pieces, but snakes and alligator lizards discard their skins in one piece. A few days before a snake does this, its eyes will become cloudy. Since it is almost blind at this time, it will also tend to get somewhat irritable. The eyes clear up about a day before the snake is due to crawl out of its old skin. By rubbing against a rock or rough piece of bark with the front of its head, a tear is made in its worn out skin. This useless integument is then peeled off the new layer of skin beneath, just as you would remove a glove.

No reptiles are slimy. In fact, they have very few skin glands. The task of breathing is taken up by the lungs, which are much more useful than those of amphibians. The urine is voided in the form of uric acid, a substance that does not require the excessive waste of water for its excretion. These are some of the changes which enable reptiles to stay away from the water for longer periods than their amphibian ancestors.

The reptilian egg is another reason for their dominance of dry land habitats. It has a protective outer shell and three more internal membranes than those of amphibians. This greatly retards the loss of water from the egg while still allowing gas exchange with the environment. These terrestrial eggs can be hidden far from water sources. They are then less concentrated and so suffer less from egg predation. This in turn makes it possible for the eggs to contain larger food supplies, because survival of each egg is more likely. Full embryonic development can then take place within the protective shell. The young that emerge from reptilian eggs are miniature copies of the adults, and are able to fend for themselves.

The main types of reptiles are easily told apart. Snakes are legless and lack eardrums. Most lizards have legs, and all of them possess external eardrums. Although lizards superficially
resemble salamanders, the reptiles move much quicker and have dry scaly skin. Turtles do not require much description. Their heavy carapace immediately separates them from all their relatives.

All snakes are carnivorous, and so are the lizard species found in Sonoma County. Turtles have a mixed diet. They lack teeth, tearing pieces out of their food with horny beaks. Snakes and lizards do have teeth, but the dentition is not used to chew food. The backward projecting teeth are an adaption that insures the prey has only one easy way to travel, down the gullet of the reptilian captor. Many species will bite to defend themselves. Expect it whenever you pick one up, but do not let the prospect upset you. Unless the bite was from a poisonous species, the tiny pinpricks from the teeth are rarely significant. However, they should be cleansed to prevent infection. In California, only rattlesnakes are poisonous, and so you should be able to tell if disinfectant or a stronger remedy is required. Be sure to remember. that many snakes will rattle their tails in dry leaves or grass when disturbed, resulting in a sound that many people confuse with a rattlesnake. This mimicry is an adaption that evolved to give them some protection from being trampled by grazing animals, but with today's large population and abundance of macho humans it frequently results in the decapitation of a harmless animal.

Very few people fear the ground beetles that crawl about the marsh and other communities. These insects are committed to earth bound life; their external armor has thickened to the point that they can no longer fly. They are omnivorous animals, although they do exhibit a strong tendency to be predaceous. Any other small animal they come across is promptly dispatched by the powerful mandibles and eaten. Some have strong diet preferences, including a group that is specialized in form and behavior to eat snails. Ground beetles are an important group, and represent one of the largest families of beetles.

Beetles are the largest order of insects, comprising about forty percent of all insect species. This in turn makes them the most successful group of animals on earth. Part of their success is due to their exceptionally hard exoskeletons, an anatomical defense that makes them difficult to consume. Another factor is the great adaptive ability that they have realized. The evolutionary process has molded them into a vast variety of different shapes, sizes and behaviors. This allows them to occupy a great number of ecological niches. Since they have complete metamorphosis, the immature larvae do not compete with the adults for food. These immatures are often soft bodied and found in more protected habitats than the adults. No matter what their specialty, adult beetles are all recognizable by the sharp line the folded forewings make down the middle of the abdomen. Some of the more common families are the ladybird beetles, leaf beetles, ground beetles, weevils, rove beetles, scarab beetles and long-horned beetles.
There are also other types of ectothermic carnivores in the marsh. Orb web spiders stretch 10-15 inch diameter webs between the plants of this community. Only the circular strands are sticky. Radial ones do not contain adhesive threads. The beautiful black and golden banded spiders wait in the center of their architectural masterpiece until the web snares some passing insect. Caught in the sticky fibers, the prey will struggle in an attempt to get free. Few ever do. The adhesive is tenacious and the silk strands are exceptionally strong. A single strand, .1mm in diameter, can support 80 grams and stretch 20% before it breaks. Spider webs are so fine and strong that strands were used as cross hairs in bomb sights before the invention of synthetics. As strong as their webs are, spiders are not animals to take chances. They quickly run in and throw silk over the prey, often turning it around and around as they release the threads, only finishing when they have tightly packaged the victim in bonds of silk. The captured animal is then totally immobilized and neutralized. It can be sucked dry at the spiders leisure. Spiders hardly ever chew their food, nor do they swallow it whole. Instead, they inject poisonous digestive juices into the captive, which serves to subdue and partially digest the animal. The spider then alternates between sucking out the partly digested fluids and injecting more of its own secretions. Most species are not too particular about the types of prey that are eaten, but some spiders will cut difficult animals like ants and wasps out of their webs.

Spiders are not insects. They have a two part body and eight walking legs, Population sizes are often quite high. A single acre of meadow or marsh might contain around 2,300,000 spiders. Everyone of them has the capacity to spin silk. The spinnerets are located underneath the body at the posterior end of the abdomen, and silk of many different properties and thicknesses can be produced by these organs—Silk is the universal spider tool, although the various types of spiders use it for different purposes. Almost all will lay out a dragline of silk whenever they move about, every so often fixing it to the surface they are walking upon. That is why a dislodged spider is often seen hanging in midair; it had already taken the precaution of establishing a safety line.

Silk is often used to make a cocoon for the eggs. Toward fall, the Banded Garden Spiders' webs will almost all display a 1 inch diameter egg sac suspended from the strands. Before this could happen, mating had to occur. The male spider will usually build a small platform of silk and deposit sperm on it. He then sucks it up inside the leglike pedipalps at the front of his body and immediately starts his search for a willing female. The use of the pedipalps as the copulatory organs gives the male a little more reach when making amorous advances, helping him to make sure the female is more willing to mate than feed. If she responds too quickly, the wise male will make a hasty retreat. Spiders are not too particular when they are hungry, and the female may decide to satisfy one appetite instead of another.
Young spiders sometimes use silk to disperse to far distant places. They manage this feat by releasing strands from the abdomen until enough lift is created to carry them aloft. Spiders have been found 5000 feet up in the air, and they are the first animals to land on new volcanic islands. Of course, they are most famous for their webs. These structures are manufactured in diverse forms, but the type of web is fairly constant for each species. The percentage of sticky and non-sticky fibers also varies with the species, and many spiders never make a web at all.

Although one must get close to view the spiders, the numerous Song Sparrows in the marsh can be seen from a distance. Several are often in full view. They have calls and songs of different meanings, most of which can be heard just by walking along the marsh. Food consists of both seeds and insects. Territorial conflicts are frequently observed during the nesting season. At this time, each male attempts to stake out enough of the marsh community to raise a brood. The females will later select their mates, partly on the basis of the size and worth of the male territories. Once that has been accomplished, the small twig nests will be constructed in nearby shrubs. The eggs are incubated after the last is laid. This makes certain that the young are of equal size when they hatch, which means there will not be a larger one that gets all the food. Even so this is still a difficult time for the parent birds. They must gather enough food for the young and themselves, while taking precautions not to lead a predator to the nest and defenseless young.

The liquid notes of the male Brown-headed Cowbird are also heard during the spring, but it is not staking out a territory in which to raise its young. That problem is taken care of by the female, who watches the other nesting birds in the area very closely. Warblers are particularly vulnerable. When both parents are gone and the nest vacant, the cowbird female will quickly fly over and lay her own egg among the others. She will not stick around to incubate it. Her egg will hatch long before those of the rightful nest owners. After emerging from its egg, the cowbird nestling will be more vigorous in claiming food from its foster parents. It may even push the eggs and young of the host species right out of the nest. In any case, the adults dutifully feed the young cowbird as if it were their own. Many bird species, including Song Sparrows, are intolerant of cowbird eggs and build a new bottom over the eggs or abandon the nest completely.
Flying ten to thirty feet above the marsh, an occasional Marsh Hawk will search for any mice, frogs or other small prey that are exposed to its senses. If it sees or hears a likely meal it will hover over it briefly before it dives to earth; talons outspread wide as it narrows the gap between the smaller animal and itself. More often than not, the searcher detects nothing and continues to travel off the preserve. Our marsh communities are not large enough to support the energy needs of a specialized predator of this type.

DOUGLAS-FIR COMMUNITY

The Douglas-fir community exists as small pockets of growth within the oak woodland. It occurs wherever a Douglas-fir tree has managed to reach maturity. Such adults serve as nuclei around which the rest of the community can develop. These immense trees can be well over 150 feet tall, exerting considerable influence upon the light, moisture, and wind conditions of the surrounding area. Madrones grow well in this altered zone, and shade tolerant plants such as starflower, rein orchid, and milkwort flourish on the forest floor. Due to the immature nature of this community on the preserve, occasional oak trees are also scattered through it.

The boundary between any two biotic communities, where they slowly intergrade into one another, is called an ecotone. It contains many of the species found in the adjacent communities, and often contains a few additional ones that are not found anywhere else. For that reason, ecotones are a good place to look when you want to find the most species in the least amount of time. The ecotone between the oak woodland and Douglas-fir communities is relatively indistinct, because a mature Douglas-fir community has not formed yet.

It is only a matter of time. Each adult Douglas-fir sends out thousands of tiny seeds, every one of which may travel up to a quarter mile in just a moderate breeze. There are already hundreds of seedlings scattered throughout the oak woodland, all waiting for breaks in the oak canopy that will allow rapid growth up toward the light. With a large deer population and current fire suppression tactics, time is definitely on the side of the Douglas-fir. Ecological succession may result in it becoming the dominant biotic community on the preserve. Deer eat acorns and almost all of the oak saplings, but they only feed on the new bright green foliage of the conifers. Any Douglas-fir that makes it through the first year is here to stay, joining the other members of its population in their bid for eventual supremacy. Fire would destroy many of the young conifers, even if they were old enough to escape the deer; but fire is strictly controlled. In a totally natural system the oaks would be favored, because they have evolved ways to counter its effects. The environmental conditions of this area probably only marginally allow the growth of the conifers, so with no management at all the oak woodland would probably remain dominant. With the present policy of excluding fire and maintaining large deer herds, the Douglas-fir community could very well continue increasing in extent at the expense of the oak woodland.
The madrone trees split their older reddish bark as they expand in diameter. When the bark exfoliates, it produces complex and intriguing patterns; revealing the fresh green bark underneath. In most trees, the outer bark splits and furrows as they grow, but it always remains attached to the trees. Madrones keep little of their older bark when the trunks increase in girth.

Weighted down by clusters of bright red berries during the fall, they are visited by flocks of Robins. Flickers, Varied Thrushes, and other forest birds that come to fill up on the fruits. The seeds are not harmed by this process. Unaware of their horticultural activities, the birds spread the seeds throughout the forest in their excrement.

Only lucky observers are able to catch a glimpse of a Pileated Woodpecker, due to their rarity in this area. They are noisy, large birds with black bodies and red crests. Like other woodpeckers, they are well adapted for the task of drilling holes in trees. Their toes end in sharp claws and are arranged two forward and two back; splendid footware for animals that have to maintain a firm hold on the bark of trees. Woodpeckers also have extra stiff tail feathers, and these help them to brace their bodies firmly against the wood. When a woodpecker wants to start a hole, it hurls its heavy wedge shaped bill against the tree with great force, chiseling pieces of wood off with each blow. Once a hole is drilled through the outer bark, the bird can probe around inside the tree until it finds a beetle grub or similar prey. The insect is quickly impaled on the recurved barbs at the end of the sticky tongue, and then withdrawn out of the tree and swallowed.

Some woodpeckers can actually extend their tongues six inches beyond their heads. It is not a random hunting process. When they climb up the bark of a tree, woodpeckers listen for the activities of insects within their galleries in the tree. Once they hear an animal crawling through a tunnel they know exactly where to drill and probe with their tongues to obtain the insect reward. The woodpeckers' hunger and skill help to control the populations of insect larvae that feed upon tree tissues. Some woodpeckers are eaten by Coopers Hawks and other diurnal birds of prey, but the greatest danger is to the eggs and young in the nest. Woodpeckers carve a nest hole in a tree wherever they wish to have one. Unfortunately for them, jays and squirrels frequently find these cavities and rob the nest.

Warblers are active birds with narrow, sharp pointed bills. They are insectivorous, and use the bills to capture any insects they find while searching through foliage. Occasionally, they will fly
out a little from a tree to capture an insect on the wing. They are mainly migratory animals, spending their winters in warmer regions. There the grip of winter has not lessened the abundance of insect prey. They return north for the breeding season and build open cup-shaped nests in trees. Often very colorful birds, many are also graced with beautiful song.

Like mammals, birds are capable of sustaining a high body temperature. This means that they can function at their physiologically best temperature all the time. They can also prosper in habitats that are too cold for ectothermic animals like reptiles and amphibians. Since the source of the heat in the bird’s body is obtained by the internal burning of food, they are called endothermic animals. A high body temperature allows birds to be alert at all times and capable of sustained activity at a second’s notice. The price is high. They must eat a great deal to keep the physiological fires burning. By contrast, ectothermic animals can get by with much less food, and can enter periods of dormancy when their body temperatures get too low. They do not eat at all during these times, relying on their fat reserves to keep them alive. No energy has to be wasted to maintain a high body temperature.

Flight, that characteristic so typical of birds, is an extremely exerting activity. It requires a tremendous amount of energy and depends heavily on the specialized circulatory and respiratory systems of birds. These unique systems allow them to get the large amounts of oxygen needed for respiration (food burning) to the tissues. High energy molecular bonds can be created that will supply the energy used to contract powerful flight muscles. These adaptions are particularly important to those migrating birds who fly thousands of miles every year.

Feathers are only found on birds. No other animals have them. They insulate the bird by slowing down the rate of heat loss. When the birds are cold they fluff up their feathers, to enlarge the width of the insulating dead air space. In warm weather they reverse the process and slick down the feathers, increasing their ability to radiate heat to the environment. In exceptionally hot times birds will pant to cool themselves off, but they are incapable of sweating like mammals.

Feathers are fantastic structures; light, hollow, and very strong. They help support the bird’s weight by increasing its lift, and streamline the shape of the bird to reduce turbulence in flight. Since a feather is dead by the time it becomes functional, any damage to it does not directly injure the bird (unlike the skin membrane of a bat’s wing). Regular molting replaces the damaged feathers.

Since birds do fly, weight is an important consideration. There is much fusion in the skeletal system to help reduce its weight. Where there were many tiny bones in the reptilian ancestors, such as in the fingers and toes, the bones have grown together for added strength. Much of the
torso is a fused inflexible structure, which helps to maintain a streamlined shape in flight while the powerful muscles pull on it. More importantly, it serves to absorb the shock of landing, particularly in those birds like the kingfisher which dive for prey and hit the water with considerable force. Due to all this fusion the bones do not have to be as massive, and many of them are actually hollow. They are reinforced inside like the girders of a bridge; strong, but not heavy.

Birds have also eliminated teeth from their skulls and replaced them with a horny beak. This is hard but light, constructed of a material similar to that of fingernails and claws. Many of the more advanced birds have gone to even greater extremes for the sake of weight loss. In some females only one of the ovaries matures and produces eggs, and the males lack the copulatory organs found in many other vertebrates. As strange as these changes may seem, a look at the rich diversity of bird life should convince you that birds are successful for endothermic animals.

Although the basic structure of a bird has to remain within the dictates of aerodynamic soundness, there is much secondary adaption built on top of the required form. Each species has developed a body that closely corresponds to the role or ecological niche it fills in the community. The Yellow-rumped Warblers moving through the Douglas-fir foliage have long pointed bills to secure the insect prey they find there, while the Western Flycatcher has a flattened bill and supplementary bristles to increase its gape when it flies out to intercept many of the same insect species in flight. The Chestnut-backed Chickadees and Golden Crowned Kinglets feeding on the insects in this community have shorter bills, as they capture the slower insects closely adpressed to the tops and bottoms of twigs and leaves. The adaptions of many other birds to their ecological niches have already been described.

The Douglas-fir community is the place to look for the nests of Red Tree Mice, a bright reddish brown species with a hair-covered black tail. Their nests can be anywhere from ten to a hundred feet above ground, and are built at the tops of small trees or well out on the branches of large ones. The mice construct them out of twigs and the resin ducts from the tree’s needles. The nests may range from a few inches to over two feet in diameter. Occasionally, they will use an old bird, squirrel or wood rat nest as a foundation. The rests have several entrances, a necessary precaution against predators. Spotted Owls, not found in our area, are the only animals known to feed on them heavily.

These small rodents probably have the most specialized diet of any mammal on this continent. The food consists entirely of conifer needles. When feeding, the mice discard the resin ducts on either side of the needles, and when the ducts are dry the mice line their nest with them. The young terminal needles, which the mice prefer, are eaten whole. Conifer needles do not contain much energy. Because of this, the tree mice have a much longer reproductive period than their relatives. The young are born after a 28 day gestation period, and only number one
to three in a litter. Lactating females may even nurse for up to 48 days, since juvenile tree mice are very slow to develop into adults;

All mammals are haired animals which nurse their young with milk and maintain a fairly constant body temperature. The warm fur of mammals provides an insulating layer by trapping air. When the environment gets colder, small muscles attached to each hair cause them to erect, thus increasing the thickness and efficiency of the air layer and resulting in even less heat being lost from the body.

As in birds, the insulation is important because they are endothermic. They maintain reasonably constant body temperature by burning foods internally, even though the temperature of the environment may fluctuate widely. This allows them to be more efficient and active at all times, but only at the expense of having to be more efficient and active at all times to obtain the necessary food. Definitely a "Catch 22" situation. In contrast to a reptile, a mammal cannot go very long without feeding.

Mammals are capable of sustaining activity for a lengthy period of time. This is partly due to the efficiency of their circulatory and respiratory systems. The muscular diaphragm allows the lungs to be filled and emptied of air very rapidly. The mammalian four chambered heart prevents the oxygen rich blood from the lungs from mixing with the oxygen poor blood coming from the active body tissues. Birds have taken all of these steps a little further.

Mammals have a fairly low birth rate, because the young are cared for until they reach a high level of maturity. The fertilized eggs are retained within the body of the female, where they become attached to the uterine wall by the placenta. In the placenta, the blood of the embryo and the female come into close contact. This is how the embryo manages to obtain its food and oxygen from the mother. It passes its metabolic waste products back to the female who can then excrete them. This exchange does not take much energy, since the molecules are always traveling from an area of higher concentration to one of lower concentration. There is more oxygen in the female's blood stream so it passes over to the embryo, and there is more carbon dioxide in the embryo's circulatory system so the excess CO₂ goes over to the mother who has the lungs needed. to breathe it out. Passive diffusion is enough to take care of most of the transfers.

Mammals are born at various levels of development. Deer and hares are precocial, and so have young which are born fully furred with open eyes. They are even ready to partially fend for themselves. Rabbits and mice are born naked with eyes and ears fully closed. They are totally dependent on the female for protection and are said to be altricial. In both cases, the young obtain their first food by nursing from the female's mammary glands. After a variable amount of time they will be able to obtain all their food from the environment.
Most mammals are secretive and/or nocturnal. Deer, meadow mice, squirrels, hares and rabbits might be seen during the day by a careful observer. Most of the others reveal their presence only by signs such as tracks, burrows, nests, or fecal remains (scats). They seldom show themselves before dusk or after dawn.

**GRASSLAND COMMUNITY**

This is the second largest community on the preserve, and consists of several large patches and a multitude of smaller ones. It occurs wherever conditions are too dry to support forest growth, either due to a thick clay soil over bedrock or exposure to excessive wind desiccation. Some of it has also been created artificially, by ranchers cutting down oak woodland in an effort to create a better grazing habitat. Grasses dominate this community. Over forty species have already been identified and others probably await discovery. California's grassland was originally mainly composed of perennial bunch grasses, but the combined effects of overgrazing, agriculture, and European introductions have altered it severely and permanently. Today the dominant species are European annuals. On the preserve, the exclusion of disturbance appears to be benefiting the natives, as they are regaining some of their former influence over the grassland. They are more numerous and widespread each year, and the characteristically clumped bunch grass growth form is becoming a much more familiar sight.

Grasses, being green plants, carry on photosynthesis, manufacturing sugars and other materials by tapping into the energy of sunlight itself. Grasshoppers, like all animals, must obtain their energy by feeding upon other organisms. Life is an unstable phenomenon. It requires a high degree of internal order, both in structures and physiological processes. Energy is constantly needed to maintain this state. Every cell in an organism is surrounded by a working membrane that regulates which substances can enter or leave the cell, and there is often need to work against a diffusion gradient. Muscle contractions and the transmission of nerve impulses require still more energy. This is also true for all the activities of growth and tissue breakdown, and the maintenance of a constant body temperature in endothermic animals. Animals can only obtain this energy through respiration. This is the process by which high energy molecules such as glucose are broken down into useful chemical energy.

Grasshoppers are herbivores. They have simple chewing mouthparts which efficiently shear off pieces from the grass blades that serve as their source of food. Many are able to produce and perceive sound. The males usually do the singing, an activity which serves to bring the sexes together. Females wander over toward the musician of their choice. Young grasshoppers look just like adults, except they lack the fully developed wings of their parents. Throughout their gradual metamorphosis to the adult form, they feed on the same foods as the rest of the population. When faced with a predator, the young grasshoppers rely on their strong hind legs and leap to safety. Adults also leap when in danger but then use their newly gained altitude to
greater advantage, spreading their wings and gliding to another location. If approached again, they take flight a second time, repeating the process until the predator loses their position amongst the grass or consumes them.

Although similar, there are actually many different species of grasshoppers within the grassland community. Some of the adults have red or yellow flash colors on their wings. As soon as they become airborne, the predator sees the bright patch of color and fixes its attention upon it, but once they land the wings are folded and the color disappears. This gives them additional protection. Even if they are overtaken, the predator might pass directly over them in its search for the brightly colored insect that no longer exists. Still, many are captured and eaten. Much of the grassland's energy flows through the grasshopper population. Racers, fence lizards, mice, Kestrels, alligator lizards, bluebirds, and many other species share in the bountiful harvest provided by these herbivores.

Alligator lizards are fierce reptiles who prowl through the grassland in search of unwary or sluggish animals. They have elongated bodies, and the dorsal and ventral scales are separated by a fold of skin that runs along the entire body.

A hopping grasshopper will be pursued until it is lost from sight and smell. However, if the insect falters, it will be grasped in the unyielding jaws and eaten. As in other lizards, the prey is not chewed. The head is tossed upward, and the struggling animal slides down the reptile's throat under the pull of gravity. If the hunting is good, many insects will be eaten in succession. This is the purpose of the folds along the sides of their bodies. They will be taken up gradually as the stomach expands under the accumulating bulk of the prey within. (We tell children that they have "lots of notches in their belts".) The diet also includes beetles, flies, crickets, termites, sowbugs, scorpions, spiders, snails, the eggs and young of birds, and maybe even small mammals. They will even eat the poisonous (to humans) black widow spider. In short, they will eat any animal they can overcome.

Alligator lizards' aggressiveness does not stop with their prey. They will almost certainly try to bite anything that captures them. If their jaws alone do not seem to be an effective deterrent they will rapidly turnabout and smear their captor with excrement. If a persistent predator tugs forcefully enough on the tail, it will pull free and the rest of the lizard can escape. This is done only as a last resort, because alligator lizards have other good uses for the tails. They are
prehensile, and these lizards wrap them around the branches when they are climbing in bushes or trees. The muscles of this organ are exceptionally strong. If the tail is wrapped around an object, the lizard can pull itself up by tail movements alone. Between April and June, the males experience a compelling urge to mate. Once one locates a female, he grasps her head in his mouth, bending the lower portion of his body under hers. A hemipene is inserted into her vent. Although not long on foreplay, the resulting copulation may last as long as twenty-four hours. The Southern Alligator females will lay eggs, while those of the Northern Alligator Lizard will bear live young. In the latter case, the young are born in a thin transparent membrane and quickly struggle free. The two species are difficult to tell apart, but it is easy to identify them as alligator lizards.

Bluebirds are often seen perching on the fence posts of the grassland community. Just like flycatchers and swallows, the bill is flattened from top to bottom. This enlarges the size of the mouth opening, increasing their ability to capture insects on the wing. In addition, they will also flutter down from their observation posts to snap up insects seen moving in the grass. It is not surprising to find that much of their animal food consists of grasshoppers. Sometimes the grasshopper will see the bird approach and will jump away in time. This can result in the bluebird immediately taking to the air again, and with its good eyesight and coordination it often catches the insect before either comes back to earth. Although insects do form most of their diet, vegetable matter such as mistletoe berries and elderberries makes up twenty percent of the bluebird's fare.

The grassland's vegetation is not just consumed by grasshoppers. There are many herbivores in the community. Meadow mice can have a very high population level, and they feed only on grasses; sedges, and other green vegetation. The introduced wild oats are one of their favorite foods. These social animals have a stocky build with long loose fur, short tails, blunt muzzles, and small eyes and ears. They make runways through the grass that lead from one burrow to another, and seldom venture out of the security of this system even when feeding. Upon parting the overlaying grasses; the runways can be seen to be strewn with droppings and plant cuttings. These small rodents are active both day and night, and they do not hibernate or aestivate.

For some reason the population of meadow mice is cyclic, building up to a peak every three or four years and then declining. The peaks are easy to understand. There are several litters per year with four to eight mice in a litter. Fifteen hours after giving birth females can ovulate and be receptive to fertilization. The population decline could be due to vital nutrients becoming "locked up" in their bodies and unavailable to new mice until they are recycled. Another possibility is that the combined activities of their predators is finally having an effect. Hawks, owls, snakes and a host of mammalian species find them edible. In any community, the
population of a species can only increase to a certain level before the environment prevents further increase. Food availability is a very strong limiting factor, and others would be nest site shortage, increased disease transmission, the attraction of more predators, and physiological stress from overcrowding. The meadow mice do not always eat themselves out of house and home before their population crashes, so the population changes may be subtle to the casual observer.

In any case, when an animal population reaches the upper limits that the environment can support it is said to have reached its carrying capacity. The populations of some species rise to the upper limit and then oscillate around the carrying capacity level. Other species of animals overshoot the carrying capacity level, then the population has a dramatic crash to a much lower level when the degraded environment can no longer support them. Eventually, the population will build up again and there will be another crash. This is the pattern that seems to fit both the meadow mouse and technological man. We just have not gone through our first big crash yet.

Kestrels survey the grassland from the tops of trees, or more frequently, conveniently located strands of telephone wire. They are falcons, and have long narrow pointed wings and a narrow tail. This arrangement is suited to high maneuverability and rapid flight. The Peregrine Falcon is the swiftest animal in the world, and it is also built along the same body plan. It can easily capture fast birds in flight. Despite the former name of Sparrow Hawk, Kestrels are not so talented. They only have a 21 inch wingspan and a Robin sized body, so they cannot depend on capturing birds. Most of their diet comes from small animals such as meadow mice and insects. When abundant, grasshoppers make up a large part of their food.

Western Fence Lizards are also part of the Kestrel menu. They are the most abundant lizard on the preserve, and are often seen sunning themselves on rocks or fence posts. These brownish to blackish lizards are covered with rough backward directed scales, and there are bright blue patches on the sides of their bellies. By flattening his sides and lowering his throat folds, the male shows off its bright blue markings. This display is often accompanied by a push-up activity. These combined actions announce his sex, serving to intimidate and frighten off other males. If a newcomer wants to contest another lizard's claim to a territory, it will resort to similar behavior. Before long a chase will occur, possibly with a brief fight, and the victor remains and bobs up and down more than ever but in any territorial encounter, the original occupant of the territory usually wins. The same kinds of activities are utilized during the courtship. The female is held in the male's jaws by the neck during copulation. If she wishes to avoid mating, a nonreceptive female flattens herself, humps her back and moves off with short stiff hops. Fence lizards are much more docile than alligator lizards, but they feed on similar animals' spiders, beetles, ants, wasps, leafhoppers, aphids, true bugs, butterfly and moth larvae. However, they tend to take smaller individuals and to feed in more open areas.
There is also a snake in the grass, because this is the preferred habitat of the Western Racer. Adults are 2½ – 4½ feet long and have a uniform brownish-green dorsal surface with pale yellow ventral coloration. Curiously, the juveniles have brown blotches on the dorsal (back) portion of the body, which makes them look like little Gopher Snakes. No other western snake shows so much variation between the offspring and the adults, but the reason remains obscure. They are diurnal snakes and are frequently encountered during grassland walks.

Racers are fast movers. Although the speed is not actually as rapid as it appears. When they move through the grass, these reptiles often elevate the head and neck. This is a foraging aid, since it gives them a little more height to see potential prey. Juveniles feed on insects such as grasshoppers, crickets, and moths. The adults have a tendency to go for larger items: frogs, toads, fence lizards, small mammals, birds and their eggs. Racers do not constrict or poison their prey, although they may pin it down with a loop of their body. They swallow it alive.

The grassland community owes its basic structure to the innumerable grass plants, but it also contains representatives of other types of higher plants. At the proper time of year, most of these produce the spectacular structures we know as flowers. Although there is an infinite variation in floral form and color, close examination will show that all flowers follow the same basic plan. Each flower consists of four whorls of modified leaves. The sepals are the most leaf like and are usually green and leaf shaped. When the flower is in bud, they sheath the delicate tissues within, protecting them from injury. After it blooms, they can be found at the base of the flower where is attaches to the stem. The next set of modified leaves is found just above the sepals. This whorl is made up of the petals. These are softer than the sepals and are frequently very showy and attractive. They make the flower stand out sharply from its environment, an important quality if flying animals are to quickly locate it. Moreover, their spatial arrangement often serves as a landing platform for the pollinating animals. The stamens form the male portion of the flower, and consist of pollen sacs mounted on hair-like stalks. The female parts, usually fused together into structures called pistils, are found in the center of the flower. All four whorls of modified leaves have now been accounted for: sepals, petals, stamens, and pistils. Much of the variation between flowers results from differences in the numbers of these floral parts, or in the degree of fusion between them.

Pollination occurs when pollen is transferred from the male stamens to the female pistils. Although flowers usually have both male and female parts, various devices make self-fertilization difficult or impossible. In some the pollen will not germinate on a pistil of the same plant it came from due to genetic factors, while in other species of plants the stamens and pistils mature at different times. Cross pollination, or pollination between separate plants, creates more variability in the resulting offspring. This is vitally important in a changing world, and since conditions are rarely stable for long, the course of evolution almost always selects for
cross fertilization. Of course, plants cannot physically cross the distance that separates them, and so they must rely on other means to effect cross pollination. Plants with very inconspicuous flowers are mostly wind pollinated. They have no nectar or showy floral parts and release large quantities of pollen directly into the wind. Some of this will reach the female portions (pistils) of plants of their species. Most will land on the wrong type of plant or otherwise be totally wasted. A small percentage of this wayward pollen will be inhaled by people who are allergic to it. They will say they have hay fever. Grasses, sedges, alders, oaks, and conifers are some of the types of plants that use the haphazard technique of wind pollination.

In contrast, the typical showy wildflowers with which we are so familiar are almost pollinated by animals. The various smells, colors, and shapes are attractive to different kinds or organisms. For example, red flowers are visited by birds and butterflies, because they can see the color red. To a bee and most other insects, a red flower would appear an inconspicuous gray. The Red Larkspur in the riparian community is mainly visited by hummingbirds, which hover in front of the flower, inserting their long bills to suck up the nectar hidden deep inside. Nectar has no other purposes it is a high energy sugar reward used to bribe animals into visiting flowers. Almost all flowers have nectar containing structures, called nectaries, located somewhere among their parts. Flowers are visited for pollen as well as nectar. This high protein substance is gathered from the stamens. Although it is composed of male sex cells and needed to fertilize the eggs in the female pistils; the pollinators intend to use it as food. Fortunately, enough of the pollen is inadvertently transferred from one flower to another during the extended food gathering forays. When the sticky pollen grains are rubbed off or the pistil of the correct species they germinate. Pollen tubes grow down through the pistil to fertilize the eggs in the base of the pistil. After fertilization, the eggs and surrounding tissues will develop into seeds, The seeds are still inside the ovary (the base of the pistil), and the whole structure is called a fruit.

Most pollination vectors are insects. Bees are especially important, because they also feed their larvae pollen and nectar. They have to visit flowers much more frequently than animals which just go to the blooms to feed themselves. Due to their more numerous floral visitations, the bees are more prone to cause cross fertilization between the plants. Bees are covered with branched hairs that serve to capture and hold the tiny pollen grains as the bee moves about the flower. The pollen is regularly combed off the general body surface and concentrated in certain areas that have evolved to carry it. There are many native species of bees in California, most of which lead solitary lives and are never part of a hive. The social honey bee, which was introduced into this country around 1854, is incredibly efficient and may be out competing the native solitary bees. Complex dances tell the other members of the hive exactly where the food is located, what kind it is, and how much is there. This type of behavior is contrary to the cross pollination concept. Honey bees will often return to the exact same plant until the nectar and
pollen supply is exhausted, and sometimes even return to the same large flower throughout their entire working lives.

Many different types of flies visit flowers. They are unlike almost all other adult insects in one main characteristic. Flies only have a single pair of wings. Bee flies are fuzzy little animals that only resemble bees from a distance, but the similarity is enough to give them some protection from bird predation. They often have a long proboscis, and use this to extract nectar from flowers while hovering above them, possibly holding on to the petals slightly with a few of their long, slender legs. Flower flies are much more numerous, and wear bright color patterns that make them strongly resemble bees and wasps. Such mimicry of bees and wasps also functions to protect these insects from avian predation, as the vertebrates learn early in life that animals that look like bees hurt when swallowed. Flower flies are superb fliers, almost always hovering above a flower before landing delicately upon its petals. Once safely alighted, they feed upon the flower’s nectar and pollen. The-hovering behavior serves as a type of reconnaissance, informing them that the flower is fresh and that it is safe to land.

Indeed, flowers are not always the safe landing platforms that they appear to be. There may be a crab spider lurking in concealment. Such spiders do not make webs, tending instead to rest motionless on a flower, waiting for prey to come within easy reach. Often brightly colored, crab spiders soon adopt the color of the bloom on which they reside. If an unwary pollinator cuts short its aerial surveillance and makes a hasty landing it may be its last. The spider will rush over and seize it, injecting the poisonous digestive juice that serves spiders so well. Even bees occasionally suffer this fate.

Wolf spiders do not make a web either, but differ entirely in their method of obtaining prey. They rely on speed much more than camouflage. These dull brown animals are very common in the grassland, and can be seen running across the ground as they search for small insects to ambush. Then their eggs are mature the females place them in egg sacs, and then attach these silk lined nurseries to the back of their abdomens. Even after the young have hatched they will stay with the mother, climbing-aboard her en masse and using her for transport. They will depart to lead their own lives sometime before her hunger gets the better of her maternal feelings.

Jumping spiders are still another type of spider likely to be encountered in the grassland community. They resemble wolf spiders in lacking a web and actively searching for prey. they differ from them in that jumping spiders are often very colorful, possess large eyes, and leap upon their prey while still some distance away. The male also often signals the female with his brightly colored pedipalps before approaching, and some species engage in elaborate dance-like courtship rituals prior to mating.
Foxes move about the grassland community at night. They are striking animals with an overall greyish-white coloration and rusty-yellow along the sides, neck and legs. The bushy tail can be as much as sixteen inches long and has a black tip and a black stripe along its length. Slender and graceful in build, the body is about twenty-five inches long while only weighing around ten pounds. Foxes will bark when disturbed, which is only a shock until you recall that they are members of the dog family. This is all bluff: they are very timid, moving away from their food when threatened by smaller animals. Secretive and nocturnal habits help them to avoid their main predators; eagles, men, and dogs. To escape, they will climb leaning trees, or even vertical ones if the lower branches are close to the ground. This limited arboreal ability also helps them to obtain the fruit of elderberries and coffeeberries, a welcome supplement to their diet.

Fruits are often fleshy to attract animals to them. After eating the fruits the seeds are defecated far from the parent plant. Naturally, plants using this method of dispersal have seeds which can survive the passage through an animal's digestive tract. It makes no difference to the fox that the seeds survive, because it obtains nutrition from the tissues of the fruit itself. Fruit alone is an inadequate diet for foxes and so they must also feed upon gophers, mice, acorns, wood rats, birds and carrion. Wood rats often build impressive stick structures on the ground, but on the preserve they prefer, to construct their fortresses up in trees or within the security of stone walls. This is due to the high fox population, since hungry foxes will tear wood rat nests apart with their front paws to get at the rodents hiding inside.

All flowering plants produce fruits, but many of them are not the fleshy water filled objects that first come to mind. The vast majority of them merely consist of a thin additional layer around the seed, and most people erroneously call the whole object a seed. The fruit of a sunflower seed is the outer shell that you remove before eating the seed within. These nonfleshy fruits are not attractive to mammals, so they must utilize other means of dispersal. Some plants simply drop their fruits beneath them, but this is fairly inefficient. It is unlikely that the seeds will travel far from the parent plant, and seed predators can collect most of the crop by searching around the base of adult plants. The fruits of wild oats, Sweet Cicely, Hedge Parsley, and Prickleseed Buttercup are equipped with recurved spines that enable them to catch into the fur or feathers of passing animals. They are eventually dislodged or pulled off by the animal vector, but by then the fruits have been carried quite a distance from the parent plant. Milkweed, Bull Thistle, dandelions and similar plants have delicate, bristled, long hairs attached to the fruit, and these create enough lift for them to be carried off in the winds.

Eventually, all the surviving fruits will fall to the ground and the seeds will be liberated. Most will not germinate until the environment alters the seed in the proper way. Many need to have an inhibitory substance removed from them by the heavy winter rains. If the storm does not remove all of the material, the inhibitor is built back up to its former level by the seed embryo.
This prevents several small separate rains from causing the seed to germinate when the overall conditions are still too dry. Other types of seeds require a cold spell or a scratched seed coat before the embryos are awakened from dormancy. Whatever the method used, it helps to insure the seed sprouts when the environment is most favorable to survival of the resulting seedling. Without these precautions, an entire year's seed crop could be destroyed during an unfavorable year. Until everything is just right, the seeds will wait.

Because seeds are nutritious and full of energy, they are still vulnerable, even during dormancy. Harvester ant hordes wander out into the grassland, and the individual workers bring back many of the portable objects found during their forays. Much of this is worthless debris, subsequently left in a pile at the mouth of the nest. In some way the collective minds of the ant colony can differentiate between the edible and inedible, while the single workers in the field cannot. Perhaps it is as simple as a taste test that does not occur until the object is inside the nest. In any case, seeds are found worthy and carried beneath the surface. The energy within them will be used to power all the activities the ants perform.

Ant workers are expendable; it is the queen, eggs and pupae that represent the currency of the colony. These are located deep within the soil where there is more security. The workers on the surface are the ones who must face the depredations of the Common Flickers. These birds land near the opening to a colony and lap up scores of the ants with their sticky tongues. Although woodpeckers, they prefer this method of feeding to the more traditional wood drilling behavior of their relatives. The ants have no adequate defenses against them. The bites and squirted formic acid of the workers are inadequate. In fact, as with many birds, the flickers will actually pick up the ants and place them between their feathers. The infuriated ants bite and destroy any bird lice they come upon, and the pungent smell of the formic acid acts as a disinfectant against further infestation by lice. The flickers must constantly stay alert while they feed. A passing shadow may warn of the approach of a Coopers Hawk, and an immediate takeoff could be the difference between death and survival.

Mourning Doves remain vigilant for the same reason. They are beautiful birds with long pointed tails and grey-brown plumage. Their streamlined shape and rapid wing beats allow them to fly faster than most birds. At one time, their chief predator was the Peregrine Falcon. This bird of prey could overtake the doves in flight, knocking them to the ground with a blow from its clenched talons after a frantic chase. Unfortunately, the insidious nature of DDT has done irreparable harm to the Peregrine Falcon's population. It resulted in fragile egg shells that cracked when the parents incubated the eggs. Any nestlings who do survive incubation are often so sickly that they soon die. Today, the Mourning Dove is only really vulnerable on the ground, because the Coopers Hawk is a much slower bird. Nevertheless, the doves must come to earth, being competitors with the ants for the dormant seeds. Over ninety-nine percent of
their diet consists of seeds, which makes them susceptible to man's poisons. Many die because of the poisoned grain set out for rodent control.

Those that escape the dangers of the modern environment feed their young by regurgitation. This mixture of partially digested seeds and glandular secretions is often referred to as "pigeon's milk". Nests, in trees or on the ground, are such flimsy affairs that when they are in trees you can see the eggs by looking up through the nest.

California Quail are also ground nesters, usually choosing a site below a shrub or near a tuft of grass. The precocial young are covered with down and active soon after they hatch. This is practical in quail because the young do not have to fly to find their food. In addition, it is important for the offspring to get out of the nest soon, because ground nests can be destroyed by a large number of terrestrial carnivores. Like the adults, they primarily feed on the seeds found upon the ground. Some berries and green vegetation are also eaten, and animal fare like insects, spiders and snails only makes up three percent of the diet. The eggs and young are consumed by jays, crows, snakes, weasels, squirrels, raccoons, skunks, and others. The toll would be even higher if the young were confined to a nest and could not try to outrun their predators.

Wings are used reluctantly by quail. They prefer to run whenever possible, resorting to flight only as a last option. Quail feed in family groups during the spring and mixed groups during the fall. They usually post an adult as a sentry while the rest are looking for food. This observer, almost always a male, will stand on a higher point than the rest of the flock and survey the surrounding area. At the first sign of danger, an alarm call is voiced, and the whole group of birds dash for cover. This lessens the effects of predation, but a great many are still taken by hawks, owls, bobcats, foxes and coyotes.

Contrary to popular speculation, Striped Skunks have an acute sense of smell. They emerge from their dens shortly after sundown and begin to hunt. Skunks are patient animals and waddle slowly through the grassland or woodland habitats in search of food. They probe about beneath individual grass clumps, digging diligently with their powerful front claws whenever they smell something of interest. Occasionally the eggs or young in the nest of a ground nesting bird are discovered and the animal feeds well. Even quick moving mice can be captured if the skunk strikes immediately after it digs them out of their burrows. These are all lucky finds, and the bulk of the diet consists of insects, berries and carrion.

During their hunting, skunks are relatively safe from predation. They are members of the weasel family, a group of animals noted for their agility, fierce hunting and defense instincts, and alertness. Skunks, of course, have a different method of coping with a belligerent animal. They have intensified the scent gland secretions that are characteristic of the family. When first
annoyed, a Striped Skunk will often pound the ground with its feet. It may even make short rushes toward the intruder before resorting to its ultimate weapon. Once a skunk turns away and lifts its tail, however, it is past time to make a hasty departure. The fine odorous spray can be accurately discharged as far as twenty-five feet. This is such a good defense technique that it protects them from almost all predators. If all goes well during its hunting forays, the skunk will return to its underground den shortly before sunrise. This retreat is usually located beneath rock piles, fallen trees, boulders or buildings. It is also resorted to during the winter when skunks sleep for weeks at a time they do not hibernate.

Unfortunately for the skunk on the prowl, Great Horned Owls have a weak sense of smell. Owls are the night time equivalent of hawks, sharing with them the possession of large hooked beaks, powerful feet, strong talons, and predatory instincts. In addition, owls are specifically adapted to nocturnal life. Their eyes are exceptionally large, which enables them to see in the dim starlight of moonless nights. Hearing is also extremely acute, and this allows an owl to capture prey even in total darkness. Ears and eyes are both located on the front of the bird's head. This means that the primary senses are directed toward the ground. One of the ears is positioned lower on the head than the other, an anatomical peculiarity that creates an asymmetry in sounds perceived, a requirement if the owl is to accurately pinpoint the source of a noise. The squeak of a mouse, the rustle of a skunk among grass, or an untold number of other clues is enough to tell a Great Horned Owl where to hunt for prey.

Once aloft, flight is virtually silent. As the owl swoops down upon its prey, its soft, irregular feathers muffle the sound of the air rushing between them. Speed is sacrificed with this type of feather, but at night swiftness is of much less importance than silence. The owl will hold its toes close to its head as it approaches the prey, maximizing the orientation of the talons with the perception of the visual image or sound of the prey. An owl can hold its toes in either the three forward one backward position or two forward and two back. Now, as it nears its goal, they are in the two forward two backward position, and are spread as wide as possible to almost assure the prey will be struck. For a small quick moving mouse, this technique is essential, but for larger animals, it is only a refinement. The owl lands with the full force of its weight, digging its talons into the prey.
with terrific impact. Death is usually immediate; mammalian spinal columns snap under such sudden pressure. A raccoon would have little chance to defend itself, and it would not matter much to the owl if a skunk managed to release its scent before it died.

Afterwards, the owl tears large victims into small chunks before swallowing the pieces. Mouse sized and smaller prey are swallowed whole, head first. Since fur and bones are indigestible, they are later regurgitated in the form of a pellet. A great many of these may accumulate beneath the nests and favorite perches of owls, giving scientists an important clue in determining the dietary preferences of these magnificent birds. By this humane method, it has been determined that Great Horned Owls feed upon hare, raccoons, brush rabbits, and a large number of skunks. Smaller prey such as gophers, rats, mice, lizards, snakes, small owls and insects are used to fill in the gaps between the larger meals. Since it is our largest owl, with a wingspread of 4 feet, a healthy specimen has no natural enemies.

In most birds, incubation begins after all the eggs are laid. Once heat is applied from the bodies of the parents, the tiny embryos begin to develop. Since the eggs all received this heat at the same time, they will hatch more or less together at equal stages of development. With this method, appetites of the young start out small, but reach a peak just before fledging when the adults have to procure a tremendous amount of food. Owls have a different approach. Although it may seem less civilized, it is certainly less taxing on the parents. They begin to incubate immediately after the first egg is laid. Sparked by this energy subsidy, the embryo grows rapidly and hatches first, possibly as much as two weeks ahead of the last egg laid. By the time the last one hatches, the parents have a nest full of young in graduated sizes. In good years, the adults will manage to provide enough food to feed them all well and the entire clutch will mature. In the years of food scarcity, the larger owl nestlings will attack and consume their smaller brothers and sisters or simply out compete them for food. This insures that at least some of the offspring will be able to fledge.

The Great Horned Owl hunts in both open and wooded areas, but Barn Owls tend to stay in open grassland habitats. They differ from other owls in lacking the heavy feathering on their legs and feet. They are also at home around the dwellings of man. Farmers all over the world have learned to leave openings in their barns to allow these birds to come and go at will. A man provided roosting place is often the only suitable one available in the open regions this species prefers to hunt. They venture forth from their adopted buildings at dusk, searching out the mice, rats, gophers, and squirrels that are often in direct conflict with the interests of man. Rabbits, birds and shrews are also occasionally eaten. A pair of Barn Owls feeding their young have to capture an incredible amount of prey. Each of the nestlings, and there may be seven or more, will eat its own weight in food every day for the entire six week period they are in the nest!
Black-tailed hares are mainly active in the early morning and evening, resting during the greater part of the day in open grass or up against a bush. Their long black tipped ears and short black tipped tail quickly distinguishes them from all the other preserve animals. They find many species of grasses, other herbaceous vegetation, and shrubs edible. All succumb easily to the gnawing actions of their powerful chisel like incisor teeth. Oddly enough, black-tailed hares are also coprophagous. Two kinds of pellets are produced in the digestive tract; hard ones are made in the intestines and soft ones in the intestinal enlargement called the caecum. During the day, the soft pellets are taken directly from the anus and reingested. This curious behavior is assumed to have something to do with vitamin nutrition.

A large volume of plant matter is channeled through these herbivores. Twelve of them eat as much as one sheep and fifty-nine consume as much as a cow. This argument is often used to infer that the hares should be done away with, but in fact the opposite is also true. For every cow eliminated, the range will be able to support fifty-nine more hares.

Hares have a difficult life, always having to be ready to flee from a great diversity of potential predators. Although rabbits have altricial young, those of hares are precocial so they can start to run from predators all the sooner. Gopher snakes, king snakes, Red-tailed Hawks, foxes, coyotes and Bobcats find these younger animals easy game. Healthy adults, however, must be surprised to be captured at all. Their fast hopping mode of locomotion is erratic enough to elude most pursuers. They can turn about sharply while in midair, which allows them to bounce off in a totally different direction upon landing. Hares breed throughout the year, with as many as seven young per litter, and so can replace those that were taken by predators. This is the normal pattern in nature among vertebrate animals. The young, old, and sick are culled from the population by predators, while the breeding group of healthy adults is relatively secure.

Another type of herbivore is found in the grassland above the willow pond, where a rocky ridge gives them the protection they require. These are California around Squirrels, which display a brown body flecked with buffy white. The sides of the neck and shoulders are also whitish, a total combination which assures they blend well with the rocky grassland they inhabit. They are social animals, preferring to dig burrows among those of their peers. Each of these excavations is usually provided with several openings, and may be anywhere from five to two hundred feet long. Most of the adults aestivate in the burrows during July or August, and all the animals in the colony hibernate in October or November, remaining underground until January.

The burrows are mainly used as retreats in times of danger so these animals never venture far from their tunnel mouths. They forage during the day, examining the local terrain for any seeds, acorns, berries, roots, nuts, or herbaceous vegetation that is within their reach. Now and then; insects, birds eggs, and young birds are discovered and consumed. In the spring, each
female gives birth to a litter of seven or eight young squirrels. Many of these are taken by
eagles or large hawks when the rodents wander around the colony. Others suffer a similar fate
through the nocturnal predation of foxes, Coyotes, Badgers, and Bobcats. When these natural
predators are removed from the community, the ground squirrel population can expand
rapidly. This often leads to extensive crop damage, and the spread of fears regarding the
squirrels role in harboring the fleas and bacteria that cause bubonic plague. Many of the same
California farmers who advocated the destruction of the squirrels natural predators are also the
first to cry for the use of poisoned grain to lower the squirrel numbers. The grain seeds are also
eaten by many other animal species, and a wave of imbalance and destruction surges through
the grassland community. As always,. it is best to meddle with natural systems as little as
possible.

Gophers are another type of burrowing animal, but differ in that they rarely leave the security
of their burrows. They prefer a loamy soil, but will also dig in rocky or sandy soils. Suitable food
consists of the roots, stems, and leaves that are accessible from their underground passages.
Whenever a plant is seen to disappear underground in successive jerks, it is likely that a gopher
is tugging at the end that is beneath the surface. In this sly manner, they can feed on all kinds of
vegetation without ever having to venture above ground. Cheek pouches make it possible to
carry food in quantity. Burrow systems are extensive, and those of older adults may cover 2000
square feet. Intolerant of their kind, they almost always expel intruders from their burrows. The
young are also pushed out once they are weaned. Any openings to the surface world are
covered with soil to impede the entry of other animals. These mounds of dirt, frequently with
an earthen plug to one side, are numerous in the grassland community. The plug marks the way
into the tunnel itself.

Gopher bodies show many fascinating adaptions to the underground realm. Their eyes and
external ears are small because larger structures are useless in burrows and would only become
plugged with dirt. Sensitive vibrissae on their snout and short tail gather information about the
tunnels through sense of touch, thus allowing the gophers to run both forward and backward
with relative ease. In addition, a gopher must be able to turn around rapidly in its burrow; yet
the tunnels must be narrow to restrict predator entry. The solution is provided by the fusion of
the pubic bones, a modification of the pelvic girdle that results in small hips. Five or six young
are born in a litter, and each female may have three or more litters each year. Because of this
high birth rate, their population can increase dramatically. They evolved this high reproductive
potential because they have to cope with heavy predation in undisturbed environments.

Digging is an important part of their life. They are aided in this by the possession of sharp claws
and strong shoulder muscles. When the soil becomes too hard and resists normal digging
methods, the gophers bite off chunks of earth with their powerful incisors. The resulting loose
dirt is kept out of the mouth by another adaption, a perforated furry membrane that crosses the mouth behind the incisors. Although the teeth wear down rapidly from these actions, they are constantly growing to compensate for the wear. Through these digging activities, a large quantity of soil is loosened. Gophers have to open up their burrows and push the accumulated earth out onto the surface. This results in about a ton of soil being brought to the surface on each acre per year. Most authorities agree that this soil turnover is beneficial, but gophers are still considered a pest in cultivated areas where their natural predators have been eliminated. Ordinarily, the population level is controlled somewhat by owls, hawks, coyotes, and weasels; since they can easily catch them when the rodents are in the exterior world to which they are so poorly adapted.

Once the sun has risen, the ecological niche of the owls is taken up by the hawks and eagles. Like owls, they have keen eyesight, sharp bills, and powerful feet with long talons. Their feathers, however, are quite different, having smooth edges. This reduces friction and turbulence and allows the daytime raptors to fly much faster than owls. When the air rushes past these feathers a certain amount of noise is created, but during the daylight hours speed is much more important than silence.

The Red-tailed Hawk is a soaring bird and so it has large wide wings and a triangular tail. These adaptations help this species to ride the air currents for long periods of time with only a minimal expenditure of energy. Occasionally, the sunlight hits the tail from just the right angle and the red tail can be clearly seen. From their high vantage point they can scan the ground for visible targets of opportunity. Perhaps a gopher is seen in the act of pushing soil out of its burrow, or maybe a ground squirrel has wandered too far out into the open. Hares, rabbits, quail and snakes are also considered fair game. Once the prey is sighted, the hawk folds its wings, temporarily discarding the aerodynamic form which kept it aloft. The hawk begins to hurtle downwards at ever increasing speeds, pulled by the gravitational attraction between its body and the planet Earth. Minor flight corrections can be made during the drop. If the intended prey notices the descent of the hawk and flees, it is unlikely the raptor will be able to catch it at all. Its round wingtips are not suited to quick aerial maneuvers. Surprise and speed are both essential for a successful capture. Once contact is made, the talon and beak armament of the hawk makes escape unlikely.

The airways above the preserve are shared by an even larger soaring predator, the Golden Eagle. Although the Red-tail has a wingspan of four feet, the wingtips of this eagle are separated by over six and a half feet. Since they both fly very high, it is sometimes difficult to tell whether you are looking at a distant eagle or a closer hawk. Careful observation eliminates the possibility of it being a Turkey Vulture, since the vultures hold their wings in a "V" while the raptors have a flatter flight profile. If you watch for long, the golden glint off the eagle's head or...
the reddish tint of a redtail will probably be seen. The immature eagles are easier to distinguish because they have large areas of white within the wings and tail.

On rare occasions, a Red-tail Hawk will contest the right of an eagle to enter its realm and will scream into an attack on the larger bird. With the two species so close together, their identities are certain. The Red-tail can be seen to be a much smaller bird, and it is this smaller size which gives it the added maneuverability that allows such aggression. Climbing above the eagle, it dives down and strikes the larger bird as it passes. Sometimes the eagle tires of this impudence, turning over in midair and extending its talons directly upward just as the Red-tail nears it. The hawk usually veers off in time, but the close call is not lost on the Red-tail, which is likely to terminate its hostility and accept the eagle in its airspace. Both birds feed on similar items so there is some competition for food, but the eagles tend to concentrate on larger animals like ground squirrels and hares.

Rodents which escape the attacks of the birds of prey are still in danger from the activities of Badgers. These are heavy bodied, short legged animals with a white stripe down the top of their face and back. Although active both day and night, they are particularly busy in the late afternoon. Badgers are stocky animals with disproportionately strong front legs and feet. The toes are equipped with long, sharp claws, and the Badger utilizes this equipment to dig rodents out of the supposed sanctuary of their burrows. These digging machines can burrow out of sight in a few minutes, even in hard packed earth. Their efforts are rewarded by a bountiful supply of mice, rats, gophers and ground squirrels. The females must dig even more often after giving birth. The male prefers a solitary life, leaving the whole task of feeding the young to her. The Badger’s efficiency is one of the main reasons ground squirrels prefer to dig their tunnels in rocky areas, as this impedes the attempts of Badgers to dig into their burrows. Badgers themselves inhabit roomy elliptical burrows about eight inches in diameter.

Like other members of the weasel family, Badgers are equipped with powerful scent glands, but unlike their skunk relatives they never have to resort to them for defense. It is unlikely that anything smaller than a mountain lion could subdue such incredibly powerful animals. Unfortunately, the combined effects of low birth rate, hunting pressure, and the poisoning of their rodent food source have brought about a rapid decrease in their numbers. Their holes are considered to be a hazard to stock animals and, as always, whenever something impedes man’s total subjugation of the environment it is considered detrimental, and efforts are made to eliminate it.

While digging for rodents, Badgers are likely to inadvertently wrest a few earthworms from the surrounding soil. They pay them little attention; Badgers do not consider them worth eating. Reprieved for now, these small pinkish, cylindrical organisms will immediately start to dig back beneath the protective layer of soil. The powerful circular muscles ringing their bodies contract
first, causing the animals to become thin and elongated, pressing their snouts between the particles of surface earth. Tiny stiff hairs at this end of the worms are then erected and fixed firmly to anchor the anterior of the worms in place. Now the longitudinal muscles running the length of the worms contract and their bodies become short and fat. Since the front end of the worms cannot move, the posterior portions of the worms are dragged forwards. Hairs at this end of the animals are then stuck into the soil as those at the anterior end are released. The circular muscles contract again and the worms penetrate deeper into the soil. By this alteration of opposing muscle groups, the worms manage to get their vulnerable bodies completely underground. Throughout the entire procedure, copious mucous secretions from the thickened rings around the anterior ends of their bodies help to lubricate the passageways and speed the animals downward movements. When they reach hard-packed solid earth the technique is altered somewhat. The worms simply proceed to eat their way through the compact earth, leaving a convenient tunnel system behind.

The digestive system of an earthworm extracts important trace nutrients and plant materials from the soil during its movement through the gut. In addition, the worms come to the surface at night. Under the cover of darkness, they pull pieces of leaves and other vegetable matter into their burrows. To a worm, all plants are not equally edible; and they select those pieces with high nitrogen and sugar content. The more decomposed material is also preferred, because chemicals in fresh material make it distasteful and hard to digest. After passage through the entire digestive tract, fecal residue is deposited on the surface in the form of coiled crumb-like casts. These have been cemented firmly together by the actions of the digestive process, bacterial secretions, and the binding nature of the enclosed fungal hyphae. Because of this, casts are thought to increase soil stability. The worms are also lauded for their redistribution of organic debris and nutrients, and the increased movement of gasses and water through the tunneled soil. Humans praise them still further when they impale the worms on hooks and use them for fish bait.

Even during the night, the worms do not fully emerge from their burrows. The posterior end of each worm remains firmly fixed against the sides of the tunnel and if any animal tugs on its anterior end, a lightning like contraction of most of the longitudinal muscles will pull it down to safety. The daytime tug-of-war often is seen between Robins and worms shows just how tenacious their hold on the earth can be. If, while their anterior ends are above ground searching for food, they chance to come across another worm, mating is likely to occur. Any mature individual of the proper species will do, since worms are hermaphroditic animals, possessing both male and female sexual structures. While their bodies are firmly adpressed in a sheet of mucous, sperm are transferred between them. They then separate to go their own ways. One meeting has resulted in two fertilized worms, an efficient system for animals which
seldom encounter other members of their own species. Later, the eggs will be deposited on the surface in small cocoons.

Heavy rain is a local tragedy for these subterranean denizens. The rainwater percolates through the soil and fills their complex burrow systems with water, and the worms and plant roots quickly use up the small amount of oxygen in the water. In addition, respiration of the combined life forms adds CO₂ to the burrow water, increasing the acidity of the now aqueous environment. These conditions are intolerable to the worms, which must desert their burrows and come to the surface. If this occurs during the day, they are faced with the additional hazard of ultraviolet radiation from the sun. Their unpigmented bodies afford no protection against this form of energy. They will become completely paralyzed after as little as an hour of exposure, being then at the total mercy of the birds that flock to the unexpected food source. If chance spares them from predators, the sunlight will soon desiccate and kill them. Some will crawl into small puddles in time, and in these relatively huge basins of water they can live for over a day. They wriggle constantly on the bottom, drawing the oxygen laden waters toward them and pushing those with a high CO₂ content away. The ultraviolet rays of the sun are blocked by the water molecules. If luck is with them, 'they will be able to survive until night falls and the soil conditions become more acceptable. They pan then dig down. into the comparative safety of the earth. Once underground, their only real problem is the Broad Handed Mole.

Moles are superbly adapted to underground life. The cylindrical body of these animals tapers at one end to the sensitive snout and at the other end to the equally tactile tail. Their soft, velvety fur can lie down in either direction, making it possible for them to travel towards or backwards with equal facility and at great speed. The eyes of moles are nonfunctional and external ears have been lost through the course of evolution. However, their sense of smell is exceptionally acute and their body is very sensitive to vibrations. Since sound waves are conducted by soil more readily than air, moles can actually hear with their entire bodies. Powerful muscles move their short spade-like forelegs as they practically swim through the soil. They are entirely hipless; and solve the problem of giving birth by having the digestive and urogenital tract pass completely outside of the pelvic girdle! Finally, their lower vertebrae are fused solidly to the pelvic girdle, an adaption which gives them the required support to move large loads of soil up vertical tunnels to the surface.

Moles are active all year in their extensive burrow systems. During the course of the rainy season, a single mole may produce 200 - 500 molehills. These are differentiated from those of the Pocket Gopher in that they are cloddiier and lack a plug at one side. The tunnels running between the molehills sometimes appear as ridges on the surface, and there are common highway tunnels in between the private systems. The public passageways may be shared by as
many as twenty to thirty moles. They recognize their own quarters easily, and expel any other mole that attempts to enter.

They hardly ever go above ground, digging steadily through the soil in search of prey. Earthworms make up over eighty percent of their diet, and they can easily pinpoint and reach the exact point where the earthworm is digging. Surplus worms are stored in underground caches; after their anterior regions have been biten off to prevent them from tunneling to freedom. The rest of the animal then remains fresh until the mole has need of it. Snakes and weasels who gain access to their burrows eat some moles, and on the rare occasions when they venture aboveground hawks, owls, and many other animals can capture them with ease.

Gopher Snakes can be up to eight feet long, with a yellowish ground color and reddish-brown dorsal patches. They are common throughout the United States and occupy almost all types of terrestrial communities. You stand a good chance of coming across one while in the grassland, since they are numerous and primarily active during the day. Good climbers, they often go high in trees to search for birds and their eggs. On the ground, mice, young rabbits, lizards and small ground birds are captured. Burrowing rodents such as ground squirrels, gophers and moles are stalked underground. They will dig into a closed off burrow by loosening the soil with the snout, and then pulling it away with a loop of the body. Prey items are identified with the forked flickering tongue which carries scent particles emanating from the animals to a sensitive organ at the roof of the mouth.

When close enough, a Gopher Snake strikes with a quick motion of the neck, grabbing the chosen animal securely with its many toothed jaws. Almost immediately after making contact, a loop or two of the snake's body is wrapped around the startled animal. This both immobilizes and kills the prey; the tight coils prevent breathing and inhibit heart beat. When the snake begins to sense the death of the animal, it slowly releases its coils and searches for the victim's head. Starting at this end, it begins the complex chore of swallowing the morsel. A breathing tube at the front of its mouth assures a steady air supply as it struggles to work the bulky bundle of food down its throat. Even the bones are digested, and the feces consist merely of a tightly wrapped bundle of fur. There is little waste.

Gopher Snakes are aggressive animals that may hiss loudly when disturbed. This unnerving sound, out of all proportion to the size of the reptile, is enough to cause most animals to leave them alone. They may also vibrate their tails rapidly in the grass or leaves, a procedure which mimics the sound of a rattlesnake. If pressed further, they will hot hesitate to strike and bite the offender. As with all nonpoisonous snakes, the bite itself is minor, with possible infection the only cause of concern.
Western Rattlesnakes are rare on the preserve. These blotched reptiles are 1 ¼ to 4 ½ feet long, have live young, and are easily recognized by the rattle and large triangularly shaped head. The rattle is composed of loosely interlocking horny segments at the end of the tail. You cannot age a rattlesnake by the number of segments in the rattle, because a new one is added every time the snake sheds. Young animals may shed three or four times a year, while the slower growing adults only need to crawl out of their skins around once a year. At birth, the young have a small button at the base of the tail, but this usually breaks off when they get older.

Like the other members of its family, this species has large, moveable hollow-fangs. They are folded back against the roof of the mouth when not in use, but can be swung out rapidly to stab and poison the prey or a threatening animal. Rattlesnakes are mainly nocturnal, using the pit organs on the sides of their heads to help locate edible animals. These are sensitive to any temperature differences, and so both ectothermic and endothermic organisms can be differentiated from the inedible bulk of the environment. Suitable food includes ground squirrels, rabbits, mice, skunks, alligator and fence lizards, quail and other ground birds, and an occasional amphibian. The lizards are usually only eaten by the younger specimens. Prey must come close: at best, they can only strike one half their length. After it has struck and injected poison, the rattlesnake releases its hold following the trail of the stricken animal with its flickering tongue. When it finally comes upon the prey, the poisoned animal will probably already be dead. It can then consume its meal without any resistance or risk to itself.

If you hear a rattlesnake, it is best to locate its position before you quickly move away. The worst action you could take is to accidentally step on the rattlesnake while trying to flee from it. These snakes do not pursue people. Remember, it is trying to warn you! If you are bitten, remain calm and obtain help as soon as possible. Suction cups from a snakebite kit are likely to do some actual good and have lots of positive psychological effects. Self-inflicted incisions are likely to do more harm than good. Bacterial infection is probable and delicate ligaments and arteries of hands or feet may be severed. Tourniquets and cryotherapy should be avoided by all but the most experienced, the resulting extensive tissue destruction might require amputation of the affected limb. Take heart from the fact that more people die from lightning each year...
than from snakebite, and with any treatment at all, survival is almost certain. Remember that the snake does not want to waste its venom and might not have even injected any at all. The poison works mainly against the red blood cells in the bloodstream: you have a lot to spare and are capable of manufacturing more. After all, many people routinely donate a pint of blood at the bloodbank and think nothing of it.

The white and black banded Common Kingsnake may reach five feet in length and is immune to the venom of the rattlesnake. When a rattler smells one of these snake predators, it exhibits a characteristic defense position. As it retreats, the central portion of the body is elevated while the head and tail are held close to the ground. If the kingsnake caught the scent and manages to get close it may be dealt heavy blows with the upraised part of the body. Since the ends of the rattlesnake are ad pressed to the ground, it's also possible that the kingsnake may have difficulty deciding where to strike or place its coils. This defense does not always work, and rattlesnakes do form a portion of the kingsnake diet. These constrictors also feed upon other snakes, rodents, birds and their eggs, turtle eggs, lizards and some amphibians. They are most active during the day and are occasionally found in trees. Kingsnakes are very docile, rarely biting even when picked up for the first time. They do resort to vibrating their tails in leaves if they feel sufficiently alarmed, a rattlesnake mimicry that we have already seen in the Gopher Snake.

Soon after sunset, the small dark-bodied California Myotis crawl from their crevice hideaways in buildings, loose rocks, and rotten trees, surveying the night-shrouded world from the safety of their daytime retreat. When all is deemed well, they release their holds and fall out into space, soon spreading their wings and initiating flight to stop their fall. Like all bats, these mammals show many adaptations for flying. The bones of forearm and hand have been greatly extended in length, with a delicate membrane stretching between the bones and the main body to form a wing. A similar flight membrane is found between the tail and hind limbs. Unlike most mammals, the knees bend backward instead of forward, which helps to absorb the shock of landing. Energy conserving features include winter hibernation and the assumption of a daytime temperature close to that of the environment. This helps to make up for the tremendous amount of energy expended in flight. Hoary Bats and Red Bats are solitary and they are sometimes found roosting in trees in a fairly torpid state. It takes a considerable amount of disturbance just to get them to spread their wings. Young bats cling to the mother for the first few days. They are capable of flight after about a month.

Unlike birds, bats have retained their teeth and use them to capture insects while winging their way about fifteen feet above the ground. Darkness is no hindrance. They find their prey by echolocation. High frequency squeaks are emitted constantly and the bat listens for the returning echo bounces that signify the orientation of nearby objects. This sense system is
highly refined, and the bats can detect anything over two millimeters in size. With it as part of their sensory apparatus, they can avoid obstacles and obtain their food in total darkness.

Most of these squeaks are above the frequency level that humans can hear, but there are moths which perceive them very well. When a noctuid moth hears the widely separated pulses from a bat, it turns and flies directly away from the source of the sound. It is essential to get away from the bat as quickly as feasible, while the echoes are still weak and the bat might not know of its existence. Once the mammal does become aware of the insect, it flies toward the moth. When it gets fairly close, it sends out a much finer spaced series of squeaks. These will reveal the moth's exact position in the air. By this time, it is impossible to avoid the bat by flying directly away from it, because the mammal is a far stronger flyer. The start of the rapid series of squeaks is the signal for the moth to engage in erratic flight, throwing its wingbeats out of synchrony and so causing it to spiral rapidly toward the ground. With its sophisticated echolocation system, the bat then attempts to match the exact spiral pathway of the moth, narrowing the gap rapidly as they both head toward the ground. Some moths are overtaken and eaten, while others manage to obtain an immobile earthbound position in time. A few species, like the Pallid Bat, will alight to take prey off the ground, but even they are not interested until they detect motion. Some toxic moths, such as tiger moths, produce a clicking sound as they fly. This noise probably serves the same function as warning coloration; advertising the presence of the toxic animal so predators can avoid them.

Injuries to the wing membranes are extremely serious, because they are living tissue and are essential for flight. No matter what the pain, bats will continue to fly if it is still physically possible. Only flight can provide the food needed to heal wounds, and examination of bats reveals that many carry the scars from old wing membrane injuries. They are infrequently predated upon, but owls and snakes do manage to catch a few of them. Large fish also capture some when the bats skim over the surface waters to obtain a drink.

Since bats are often infected with rabies, the bite of one is something of grave concern. It is thought that just a drop of urine on an abraded piece of skin, or maybe even the stagnant air of the colony cave itself, may be enough to transmit the disease to humans. Roosting bats are sometimes found on trees or in rock crevices. These should not be touched because of the danger of rabies.

Coyotes are also children of the night, only venturing forth during the day in the few areas where they are not heavily persecuted. They look like medium sized dogs with a grey or reddish-grey coloration over most of the body. The throat and belly are whitish; and when they run, the tail is held between the legs. Extermination of wolves throughout the country has led to the expansion of the Coyote's range. It has stepped into the niche of its larger and more powerful relative and is now found in almost every dry land habitat. Coyotes do not hunt in
packs, although they may search for prey in pairs. A truly omnivorous mammal, they feed upon rodents, rabbits, berries and carrion. A Coyote can sometimes be seen following a Badger about its rounds, running down the rodents which escape the more powerful animal when it digs them out of their burrows.

Coyotes den in the ground, frequently in a natural crevice or cave. If these sites are scarce, they might choose to enlarge an old Badger or squirrel hole. Ranchers throughout the country have tried to exterminate the coyote as they did the wolves, but their efforts have been generally futile. Coyotes are admirably suited to resist persecution. When pressure is put on the Coyote population, they become sexually mature earlier and have larger litter sizes. The males help the female in raising the young, taking over the task completely if anything happens to her. Finally, the beautiful call of the coyote, heard so often on moonlit nights in the desert, is not voiced where they have reason to remain silent.

Coyote scats are common in the grassland community of the preserve, but none of the animals have ever been sighted. They are seldom seen in ranching communities. Part of the whole Coyote problem stems from the concept of assuming a clean kill at the throat of a sheep is the work of Coyotes, when this could have been the result of a pack of experienced wild dogs. Missing sheep are seldom looked for, and written off as Coyote kills so the ranchers can obtain government subsidies. Poison bait is often put out to reduce the population of Coyotes, and this results in the needless destruction of many other animals who eat the bait or the weakened poisoned animals. Ironically, it has been shown that many of the authenticated cases of livestock kills by Coyotes were committed by poisoned animals; Coyotes who were too weak to capture their normal prey.
Turkey Vultures are one of the species which suffers when poisoned bait is spread indiscriminately about the countryside. They are carrion feeder, and so will feed upon the animals who died from eating the bait. Although relatives of hawks, vultures are only equipped with weak, slightly hooked beaks, and their feet have little strength, ending in blunt claws. This means that they cannot kill their own food, and are destined to always follow closely upon the heels of death. They soar overhead with a characteristic “V” shaped flight profile, utilizing their keen sight to reveal any local fatalities. If they spot an injured animal, they may circle above it until it weakens and dies. Moreover, they will have to wait longer if the carcass has a thick hide. During the vigil, they can pluck out the succulent eyes and feed through any available body openings. Once it decomposes some more, they will be able to penetrate the skin with their weak beaks. The head and neck of a Turkey Vulture is naked; grey in the young and red in the adults. Feathers would tend to accumulate decaying matter, since the birds shove their heads deep within carcasses. Even so, vultures can sometimes be seen in groups with their wings outspread; utilizing the ultraviolet radiation from the sun to kill the bacteria which have accumulated in their feathers.

They are not alone while feeding on the carrion. Fly larvae tunnel through the flesh, and they are joined by both adults and larvae of carrion and dermestid beetles. Some of the carrion beetles arrive at the scene with hundreds of mites crawling on them, because the mites use the beetles as transportation between one site and another. They do not seem to bother the beetles much, and feed upon the fly larvae that would compete with the beetles' own larvae. For the most part, there is little direct competition between the species at the carcasses. Each type of animal is best adapted to a particular ecological niche on the corpses. These decomposer organisms serve an extremely vital role in the community, recycling nutrients which would otherwise remain locked up inside dead bodies. The same is true of the numerous species of dung beetles, dung flies and other organisms that consume scats in the grassland, breaking the fecal matter into smaller particles more useable by plant life. Bristletails, small elongated jumping insects found throughout the grassland, act in a similar manner to degrade the tiny pieces of plant and animal debris littering the community. Plants can then take the nutrients needed for tissue construction up into their roots. Now the plants can continue to manufacture materials from basic substances and the energy of the sun. The whole community, which depends on plants for existence, will be able to survive.
A simple food chain can be used to demonstrate the energy flow through a community. In the grassland community, one such hypothetical linkage would be: sun - grass - grasshoppers - fence lizards - Gopher Snakes - Red-tailed Hawks. In most cases there is a 90% loss of energy at each link in the chain. That is why there are fewer animals at each level. There simply is not enough energy available to support more. There will always be more fence lizards than Gopher Snakes. No animal could survive by specializing on a diet of hawks. It would not be able to obtain enough food to stay alive.

In an actual community, the interactions take a more complex form than in the simple chain shown above. Most species feed at more than one trophic level. Foxes feed on berries, insects, carrion, mice, rabbits, and anything else they can overcome that is worth eating. Because of this, the connections between the various species in a community are better described as a food web than they are as a food chain. With the food web concept, each feeding relationship within the biotic community represents a single strand in the unbelievably complex community web. More importantly, all the strands are interconnected and so it is easily seen that alteration in the proportion of any species effects all the other species.

VERNAL POOL COMMUNITY

Vernal pools represent very unique and fragile communities. During heavy winter rains, their empty basins fill with water and become shallow ponds. As the year progresses, they slowly dry up, and are usually totally devoid of water by late spring. In some years, they never even fill at all. Although an ephemeral habitat at best the waters of a vernal pool are soon teeming with life; and some types of organisms are found nowhere else.

In a good year, early spring finds the main vernal pool full of water and exhibiting a dense growth of submerged vegetation. Most of this is Aquatic Buttercup, a species which will later scatter hundreds of delicate white flowers across the surface. Pollinating insects will then risk the dangers of the surrounding waters to reap the nectar and pollen rewards contained within the blooms. At the start of the season, though, the plants have another use. They serve as an attachment point for the gelatinous egg clusters of the Pacific Tree Frog. The egg masses of this amphibian are over an inch in diameter and can be found at all stages of the developmental process. Over a fourteen
day period, the eggs in an individual cluster will gradually alter into tiny tadpoles. These will then struggle free from the rest of the restraining membranes and sink to the bottom of the pool, remaining close to the substrate until the rest of the food in their yolk sacs has been resorbed. After a few days, it is all consumed and they begin to swim about and feed on algae and detritus. This life lasts for several weeks, during which time they gradually metamorphose into frogs, animals which are adapted to a more terrestrial habitat. If the pool dries up before the tadpoles have finished their transformation, they will die.

Fairy Shrimp have a much shorter life cycle, carrying out many generations while the waters are still present. They are one of the organisms which is restricted to the vernal pool community. These soft bodied crustaceans are almost an inch in length and propel themselves gracefully through the water with oar-like motions of their legs. These appendages are not just used for propulsion. They also serve as gills and food gathering organs. While they swim upon their backs, fairy shrimp filter bacteria, protozoa, and detritus from the water with the fine hairs on their legs. This miscellaneous mixture of food is then passed to a groove running along the ventral side of the animals, whereupon it is moved in conveyor belt fashion up to the waiting mouth.

For most of the season, males are much less abundant than females. There might not even be any males in the pool at all. The females manage to carry on the race by producing parthenogenic eggs, structures which can develop directly into more females without benefit of fertilization. This is a great mechanism for rapidly building up the population of a species when it is in a favorable environment. As the pool begins to dry up, some males are also produced from the eggs. These will clasp onto the posterior region of the females, just behind the protruding egg sacs. When the eggs are mature, the male will fertilize them, providing the resulting young with all the benefits of cross fertilization. Resistant outer walls are formed around the eggs, and when they are released, they sink down and embed in the bottom. Covered by a layer of mud and detritus, they will remain dormant until the pool again fills with water. Then, when conditions are just right for their survival, they might hatch; and they might not. One of the exciting aspects of vernal pools is the hatching of resistant eggs can never be accurately predicted. The erratic nature of their appearance must help them to avoid a lot of predation, because no animal can come to depend on these soft-bodied organisms as a food source. Fish are no problem: fairy shrimp only inhabit water bodies that dry up completely every year.

Clam shrimp are another type of crustacean that is found here. They are about an inch long and all but the head is covered by a bivalved shell. Forceful motions of their antenna push them through the water and they filter small food items out of the water as they swim. Once these shrimp stop moving, they quickly sink to the bottom and fall over on their sides. Here again, the
eggs are resistant to desiccation. There have been many authenticated cases of clam shrimp spanning twenty year periods before showing up in their ponds again: even when conditions seem similar from year to year.
VERNAL POOL ANIMALS

DAMSELFLY LARVA

PREDACEOUS DIVING BEETLE LARVA

PHANTOM MIDGE LARVA

COPEPOD

WATER "FLEA"

FLAT WORM

FAIRY SHRIMP

CLAM SHRIMP cut-away & actual size

SEED SHRIMP
Seed Shrimp are also crustaceans, and no freshwater species is over eight millimeters in length. Although superficially similar to the clam shrimp, the heads of these tiny animals are enclosed within the shell. They are omnivores and decomposer organisms, feeding upon all kinds of particulate matter found attached to aquatic vegetation and on the pool’s bottom. Seed shrimp are slow and ungainly when they move through the water, apparently weighed down by the armor of their shells. There are many species. A bright orange one is very common in the water filled depressions that form in the grassland after continued heavy rains. These vernal puddles dry up within a week or two after forming. Before this occurs, the seed shrimp will have gathered enough energy from their detritus foods to allow the production of large numbers of resistant eggs. These will insure there will be more seed shrimp around when the depressions are inundated again.

Copepods are another type of crustacean, and a bright red species can be extremely abundant in the vernal pool. Over two millimeters long, this type is gigantic when compared to other copepod species, most of which are barely discernible by the naked eye under the best of conditions. Copepods are active swimmers. They move slowly through the water in a smooth motion through the feeding movements of the mouthparts and second antenna. This is interrupted now and then by rapid jerky motion, caused by quick synchronous movement of the legs. Any bacteria, protozoa, detritus or algae adjacent to their mouth parts can be filtered out of the water. It seems they can select what sizes and types of particles to consume, not having to swallow everything that floats by: a few species are also slightly predaceous. Once again, resistant eggs are scattered throughout the pool before it dries up.

Water "fleas" are the final major group of crustaceans found in this community. Only .2 to .3 millimeters long, none of these animals will ever find their way to the human gourmets table like their crab and lobster relatives. At first glance it appears they have a bivalve shell, but closer inspection shows this to be a single piece that has been folded. These tiny creatures can swim through the water fairly decisively with powerful strokes of their enlarged second antennae. Movements of the legs filter bacteria, detritus, protozoa and algae out of the environment and pass this food material to a groove on the ventral surface of the body, and from there it travels on up to the mouth. These crustaceans are mainly parthenogenic, but males are produced in numbers when the pool is about to lose its last remaining water. The females' specialized resting eggs are then fertilized by the males and shed inside protective brood chambers. Only a new kind of female is capable of mating with the males. The parthenogenic females that were so numerous in the vernal pool earlier in the season cannot copulate.

It is almost always possible to find mosquito larvae in the vernal pool. These bizarre animals are common in any small non-turbulent body of water. A siphon extends from the posterior end,
penetrating through the taut layer of water molecules stretched across the pool. It is then possible for this insect to suck in the atmospheric air it needs to breathe. While suspended in this position, the mouth bristles create a vortex which sucks bacteria, protozoa, and detritus into the organism's mouth. At the approach of danger, all the larvae wiggle violently down to the bottom of the pool, resurfacing when the shadow or other object of alarm has passed.

When they have grown about 1 inch in length, they transform into the stockier pupal stage. This is much shorter lived and is really just a transitional form between the larvae and adults. The pupae are capable of motion, but they mostly remain immobile at the surface for their few days of existence. Before long, each insect will leave this last immature stage behind. The pupal skin splits near dawn, and another mosquito crawls precariously out into the world. Once its wings dry it will fly off to a nearby shady retreat.

With the coming of dusk, the mosquitoes leave their hiding places and venture out in search of food. The male mosquitoes use their long proboscises to suck nectar from flowers, and the females frequently feed with them at such sites. In addition, the females also searbh out vertebrate hosts, which they locate by the acids and carbon dioxide that the larger animals constantly release into the air. After a cautious approach, they alight on the host's skin and penetrate it with their mouth parts, sucking up some of the blood which surges through the animal's capillaries. The blood meal provides proteins and sugars which quicken the development of the female's eggs, increasing the number of viable eggs that she can lay during her brief life. Some species deposit single eggs, while others group them together in a tiny raft. In either case, most must return to the water to oviposit, and many are eaten by the dragonflies which patrol these pools. Such natural controls are far superior to those of man, and are certainly more than adequate in our area.

Some of the flies around this community which resemble mosquitoes are actually just relatives that do not suck blood. They are called phantom midges, and the name comes from the voracious larvae. Almost entirely transparent, the larvae prey upon passing crustaceans and insect larvae, grasping them with their prehensile antennae. Only the hydrostatic air sacs are readily visible, organs that allow the phantoms to float at any level in the water column that suits them. The buoyancy of the air sacs supports them effortlessly against the pull of gravity. They do not have to make any move that might alert their prey. However, when the notion strikes them, they can move horizontally through the water with rapid undulations of their bodies.

The predaceous diving beetles are a completely different type of predator. They are often the first types to be represented in the pool, since the adults are winged and can fly into it immediately after it fills with water. In flight, the hard forewings act as stabilizers and the membranous hindwings do the beating that keeps the insects aloft. When they land, the
thickened forewings close over the soft hindwings, forming a straight line down the back where they meet. This is a characteristic of all beetles, and protects both the wings and the delicate tissues beneath from many types of predators. In contrast to most beetles, predaceous diving beetles are also excellent swimmers, using synchronized kicks of their hairy legs to push them through the water. They feed on any animal they can overpower. The larvae are also voracious carnivores, capturing many different kinds of aquatic organisms in their mandibles. As with spiders, a digestive juice helps to kill the prey and digest its organs before it is subsequently sucked dry. Stealth is important to the soft bodied larvae, because they swim awkwardly and lack the protective armor of the mature beetles. Whenever possible, the larvae prefer to crawl about the aquatic vegetation, only swimming when they have to reach a new patch of vegetation or need to come to the surface for air.

A still more dramatic group of predators could exist beneath the waters of the vernal pool. These would be the larvae of the Tiger Salamander. They would have brownish bodies and feathery gills around their necks, and be capable of subduing any other permanent resident of the vernal pool community. So far, no such larvae have been discovered, but the vernal pool community is still virtually unexplored. The adults are mysterious animals, only appearing during the first heavy rains of the season. They have an overall black coloration that is impressively interrupted by an ample supply of yellow or white dots and splotches. Once they emerge from their subterranean retreats, they head toward the vernal pools of their hatching. They enter the water, breed, lay their eggs and leave, returning to the underground realm where they spend most of their adult lives. Tiger Salamanders are on the surface for such a short time that only lucky individuals manage to see them at all.

The larvae are around for much longer, since they have to grow a lot before they can metamorphose into adults. They feed this process by consuming other aquatic animals in the pool, not even stopping short of eating smaller specimens of their own kind. Sometime before the waters of the vernal pool all evaporate, the transformation will have been completed. Air is now breathed through lungs instead of gills and they can emerge from the pool and enter the terrestrial environment. They do not hesitate, but immediately head to a suitable area and descend underground for the first time. No one knows how the adults survive the long periods beneath the surface.

Flatworms are so dorso-ventrally flattened that they appear to be two dimensional. Not able to swim, they use a combination of cilia, muscles, and mucus to enable them to glide over the bottom and vegetation. They even have the bizarre habit of crawling along the underside of the surface tension film! This particular vernal pool provides a habitat for both a green and a brown species of flatworm. They feed on detritus and small invertebrate animals, sucking these food items up into their bodies through a protrusible tube in vacuum cleaner fashion. The
adults cannot survive desiccation, but the resistant eggs are admirably suited to withstand the dry period.

Crane flies are often seen laying eggs around the vernal pool, bouncing up and down on their thin elongated legs as they thrust their abdomens into the soil. Some people think that these slender flies are giant mosquitoes and run from them, fearing they will be sucked dry by the blood hungry insects. Others claim that they are "mosquitos hawks" which relentlessly pursue and consume the much smaller mosquitoes. In reality, the adults usually do not feed at all, with an occasional sip of nectar being the only exception. Their eggs hatch into sluggish, segmented larvae with peculiar lobes at the posterior end. Most of these immatures live in moist soil and subsist on vegetation such as roots until they are able to metamorphose into adults. A few species have aquatic larvae.

After all the water has evaporated, the vernal pool takes on a completely different appearance. The muds on the bottom begin to crack as the solar rays dehydrate them still further. A few terrestrial species of plants manage to get established in the newly exposed soil. Coyote Thistle, a plant which has been growing submerged all season, likewise changes its form. The new vegetative growth is much more rigid and spiny, adaptations suited to withstand the dual forces of gravity and herbivore pressure; while the plants struggle to flower and set seed before they die.

Those animals that were capable of flight have already left by now, searching for a community which still can fill their needs by providing food and a place to rear their young. The adults of many of the wingless types were destroyed when the water evaporated, but their resistant eggs are scattered throughout the drying mud. A large number of small frogs still hop about the wet mud. They are reluctant to leave the remaining moisture and the insect prey attracted to it. Garter snakes are in the area even now, because there is a bountiful crop of frogs to be harvested. As the pond continues to dry, even these last holdouts will retreat to marsh or pond communities. Some of the frogs will stay in the same general area, hiding in the moist microhabitats beneath logs and rocks during the day. At night, they emerge to feed on whatever life forms are left from the old vernal pool community, and also prey on those from the new terrestrial community that is forming in the basin. If the rains come before their retreats dry out completely, the frogs will survive. The rest of the vernal pool community has either left or is already dormant, waiting for the revival that might be brought by the winter storms.

RIPARIAN COMMUNITY

The riparian community consists of the narrow belt of territory that is directly influenced by Copeland Creek and its tributaries. It owes its existence to the water which moves into the
stream channels from the habitats with higher elevation. Some of the water molecules entered the creeks by rapid overland flow, while others inched slowly through the interconnected pores of the soil. Under the constant pull of gravity, all this water seeks the path of least resistance as it flows down the mountain back towards the sea. A significant amount will by captured by the roots of the trees and transpired back into the atmosphere. Smaller numbers of water molecules will be incorporated into the tissues of plants and animals, delayed an indeterminate amount of time before they can rejoin the vast-reservoir of the oceans. During the transit downhill, the force of the water erodes the streambed into a more efficient form. It also provides an abundant source of moisture to those plants and animals found near its banks. This strip of riparian habitat follows the stream closely as it cuts through the preserve's other biotic communities, never straying far from the influence of the stream which sustains it.

The White Alder is the dominant tree species along Copeland creek. It is a straight trunked species with white bark that may grow to almost a hundred feet high. A member of the water loving birch family, it has toothed, heavy veined leaves which can be up to four inches long. Although a flowering plant, its seeds are produced in cone-like structures that resemble those of conifers. Flocks of Pine Siskins pass through this region during the late spring when the seeds are ripe. These birds have heavily streaked underparts and can be seen high up in the alder canopy extracting the seeds from the cones with their slender sharp bills. They often hang completely upside down during the process. The Pine Siskins frequently emit call notes while they feed, a device which allows the flock to keep together during their travels. Discarded pieces of cones and dropped seeds fall to the forest floor.

Big-leaf Maples display inflorescences of several hundred flowers in the spring, and these are visited by many different types of pollinating insects. The animals visit the flowers to obtain nectar and pollen. Nectar contains a mixture of high energy sugars and amino acids, while pollen is a very good protein source. During their food gathering, the insects inadvertently transfer pollen from the flowers of one tree to those of another, resulting in cross fertilization.
The fertilized eggs develop into seeds and these are encased in winged fruits which flutter down from the trees each fall traveling various distances from the parent tree before they hit ground. Although they do not travel nearly as far as the mature trees as the seeds of such trees as the Douglas-fir, there is more food material packed in the heavier maple seed, and so each one has a better chance of survival. They are also relatively assured of germinating in a favorable environment, something the more pioneering Douglas-fir tree seeds cannot depend upon.

The maples are hosts to the ubiquitous Western Box Elder Bugs. To an entomologist, bugs are the only kind of insect that are referred to as “bugs.” They are distinguished from the other kinds of insects by a sucking beak, and possession of wings which overlap each other at the ends when the insect is at rest. The basal part of the wings is horny and thickened while the most distant parts from the insect’s body, those which overlap each other, are thin and membranous. They insert their beaks into the maple leaves and fruits, obtaining the nutritious substances within the plant tissues. Just as in grasshoppers, dragonflies, and other primitive insects, a gradual type of metamorphosis is seen. The young bug’s wing buds are larger with each molt. They look very much like the adults except for the absence of wings. Wherever they run about on the ground or vegetation, a bright red warning patch on the abdomen is visible from some distance. This area of conspicuous pigment is concealed when the adults are at rest, but becomes very evident whenever they take flight. Even the eggs are red, an indication to potential predators that all stages in the life cycle are probably distasteful or toxic.

Mourning Cloak butterflies overwinter, and are sometimes found hibernating underneath logs or stones. On warm days they may revive and fly about awhile before returning to their retreats. Because of this behavior, these spectacular beauties may be seen all months of the year in coastal areas. The brownish-black wings are bordered with a band of yellow, the latter set off in a very striking manner by a row of sapphire dots. Colonial at first, the black, spiny larvae later disperse to feed on their own. Willow and alder are among the riparian trees on the menu.

Ferns are the dominant understory plants of the riparian community: with Wood, Shield, and Sword Ferns growing wherever there is sufficient soil.

Polypody Ferns are less particular, sprouting from the hulks of old logs or moss covered rocks. Only the fronds (leaves) of ferns project above the surface of the ground. Below are the rhizomes (underground stem~) that send off roots in many directions. In common with all roots, these
structures provide anchorage for the plant. They also serve other typical root functions, such as absorbing water and nutrients from the soil and conducting these materials back up the stem.

At the right time of the year, clusters of small brown dots can be seen on the underside of the fern fronds. A closer examination reveals that each spot is composed of hundreds of tiny brown objects. These are the sporangia, and each of them contains hundreds of spores. When conditions are most favorable, the sporangia split and the top slowly bends back. The internal stresses build up - then the top suddenly snaps back, catapulting the tiny spores out into the environment. In most ferns, a protective cover (indusium) lies over all the sporangia; making them difficult to see. This rolls back just before they release their spores. Polypody ferns lack this refinement, so they are the easiest ones on which to observe sporangia.

If one of the minute spores manages to reach a moist, bare spot of soil, it will germinate into a small heart-shaped plant less than 1 inch across. Specialized structures on these tiny plants then produce eggs and swimming sperm. When an egg is fertilized, the new plant grows right up through its heart-shaped parent, growing into the typical type of fern plant with which we are most familiar. The heart-shaped plants are usually short lived. They need moist conditions and cannot compete well with other plants. Sometimes you can find them attached to cliff banks near the larger types of ferns. The "air ferns" sold in variety stores cannot grow. They are actually dead sea animals that have been dyed green.

Mosses are another type of plant common in the riparian community, and can be seen growing on almost all stable structures. Various species carpet stones, logs, and the outer bark of trees. They do not do as well in dry communities, because they cannot close their gas exchange pores like more advanced plants; they dehydrate rapidly. Nevertheless, they are not killed by the dry season. The tissues simply shrivel up and exist in a dried up state for long periods of time. It is not known how they can survive in such a desiccated condition. When sufficient rain or fog is present, they quickly absorb the moisture and break their dormancy, expanding to their former lushness almost immediately. The complex community of microscopic protozoa, rotifers and tardigrades which live among the mosses are also capable of surviving sporadic dry periods.

After a period of growth, mosses can afford to use some of their energy stores to produce stalked spore cases. The spore sacs have tiny teeth around their tops. These bend inside the sac when the air is humid, and some of the spores adhere to the teeth. Then, when conditions become drier, the teeth expand outwards and the spores are blown off by the wind. Lower plants usually release their spores during the day, since this is the time when the air is most turbulent, allowing the spores to travel farther before falling down to the ground.

Some of the spores and young moss plants will be attacked by fungi and killed. The fine white threads visible under a rotting log, or on a dead aquatic animal, are fungal filaments. You can
visualize them as thousands of intermeshed spider webs, as this is the form they take while growing everywhere through the soil. Fungi do not have chlorophyll, so they cannot carry on photosynthesis and manufacture their own food like the green plants. They are parasites and decomposer organisms. Fungi break down complex materials into simpler compounds, obtaining sufficient food for themselves during the process. The breakdown products contain many nutrients in a form the adjacent green plants can utilize.

Without the fungal and bacterial decomposers, the short supply of nutrients would soon become locked up in dead bodies and organic debris. There are around ninety different elements found in nature, and thirty to forty of these are definitely required by plants and animals. A few of them (oxygen, hydrogen, nitrogen, carbon, etc.) are needed in large amounts, but most are only necessary in small quantities. Many of these nutrients are in short supply in the natural environment. Fortunately, none of these essential substances are permanently used up when they are incorporated into the tissues of plants and animals. When the organic matter is decomposed by fungi, bacteria, and other organisms, they are returned to the ecosystem. They can then be absorbed by the roots of green plants and recycled. Without decomposers, the green plants would die and all the other organisms would soon follow.

Some fungi also form complicated relationships with tree roots where they actually become extensions of the root system. It is now thought that most trees are infected by fungi in this manner. Nutrients and water can then flow more quickly to the higher plant, and the fungus receives sugars from its photosynthetic partner. This is not a parasitic relationship, but one where both species benefit (protocooperation). In tropical countries these root associations are even more important, since the heavy rainfall would rapidly leach away any nutrients left in the soil. The fungus threads carry the needed materials directly from the rotting organic matter to the trees; hardly any are left free in the ground to wash away.

In order to propagate their kind, the more advanced fungi produce the peculiar fruiting structures called mushrooms. These spring up during the wet season, and contain spores in pores or gills. A single four inch fruiting body of the supermarket mushroom can release sixteen billion spores during its five to six day period of discharge. Since the world is not covered with fungi, the chance of one of these spores developing into a healthy fungus must be very small. With all life forms, there is usually a balance between the number of offspring produced and the chance of their surviving to adulthood. If the cap of a mushroom is cut off and placed on a piece of paper, the discharged spores will leave an intricate pattern on the paper. This will take at least twenty-four hours, so some patience is required.

It is important to remember that most of the fungus bulk consists of the thread-like filamentous growths that produced the fruiting structure. These threads all look very much alike. Specialists use the distinct characteristics of the fruiting structures to tell the species
Apart. There is no easy way to tell a poisonous mushroom from an edible one, and every year renowned experts make fatal mistakes and die.

One of the reasons for the prolific production of fungal spores is the abundance of tiny insects called springtails. These wingless creatures are only one to four millimeters long, but most moist soils are teeming with them. They prefer soils with a heavy content of decomposing leaf litter, the same types of areas in which the fungi are most numerous. They feed upon fungus spores, fungus threads, and decaying organic matter. The gill sections of newly emerged fruiting structures are frequently covered with them, as they ride the fungus up from the soil and feed upon the spores while they mature. Although tiny, these fascinating animals will reveal themselves to anyone who takes the time to disturb the moist leaf litter under trees. When startled, a springtail releases the clasp on a fork-shaped structure held tightly underneath its abdomen. The fork then swings downward and hits the ground with great force, catapulting the insect into the air. Some of them travel several inches before they land and become motionless. It is only during such leaps that the springtails are visible to the average observer. These insects belong to a very ancient group. In fact, the earliest fossil insects known are springtails. Their exceptional gymnastic skills are probably very important in helping them to evade predators such as slender salamanders.

Pseudoscorpions are another predator that springtails are faced with most of their lives. These resemble miniature scorpions but lack the long, stinger-armed abdomen. Instead they have claws armed with poison glands which they use to subdue the tiny springtails and mites they find in the soil community. Silk secreted from their mouth parts is often used to construct a protective chamber during the vulnerable period when they are molting. Since they rarely exceed eight millimeters in length, they are able to engage in an extraordinary method of travel. They occasionally latch onto passing insects with their claws, subsequently being carried aloft when the insects fly away. When they release their hold, these aerial hitchhikers slowly fall back to earth.

Millipedes are frequently encountered by those who look underneath logs, stones, and woodland detritus. Each body segment bears two pairs of legs, and due to the multitude of segments many children refer to them as "thousand leggers". An actual count will show that they fall far short of that figure. Then the animal walks the legs move in wave patterns that travel along the body. Although slow, they can exert a powerful push with all these appendages, and this enables them to force their way through all the detritus and soil. Millipedes are herbivores and decomposer animals, feeding upon the living and dead vegetation they find around them. Many species also possess repugnatorial glands. These secrete toxic substances when they are accosted by larger animals. Simultaneously, some of them will roll up into a tight ball, exhibiting their hard skeletal plates to the aggressor. The
combination of these defense characteristics is formidable enough that most other animals leave them unharmed.

The soil community also contains another multilegged animal. These are the centipedes, extremely fast and flexible animals which run through the gaps in the soil. Their motion is so fluid that it almost appears that they are swimming through the detritus. Easy to distinguish from millipedes; centipedes have only one pair of legs per segment, are usually much speedier, and are frequently orange, red, or burgundy colored. Their life styles also differ. Centipedes are carnivorous animals, possessing a large pair of poison glands near their jaws that they use to kill their insect and salamander prey. Careless humans report that the bite is painful, but not especially serious. Centipedes are also often found within logs.

Riparian woodland is also the prime habitat for termites. These soft whitish insects avoid the light, feeding upon wood and decaying organic matter. They are often confused with ants. Ants have dark bodies, complete metamorphosis, few males, and venture out under the ultraviolet rays of the sun. Termites have none of these characteristics. They are highly social animals and often have a complex caste system composed of reproductives, unmated reproductives, soldiers, workers, and immature nymphs. All castes have both male and female members.

It is thought that regulation of this caste system is controlled by pheromones, hormone-like substances which are synthesized in the body of one animal and cause an effect in that of another. In simplified terms, if there are not enough soldiers in the colony, there will not be enough soldier pheromone being passed around when the termites exchange substances during oral greetings. The end result is that one of the nymphs will grow into a soldier. This will restore the balance, because there will now be enough soldier pheromone to inhibit other nymphs from transforming into soldiers. This is how the number of animals in each caste remains fairly constant. In the most common species in our area there is no worker caste. Manual labor is performed by the young termites before they attain their adult form. The male remains with the queen throughout his life, fertilizing her eggs as the need arises.

These insects have a great economic importance. They cause about $40,000,000 worth of damage each year in the United States by destroying wood products. In nature, however, this ability to consume wood makes them extremely valuable as decomposer organisms. Without them, trunks, branches, and other large chunks of wood would take much longer to decompose. They eat the wood, tunneling galleries through the logs and dead roots they inhabit. Surprisingly, they are not able to digest it. This task is performed by the one celled animals (protozoans) which live within their guts. The energy of the cellulose is then available to the termites. Cellulose makes up the bulk of the plant tissues and is very similar to starch, but only a few types of organisms are able to break it into simpler compounds. Even cows rely on bacteria in their stomachs to break it down. After each molt, the termites have to reinfect
themselves with the protozoans, because the lining of their digestive tract is also shed during the molting process and the protozoans are cast out with it. They obtain the new supply of microorganisms by eating shed skins and fecal material. If a termite is deprived of these protozoa it will starve to death, even if it is surrounded by potentially nutritious wood. This relationship is a true example of mutualism: both animals benefit from the association and could not exist without it.

Curious structures are often found on the tops of the fallen logs in the riparian community. Some resemble hemispherical masses, while others take the guise of human hair or wisps of colored cotton. These are a few of the fruiting structures of slime molds, and are quite a treat when come upon unexpectedly in the woods. Each of the spore sacs contain hundreds of spores. The incredible part is that the spores will not develop into anything that resembles a plant. Instead they will germinate into naked masses of protoplasm that look like overgrown amoeba. This animal-like portion of the life cycle ingests solid particles, even though it lacks both mouth and anus. It simply flows over and around the particle of interest until the food is within it. Wastes are left behind by simply reversing the process. This animal stage is thin, gelatinous, often brightly colored, and generally net-like in form.

If conditions become temporarily unfavorable, slime molds assume a hard, dormant state; returning to the active form when the environment becomes more favorable. Two moving slime molds may join together to form one larger organism, or a single larger slime mold may split to form several small ones. Such a unique life form stretches the concept of the organism, as you never know what to treat as an individual. They are not fast movers, three centimeters per hour being about top speed. Thus, the observer has plenty of time to admire their forms and diverse color patterns before they get out of sight.

While in the animal mode, they shun the light, crawling under bark and through the mass of fallen leaves and debris.

Stoneflies also have free living immature stages, and these are superficially similar to those of mayflies. Unlike mayflies, their gills are always located on the sides of the thorax, making it appear that they have hairy armpits. Stonefly nymphs are less often seen in the stream, since they have a tendency to hide underneath rocks during the daytime. Most of them are grazers on algae and detritus. Only the largest species, which gets over an inch long, is carnivorous. This one prefers to hide underneath rocks right where the water begins to get turbulent. Stoneflies do not feed as adults and are short lived, although they will come down to the stream to drink water. Their bodies are quite flattened, and the wings are folded flat on top of them. This clearly distinguishes them from the vertical winged-mayflies and the tent-winged caddisfly adults.
Smooth, black, predaceous diving beetle adults; six to ten millimeters in length; are frequently seen swimming along the bottom and through the water column. They and their larvae feed upon the mayflies and stoneflies in the stream. Smaller species of these beetles select correspondingly smaller sized prey. The adult beetles have to return to the surface frequently to renew their air supply. They break the surface tension with the tip of their abdomen, then immediately dive deeper under the water. A silvery layer of air can be seen coating their bodies. Even though they are ectothermic animals, it still seems that they can stay submerged for much longer periods of time than the silver bubble would justify. The explanation lies in the fact that it acts more like a lung than a direct air supply. Since the atmosphere is seventy percent nitrogen, the bubble also contains this percentage; a gas that diffuses very slowly into the nitrogen saturated water. When the beetle breathes oxygen out of the bubble a concentration gradient is set up and more oxygen diffuses into the bubble from the water. This method continues to work until too much of the nitrogen has diffused away, shrinking the bubble to an unworkably small size. It is then that the beetle returns to the surface to renew its air supply.

Backswimmers are another type of stream predator. These bugs have long hind legs which they use to row them in a jerky fashion through the water. They are very buoyant and float to the surface as soon as they stop moving. Since backswimmers avoid this vulnerable position, they are usually seen holding on to submerged rocks or vegetation when they are not actually swimming. They do swim on their backs, and the ventral surface is often dark while the dorsal surface is light colored. This means that to a fish below them they blend in with the light sky, and to a bird above them they blend in with the dark bottom. The similar water boatmen inhabit the same streams and lend credence to this theory of adaptive coloration. The boatmen swim on their bellies, and are light on their ventral surface and dark on their dorsal surface. Although boatmen feed on some small animals, they primarily subsist on the algae and detritus that they scrape from the rocks on the bottom.

By far the most impressive animals in the stream are the larvae of the Pacific Giant Salamander. They live up to their name, and can have a snout-vent length of eight inches, with an overall length of fourteen inches. The most commonly seen specimens, however, are much smaller. Regardless of size, the larvae are brown with reddish gills at the neck region, and blend in surprisingly well with the bottom. Almost any thing that moves is fair game to these carnivores. Many bear large gaps in their tails, visual reminders that they had a narrow escape from a larger relative. Even the cased caddisflies are not immune from their depredations. The salamanders eat them case and all; digesting the larvae and defecating the cases. Powerful lateral movements of their tails propel them rapidly through the water whenever there is need.
If these animals grow beyond a certain size without leaving the water and metamorphosing to adults, they lose the ability to do so. Once individuals exceed four to six inches in snout vent length, they will remain in the larval form forever. Amazingly, they are able to reproduce in this apparently immature state. These larger reproductive larvae are sometimes found in the deeper pools. Those which do change into terrestrial adults lose their gills and obtain a beautiful marbled pattern of dark and golden-brown colors. They can then move overland and are sometimes seen traveling through the woods on foggy or wet days. In this way, they travel between drainage systems to propagate their kind, and are less vulnerable to the danger of a particular stream drying. Still carnivorous in the adult form, they feed on insects and smaller amphibians; occasionally, they even capture and swallow mice.

A species of orb web spider builds its webs parallel to the stream surface and directly over the water. This serves to trap insects which fly to and from the stream. It is a very rewarding site for a web. Many species of insects must fly pass this web gauntlet both when they first emerge from their nymphal skins and again when they return to oviposit in the water. Most of these stream insects are poor flyers; unlikely to be able to avoid a web in the last few seconds before impact, or even to struggle free once ensnared by the sticky strands. Even-if an animal does get free before the spider rushes over to it, the hapless insect is likely to fall upon the water’s surface where the hungry striders await their prey. The surface tension itself acts as one continuous web, as most insects are incapable of freeing-themselves from its hold. Most float downstream until apprehended by a water strider or whirligig beetle. A few manage to reach shore and temporarily escape.

Raccoons leave their dens in hollow trees at dusk. Some of them come down to the creek to look for food. They probe beneath the surface of the water for giant salamander larvae and large insects. The toes on their front feet are very tactile and opposable, a combination which allows them to locate and capture underwater prey. If they have little success, they will abandon the stream and look elsewhere. Raccoons are found in any habitat that is relatively close to water. Each individual animal has a home range of only about a square mile. The young usually disperse less than thirty miles from their place of birth, although some are known to have traveled as much as 165 miles before settling down. While wandering about the countryside, they feed upon berries, nuts, seeds, fruits, insects, frogs, toads, turtles, birds, bird eggs, and small mammals. Such a varied diet makes them an exceptionally omnivorous animal. Sometimes they will take food items down to water and put them in, a process which increases their tactile sensitivity. The pepper and salt coloration of the fur, black and yellow-white rings on the bushy tail, and black mask, make them so distinctive that most people recognize them instantly.
Winter Wrens are also common along the stream. These brownish birds have a characteristic posture of leaning forward with the tail cocked up at a ninety degree angle to the body. The wings are short and the slender bill turns down slightly at the tip. This helps them to pry into crevices when they search for insect prey. Their nests are always difficult to find because they are located underneath bark and in other natural cavities. The Winter Wren has the shortest tail of all the local wrens, and is often seen hopping about the rocks of Copeland Creek. These energetic little birds examine one area for visible insects and then make a short flight to another nearby site, sometimes only being airborne for a few feet. Moving quickly around rocks, through crevices, and onto gravel bars, they are constantly on the lookout for suitable prey. When a wren disappears behind a rock it is difficult to predict where it will reappear, due to its ability to make use of all the available natural cover while it rapidly moves about the habitat. Much of this obscurity is unintentional, as the birds are just checking out all the out-of-the-way microhabitats where insects could be hiding. Their foraging is frequently rewarded: many stonefly, mayfly and caddisfly adults have ended their lives with a passage down a Winter Wren's throat.

Along the borders of the stream, still smaller predators feed upon some of the same food items. Arboreal Salamanders reach about three inches in snout-vent length and are often abundant in our area. In common with many terrestrial salamanders, the gills of the larvae are reabsorbed before the eggs even hatch. A fully formed tiny adult-like salamander can then emerge from each egg. This allows such salamanders to breed away from free water, but both the adults and the eggs are still very susceptible to desiccation. Like all salamanders, they must remain in a moist environment throughout their entire lives. The adult Arboreal Salamanders are colored with tiny light colored flecks on a dark background, and they also possess a number of obvious grooves along the sides of their abdomens. They live up to their names by climbing up into bushes whenever they feel like it, but are almost always found on the ground or under objects. Unlike most salamanders, they may also squeak when first picked up. All sorts of insect life is fair game to them, with the abundant woodland camel crickets probably forming a good proportion of their diet. They are ectothermic animals, though, and so they do not have to eat that often.

Vagrant Shrews are mammals, which means that they are endothermic and control their body temperature by internal means. However, due to their tiny two to three inch body size, a tremendous amount of heat is lost to the environment. They have proportionally more surface area per unit of volume than a larger animal, and heat is lost by radiation from the body's surface. In order to stay alive, a shrew has to eat a tremendous amount of food, and captives have eaten one and a third times their body weight each day just to maintain their body heat. They do not hibernate and are active both day and night in search of prey. The main diet consists of arthropods such as insects, sowbugs, centipedes and spiders. Some earthworms,
slugs, vegetable matter and even mice are also consumed. Their poisonous saliva probably helps them to subdue the mice. Although our local shrews have relatively weak poison, in some eastern shrews, a single animal has enough toxin in its saliva to kill six hundred mice!

During their constant hunt for energy, shrews are usually left alone by predators. This is mainly due to the strong scent that can be released by the musk glands along their flanks. Hawks and owls, which have a weak sense of smell, do capture a few of them. Overall, it is a tough life for the shrews, and few manage to live longer than eighteen months. If they are deprived of prey for several hours at any time, they die. A constant food source is required to stoke their internal fires, since the heat leaks away almost as fast as they can obtain it from their food. No endothermic animal smaller than shrews could exist. The young must huddle together at birth to have the combined surface area of a much larger animal, otherwise they could never eat enough to stay alive and would quickly starve. Heat retention is also aided by the location of the nest in a stump or log out of the wind, and by the dry grass lining of the nest.

Along steep cliff banks that are undercut at the top, you can sometimes find another animal which makes a potent toxin. Black Widow Spiders weave an irregular network of silk in such places to snare their prey. They belong to the group of spiders called cobweb weavers. The body is shiny black and the bulging abdomen has a red, orange, or yellow hourglass pattern underneath. The poison is very powerful, acting to quickly kill insects trapped in the web and also as a deterrent to potential predators. In mammals, including humans, the bite can be quite painful; causing nausea, muscular convulsions and possibly arresting respiration. In addition, the wound may take a long time to heal. However, proper medical attention will control the more life threatening effects of the toxin.

Black Widows are also common under the edges of rocks in the grassland. Particularly in the fall, they are so numerous that half a dozen may be turned up in the course of a four hour hike. It is important to warn children about this hazard and show them how to safely overturn rocks before the exuberant youngsters get away from you in the field. One should always place his or her fingers on top of the rock in clear sight, not under the edge where a spider may have taken up residence.
On a more pleasant note, the tubular flowers of the Red Larkspur contrast nicely with the overall somber hues of the riparian forest. Like many red flowers, they are pollinated by hummingbirds. These birds visit the flowers to extract high energy sugars from the floral tube; hovering before it and inserting their Peak deep inside, Due to their small size, hummingbirds are faced with the same kinds of problems as the shrews. On top of this, a considerable amount of energy is expended by their rapid wing beats during hovering and flying. They drink large quantities of nectar to compensate for this loss. Some of their food also consists of the bodies of insects captured during flight. They are the most maneuverable birds being able to hover, move backwards, or dart off rapidly in a straight line. If one is kept for a few hours without food during its active hours it will starve to death. Since they cannot find food at night, hummingbirds enter a period of dormancy to conserve energy. Their body temperature drops down close to that of the environment so they can make it through the darkened hours without feeding.

Oddly enough, the incubation of the eggs and feeding of the young is the sole responsibility of the female. This is a tremendous feat, considering the huge metabolic needs of the mother and the tiny young. Adult hummingbirds are too: fast and maneuverable to be captured. The young are more vulnerable, and are occasionally eaten by ants before they fledge. They are also sometimes thrown out of the their nests by heavy winds. Incredibly beautiful structures, their nests are composed of an intricate network of spider web and lichens. It is a real treat to come across one in the field.
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