Cave Lesson Plans

1. <u>Geology</u> is diverse due to old rock plate edges. Topics are:

<u>*Caves and old-growth as a window on the past</u>

CONCEPT: Caves save history.

Summary: Because of stable conditions, protection from erosion and competition, and relative protection from vandalism, caves parallel the preservation function of the Park Service, with fragile speleothems, delicate cave features etched out by acidic dew, historical features (graffiti, exploration equipment, stonework), fossil bones, and relict lifeforms. Caves are important to both scientists and laymen because here is preserved first hand history lost long ago on the surface.

While everything is eroding on the surface, things are being deposited in a cave. During relatively dry periods, animals adapted to wetness retreat inside caves and become "living fossils." As climates become wetter, cave animals and their descendants recolonize the surface. Bones of bears, rabbits, mountain beaver, woodrats, bats, etc., are preserved from temperature and humidity changes on the outside and may even be fossilized by dripping water. Plants found in cave woodrat nests are important in deciphering climates from 40,000 years ago to the present.

Examples: Marine animals called crinoids have been identified in argillite rock exposed in the Exit Tunnel. Acid dew in caves reliefs out delicate fossils (Marble Mountain Cave nearby has a delicate bryozoan on a cave ceiling). Delicate soda straws and cave popcorn created by evaporation and wind are preserved in caves. Such things would be removed by natural processes on the surface soon after they formed. Smooth flowstone would be roughened and cracked by surface erosion. Very soft, filamentous moonmilk is created in caves but would be removed or hardened by erosion on the surface. The relatively constant temperatures and humidities deep inside a cave tend to preserve fossils and historic objects such as carbide lamps and tools unearthed during cave restoration.

Many evidences of past geologic processes are preserved in Oregon Cave: evidence for uplift, erosion of the mountains down to their roots, glaciation at higher elevation, once-molten rock, etc. Caves provide fresh surfaces on rocks where details can be seen much more easily than on the surface where rocks are weathered and often covered by plants or soil.

Slide Presentation: **<u>Cave Minerals and Formations</u>**: Oregon Caves is contrasted with other Park Service Caves. How these features record the past is emphasized. 20 minutes.

Lab Exercise: View the vertical profile map location of bone sites in cave and relate them to airflow patterns. **Results**: The most numerous bone sites occur in areas of low airflow because they are less subject to changes that cause deterioration. **Extension**: Discuss how a museum preserves its artifacts; by reducing fluctuations in temperature and humidity, preventing light from altering paper, use of rare gases to prevent oxidation, etc. If national parks are "museums without wall" what are national park caves?

Lab Exercise: Sand Box Archeology
Objective: Students will understand the important of energy levels in preserving artifacts.

Procedure: Bury artifacts (replicas) in the sand. Leave evidence of a fire ring on the surface. Have students spoon and brush away sand to make archeological discoveries. Artifacts being uncovered could be from imaginary or alien societies. How would you decide what were the objects used for? **Answer**: Part of determining use has to do with what the artifact is associated with. Stress the value of finding artifacts in place as opposed to someone finding and putting them in their private collections. Have artifacts (such as tissue paper silhouettes) that are so delicate that they may be destroyed by too rapid or powerful erosion during the process of uncovering them. Discuss how this relates to the low energy in most caves.

CONCEPT: Erosion records the past.

Example: Only vulcanism or extreme mechanical weathering usually can produce silt-size particles found in the cave. Clastic sediments in Oregon Caves include hoodoos, silts (some may be varved), volcanic ash, clays, rubble slopes, conglomerates, breakdown, imbricated cobbles, vermiculations, and mud stalagmites, stalactites, microgours, and draperies.

Lab Exercise: Breaking Rocks
Objective: Students will list two types of erosion that can produce different size particles.
Vocabulary: Erosion, weathering
Procedure: Pound an argillite chunk into small pieces. Supply sandpaper and hammers. Use settling rates in graduated cylinder to determine size distribution of resultant particles. **Results**: Only students who use sandpaper will produce silt-size particles.

Lab Exercise: Braid a River
Objective: Students will be able to identify the features of a river system and explain how a stream becomes braided.

Background: No part of a stream or river travels in a straight line either on the earth's surface or underground. Instead they follow the easiest way that water can flow. This often follows the contours of the land or the largest underground channel. In many areas, there are characteristic drainage patterns, often resembling the branches of a tree. Glacier-fed rivers and underground channels with lots of sediment typically wander across wide, rubble-strewn beds, dividing into separate channels and reuniting. This pattern is called braiding since it resembles the strands of a braid. The intricate network of interlacing channels is caused by obstructions in the stream resulting in and from sediment deposition. When stream water picks up more gravel and rock than it can carry, the load is redeposited and a new channel is scoured around the obstacle. Braiding is a sign that active deposition is in progress.

Subjects: art, science

Skills: observation, experimenting, artistic, representation, cooperation

Materials: construction paper, sand or soil; water soluble blue ink or thin paint; pitcher or other container of water; newspaper; painting smocks; paper and pencil; straws; watercolors

Vocabulary: watershed, braided stream

Procedure: 1. Pass out a piece of construction paper and a straw to each student. You may want to have students paint the paper with watercolors first to represent land, then allow paint to dry.

2. Put a small puddle (several drops) of blue ink or thinned paint at the edge of each piece of paper.

3. Have students blow through the straw directly onto the ink or paint. Be sure that the students are blowing into the side of the drop from the same level as the paper, not down on top of the drop. The ink/paint drop should spread out in a branching pattern similar to that of a river and its tributaries. Warning: this can be messy!
4. Tell the students that they have made an imaginary river system. The force of their breath served as the wind or a force of nature to make the paint/ink (river source drain or run onto the other areas of the paper (land). They can name their river.

CONCEPT: The present opens up the past.

Summary: The present is the key to the past. By observing changes taking place before our eyes, we can deduce the past and attempt to anticipate the future.

Lab Exercise: Discuss what these features can tell us about the history of a species: scales on coralroot, rudimentary legs on boas; tailbones, backaches, flat feet, and oversize teeth in humans; cell nuclei and mitochondria with their own reproduction system, inefficient kidneys in mountain beavers; interior vestiges of shells in slugs; gills in human embryos; cave species with eyes, wings, pigment, etc., and a spring device in fleas based on a structure that once served as a hinge for their ancestor's wings.

CONCEPT: Old/new geology highlights our impacts and rare hazards.

Summary: The geologic record preserved in caves makes us aware of and helps us plan for hazards usually forgotten because they are infrequent. At the same time, mountain geology is rapid and dynamic enough that we can more easily appreciate hazards and impacts.

Floods are destructive, but between floods people often forget their power; shortsightedness which many regret. But in slow changing caves rocks eroded into bevels, rills and other cave features are steady reminders of floods millennia past. The history of the earth, like that of a soldier, consists of long periods of erosion boredom and short periods of mountain building terror.

Slide Presentation: **<u>Oregon Caves Geology</u>**: The geologic history of the Monument. 30 minutes.

Lab Exercise: Have each student research a local geologic hazard and estimate its frequency and extent. These could include flooding (make floodplain maps with overlays of 10-500 year floods), droughts, lightning frequencies, earthquakes, landslides, icestorms, and wind storms. **Source**: Computer Filename is FLOODHAZ - Flood emergency plans

Example: If we think of the four-billion-year-old history of the earth as the Eiffel Tower, then the entire history of humankind can be represented in the last thin layer of paint at the top. When we consider how young we are as a species, it seems all the more arrogant to limit our cosmology to our own history.
"History is no guide because it admits of no roots beyond agriculture. If we're going to expand our consciousness, we need to deepen our roots. The new creation stories do just this--they ground us in the earth's billion-year-old history. They give our life perspective, and out of that grows a new cosmology (Fox, 1994:201).

Lab Exercise: List local geologic and human events on a rope or clock. Compare how fast certain resources such as oil are being used versus how fast they form. For example most oil presentl being extracted formed during the mid-Cretaceous over a period of 30 million years. **Source**: 93-GEO

*<u>Plate tectonics, erosion, glaciation, vulcanism and earthquakes</u> (see also mountain building)

CONCEPT: How rock slabs interact guides regional geology.

Summary: Slow or sideways collisions favor back-arc basins and volcanic island chains. Faster or head-on collisions destroy basins and sinking rock plates and thus may allow buoyant rock masses to rise as mountains, as in the case of the Siskiyous. Intermediate speeds may allow sinking rock slabs to partly melt under continents and rise as a line of volcanoes, as in the case of the Cascades.

Example: Back-arc basins develop when a ocean floor/continent collision occurs slowly (geologically) or sideways. Of all NPS units, the Monument may best expose a back-arc basin and what were some of the world's deepest rocks. Most other tectonic plate edge effects can also be seen here: sideways and head-on collisions, subduction, obduction, and continental growth in one of the Northwest's oldest areas. Tectonic means earth movement.

Demonstration: **<u>Where Sea and Land Meet</u>**: How southwestern Oregon fits into the larger picture of plate tectonics and continental drift. 30 minutes

Lab Exercise: Use cave and geologic cross-sections to determine the vertical structure of a back-arc basin. Use clay models to show sideways tear patterns typical of back-arc basins. Compress the basin to display the folding present in Oregon Caves.

CONCEPT: Plate edges and life favor limestones and marbles.

Summary: Since most limestones are organically produced, they are indicators of the amount of life processes going on. They are not common before the Paleozoic because life was not common enough then and ocean basins may have been too short lived to collect much limestone. Rivers and oceanic upwelling along ocean edges supplies nutrients for abundant life. Limestones are more likely to be both deposited and subsequently uplifted above ocean edges. The boundaries between oceans and continents are where large rock plates come crashing together, causing mountains to form, limestones to sink deep enough to be heated into marble, marble to crack and rock plates to sink, melt and rise to form volcanoes, mountains, and ocean basins that collect limestones.

Lab Exercise: Use the provided map of the current distribution of limestones in the world and in the US. Explain the distribution. Why are some bands associated with mountains (welding of small plates or continents to continents)? Why is the most ancient, and often the most interior of continents devoid of limestones? **Answer**: The continental shields formed as archaic cores when it was too hot for most life-formed limestones. Why is there a band of limestones between Indian and the rest of Asia and between Europe and Asia. **Answer**: These areas were plate edges that collided and fused together. Why are most karst (usually cavernous limestones) concentrated in the warmer parts of the world. **Answer**: The areas relatively close to equator is where there is more vegetation and carbonic acid derived from it. Therefore, larger caves are likely to be dissolved out.

CONCEPT: Plate impacts produce land and caves.

Summary: The edges of continents are places where rocks become differentiated. The lighter rocks become part of the continents and slowly increase their size. Plate collisions is where enough carbon dioxide is released by molten rock to keep the carbon dioxide cycle going and to keep caves forming.

Examples: Without the movement of large rock plates against each other, wet rocks would not sink and partly melt to form blobs of new continental material. Without this action of plate tectonics, we would be standing under half a mile of ocean water; there would be no continents of any size. Actually, we wouldn't be here at all; the most intelligent lifeforms would likely be large fish.

Example: Plates impacts were essential for the development of Oregon Caves. Without the twisting of the Siskiyou Mountains (caught between sideways colliding plates) there might not be a marble section facing north that would receive enough water for plants to provide enough carbonic acid to dissolve out a cave, especially a large cave. And since large caves are more likely to have openings than small caves, Oregon Caves may never have been discovered if it was small. Without mountain uplift the caves would not have drained. Without the tilting of the marble, fewer passages may have formed as some passages tilt with the marble and other (water table) passages cut across the marble beds. Without cracks and faults in the marble from rock plate collisions, rise of the Grayback Pluton and/or uplift and erosion, acidic water could not get in to dissolve out a cave.

Without the abundant moisture from the nearby ocean, there would not be enough vegetation to release carbon dioxide to dissolve out a large cave and to decorate it at this elevation. Without the moderating influence of the ocean, the snowpack would stay frozen all winter so there would be little growth of formations. Without just the right amount of final uplift, the cave might not have formed. Both higher up (colder) and lower down (drier) would have lessened the amount of carbonic acid produced by plants. Without a slowdown in the amount of seafloor spreading and vulcanism (and concurrent lessened release of carbon dioxide from volcanoes) and the sliding of parts of the Pacific Northwest to the north due to a sideways collision with the Pacific rock plates, the Arctic Ocean would not have frozen and caused another Ice Age which helped create the cave.

Lab Exercise: Using the provided maps of the US, color the bands of Paleozoic, Mesozoic and Cenozoic rocks, with the Cenozoic volcanics of the Cascades removed. Why are the bands situated the way they are? **Answer**: They reflect welding onto the continent of progressively younger terrains.

<u>* Rocks changed by mountain building</u>

CONCEPT: Rocks react to change.

Summary: Generally, the greater the difference between present and past environments, the more rocks and minerals change. Minerals in the dikes and veins exposed in the Connecting Tunnel and Ghost Room are changing to new minerals as they adjust to their present conditions. The greater the difference between a mineral or rock's initial conditions of formation and the present conditions, the faster rock and minerals may alter to new rocks or minerals. Since the minerals in the dikes and veins formed at very high temperatures, they are altering faster than the flowstone which formed at much lower temperatures. Quartz is an exception to this general rule.

Example: Certain minerals act like thermometers and barometers, each mineral forming at a certain temperature and pressure range. These minerals mean the Oregon Caves limestone lay 12 miles deep and was baked into marble at 800 to 1200 degrees F., a bit hotter than the maximum temperature of household ovens.

Oregon Curriculum: 1.2 Demonstrate Change

Lab Exercise: Compare the erosion of chert and marble in the cave. Why is chert dissolving more slowly.? **Answer**: The Ph was acidic when it formed and so it is stable in an acidic environment. The marble formed in an alkaline environment and so it is less stable. What rock comprises the cliffs in Oregon Caves? **Answer**: Marble and ultrabasic rocks. The marble may have been more resistant to erosion (compared to the argillite) when the climate was much drier 8,000 years ago. It also draws in soil through cracks.

CONCEPT: Erosion shapes landforms.

Summary: Rocks vary in their resistance to erosion. Rock hardness, susceptibility to chemical weathering, and rock structure (faults, folding, bedding angle, joints, etc.) largely determine how fast rocks will erode and create differences in surface topography.

Examples: Compared to the marble wallrock, the harder and less
soluble lenses of chert jut out as ledges. Pendants, scallops, and potholes mostly occur in the lower sections of the cave near the main entrance, where stream flooding scoured out these features. Scallops are cusp-shaped depressions dissolved out by turbulent streams flowing past walls. Potholes form on the floor from the grinding of pebbles swirled by the stream. Pendants are sharp pointed rocks hanging down from the ceiling or walls. Sharp pointed ones tend to form in areas of rapid erosion, such as from very acidic or turbulent water. The stream cuts down into its floor so fast that pendants are left high and dry before they can be eroded away. Gravels armored the floor in Oregon Caves in the Passageway of the Whale and thus kept acid water from dissolving it. So the submerged passage expanded upward instead of downward. A stream then cut a canyon in the cave floor, completing a keyhole cross-section that reflects the cave's falling water level.

Lab Exercise: Compare the geologic and topographic maps of the Monument and relate the influence of rock type and slope aspect on steepness of the slopes. **Answer**: The steepest slopes occur on north facing slopes because of more freeze-thaw cycles and on marble (draws in soil) and metabasalts (resistant to erosion).
Source: Computer Filename is GEO-MAP - Descriptions of units used in geologic mapping of ORCA

*<u>Rocks changed by heat of mountain building and crystallization</u>

CONCEPT: Mountains can be like the tip of an iceberg.
Examples: Mountains rise due to plate collisions, magma upwelling, erosion, and buoyant rise due to the end of subduction, processes generally much larger than the mountains themselves. All these processes can be seen in Oregon Caves.

Examples: Processes include: 1. Deposition of Applegate limestone - Upwelling magma and thermal bulges in central part of back-arc basin. 2. Rise of Grayback Pluton - End of subduction allows lightweight continental rock to rise up much like releasing a balloon underwater. 3. Continued erosion in Tertiary - Removal of lightweight material causes further mountain rise, much like removing styrofoam from a styrofoam mound floating on water. 4. Present day squeezing and subsequent uplift between Pacific and North American plates

Oregon Curriculum: 1.2 Demonstrate Change

Lab Exercise: Measure the percent above water of a stacked layer of styrofoam sheets as each sheet is removed. Compare this to mountain uplift and erosion. Why are mountains roots rarely destroyed by erosion? **Answer**: Because the roots go so deep and mountains rarely rise much once they are down to their roots.

*Calcite; its many forms affected by climate and life

CONCEPT: Climate affects calcite.

Summary: Nearly all of the formations and bedrock of the Cave are calcite. Exceptions are the clay vermiculations, ice formations near cave entrances, various mud formations, and argillite and chert layers interbedded with the marble wallrock.

The smaller the size of the crystals the drier the climate. After thickening of a soda straw, subsequent evaporation on one side from air flow may cause calcite precipitation in intercrystalline cracks, causing one side to lengthen and bend or tilt. Thus, tilted soda straws may indicate increased dryness on the surface.

Field Exercise: Map distribution of cave crystal size, which is affected by climate changes.
Results: The largest crystals and velvet flowstone occurs deepest in the cave or in isolated caves intersected by tunnels, as in the case of the Clay Pockets. Small crystals do occur far into the cave, suggesting the cave was much drier at one time.
Oregon Curriculum: 1.1 Demonstrate Cause and Effect

CONCEPT: Crystallization is vital in cycles.

Summary: Calcite is almost always recrystallizing. Generally, the "rich" get richer (bigger) and the poor get poorer (smaller). Small crystals are dissolved and large crystals grow larger. The size of the crystals help determine how long the cycles of erosion and deposition last.

Examples: A rain of tiny, microscopic shells piled up a mile of calcite- and silica-rich mud in a deepening sea between the continent and the volcanic island chain. Pressure from overlying muds dissolved the smallest grains and grew interlocking crystals on the larger grains. This hardened the calcite muds into limestone. Silica-rich solutions from volcanic ash crystallized to form nodules and layers of chert, a rock made up of tiny quartz crystals.

Many different kinds of crystals are found in nature. A snowflake is a crystal. So are most of the minerals found in the ground. Most sand grains are small quartz crystals. In the cave, the walls, ceilings, and floors are made of limestone, a rock made out of calcite crystals. When water seeps through the cracks in the ceiling of the cave and dissolves some of that limestone, it carries the dissolved limestone into the cave and leaves it behind as icicle-shaped stalactites where it drips from the ceiling and as mound-shaped stalagmites where it drips onto the floor.

The marble near the Connecting Tunnel may have been recrystallized by being heated by the hot rock in the dark colored layer, thus blurring the layers of graphite. The broken stalactite near the Potato Patch has recrystallized, thus changing the original outline of the soda straw.

Ice formation is important in the cycle of wood growth and cave entrances. New wood must be "hardened" before it can withstand ice formation. The hardening involves the development of air spaces that can accommodate the expanding ice.

Oregon Curriculum: 1.2 Demonstrate Change

Lab Exercise: Use epsom salts and subject it to evaporation and rapid temperature changes to understand relation of crystal size to environment. The sizes of the crystals in the stalactites and stalagmites might be different than the size of the crystals in the limestone ceiling. The size of a crystal often depends on how fast it grows. You can dissolve some little crystals and grow some bigger ones from them. Since it takes a very long time to grow calcite crystals, try this with salt or sugar crystals.

You will need: 2 clear glasses or jars
Salt (about 3 teaspoons) 2 popsicle sticks or pencils
Sugar (1 3/4 cup) String
1 cup measuring cup Paper clips or nails
Pan, Spoon Dish, Water

Put one cup of cold water in a pan and add as much salt as you can dissolve in the water. If you haven't used a stove or cooked boiling-hot liquids before, ask an adult to help you heat the salt water (but do not boil it) and add one more teaspoon of salt. Let the salt water solution cool. While you are waiting, you can tie a nail or a paper clip on a piece of string and tie the other end of the string around a popsicle stick or pencil so that when you put the stick across the top of a glass the string will hang down into it but the weight will not touch the bottom of the glass. Pour the salt water into the glass and let the string and the weight hang down into the solution. Let the glass stand someplace where it will not be touched or moved for a few days and see what happens.

To grow a string of crystals you can eat, be sure the glass, the string, and the weight you use are clean. Label the glass "Sugar" so you know what is in it. Then boil a cup of water, pour the water into a dish, and add 1 3/4 cups of clean sugar. Stir until all of the sugar is dissolved. Prepare the glass the same way as you would to grow salt crystals, pour in the sugar solution when it is cool, and leave it undisturbed. You may see small crystals forming on the string in a few hours.

The crystals you can grow in this next experiment are like the shelfstone or "cave ice" that grows on the surface of cave pools. Like these crystals of Epsom salts, the crystals in "cave ice" are not really ice, they just look like ice that forms on a pond. The crystals in "cave ice" are calcite crystals.

Epsom Salt Rafts

1/2 cup of water; 1/2 cup plus 1/2 teaspoon Epsom salt

Boil the water, turn off the heat, and add Epsom salts until no more will dissolve. Pour it into a clear glass and leave it undisturbed. Observe crystals forming at and below the water surface. These will begin to form immediately and will change often for over a week.

Of course, the crystals in the cave are mainly calcite crystals, and calcite is always made of a chemical called calcium carbonate. It is a combination of calcium (which is one of the things that makes your bones strong), carbon (which soot, diamonds, and parts of all living things are made of), and oxygen (which we breathe). Not only cave rocks but also sea shells, coral and eggshells are made out of calcium carbonate. In fact, the cave is formed in marble, a recrystallized limestone made of ancient sea shells and that is where the calcium carbonate came from. **Source**: Computer Filename is CRYSTALS - Crystals and how to grow them

Results: The major mechanical weathering of rock at Oregon Caves most likely is freeze-thaw cycles at cave entrances. Use Lesson Plan #5 from Teacher's Guide to Caves and Serpentine Plants.
Source: Computer Filename is **TEACHGUI.1-3** - Teacher's Guide

CONCEPT: Calcite helps control calcium and carbon cycles.

Summary: Calcite is the mineral with the greatest reservoir of calcium and carbon in the world and so it profoundly affects life, climate, the atmosphere, and the oceans. Since calcium and carbon are vital in life, ecosystems are strongly affected as well.

Example: Some geologists think that increased vegetation and uplift since the end of the dinosaurs has accelerated weathering and subsequent absorption of carbon dioxide. This has reduced the carbon dioxide in the atmosphere which in turn has countered and balanced temperature increases as a result of increases in solar energy over geologic time.

This may be a cycle with feedback as well. During major periods of tectonic plate movement, vulcanism increases. The volcanoes add more carbon dioxide to the atmosphere and the greenhouse effect heats things up. This increases vegetative growth and limestone producing organisms, both of which absorb carbon dioxide. The edges of the continents are flooded because of mid-ocean upwelling and growth of mid-ocean ridges has displaced the water. These areas absorb carbon dioxide and deposit limestone. When continental movement and sea floor spreading slows down, the greater exposure of land absorbs more carbon dioxide and the climate cools.

Examples: Calcite is important in other ways. Limestone deposits in the ocean act as a giant buffer to keep a relatively constant pH in the oceans. The element calcium helps prevent leakage of potassium out of animal and plant cells. It preserves membrane integrity and strengthens cell walls. It protects roots against the effects of low PH, ion imbalance, and toxic ions.

Lab Exercise: Look at provided maps of carbon isotopes. The heavy isotopes means that more global photosynthesis took place during those times. When were periods of drops in photosynthesis? What may have caused these drops? **Answer**: Meteorite impact, decreased ocean upwelling due to supercontinent merger, massive vulcanism, global glaciation, or draining of shallow seas. How would the speed of the drop help support which theories? **Answer**: Only geologically sudden events would likely be responsible, such as meteorites, massive vulcanism, or global glaciation. The Permian mass extinction may have occurred in as little as a few days to a few thousand years.

*Six rock types of shallow cave

CONCEPT: All the world's major rock types illustrate cycles.

Summary: ORCA appears to be the only NPS area where all the world's major rock types can be easily seen by most visitors above and below ground. Because of nearness to tectonic processes, Oregon Caves may be the only known cave in North America where the world's three main rock types and their main subdivisions occur together.

Oregon Curriculum: 1.3 Demonstrate Cycle

Examples: These rock types include contact metamorphic (non-layered marble, sills), regional metamorphic (layered marble, argillite), volcanic (tuffs), intrusive (diorite), chemical sedimentary (cave decorations) and clastic sedimentary (conglomerate) rocks. Unlike other parks, all these rock types and most major geological processes can be easily seen by visitors in a short time.

Demonstration: **Identification**: Ways to identify the most commonly seen rocks and minerals of the Illinois Valley. 35 minutes

Field Exercise: Map the distribution of all major rock types in the main cave (chemical sedimentary (limestone), metamorphic (igneous, marble, metachert, greenstone gravels), igneous (quart diorite, ash falls argillite, contact metamorphic (recrystallization, green actinolite). **Results**: Most of the igneous features in Oregon Caves occurs to the south because that is where the Grayback Pluton is located.

Lab Exercise: Oregon Caves Lesson Plan - Rock Cycle and Cave Formation

CONCEPT: Steepness and shallowness reveals a cave's entire history.

Summary: The entire history of Oregon Caves is revealed, from complete submersion, to decoration, to destruction by erosion.
The steepness accelerates erosion so that the whole cycle is compressed in time and therefore visible at any one time.

Lab Exercise: Using the provided maps showing the highest percentages of speleothem cover, divide the vertical cave profile (north-south) map into submergence, solution, deposition, and surface erosion sections. How has this changed over time? **Answer**: Submergence now occurs at the base of the present-day cave and surface erosion at the very top. Bevels indicate areas of past submergence, especially at cave passage constrictions. The main areas of solution are the present stream (a result of stream piracy) and the area from the crawlway to the South Room to the top of the Bone Dome.

2. Ecosystems are dynamic, evolving processes. Topics are:

*Close connections of cave, surface, life and death

Summary: Ecological systems are groups of interacting, interdependent components, including biotic as well as abiotic components.

Examples: The species in Oregon Cave's native ecosystems include a wide array of bacteria, arthropods and other invertebrate fauna, amd a few amphibians, mammals, and birds. Abiotic ecosystem components include rock, sediment, water, and air.

CONCEPT: Soil, steepness, and shallowness heighten cave dynamics.

Summary: Because it's shallow and mantled by rich soil, Oregon Caves is one of the most dynamic of all caves both in biology and geology. The shallowness of Oregon Caves easily shows connections between surface and cave. The steep surface is rapidly eroding into the cave.

Examples: Surface air pressure, fire, forest succession, and rainfall directly connect to cave wind, streams, speleothem color, and millions of drips. The Cave formed mostly underwater as a braided passage network overlaid by subsurface stream piracy and flooding events. The present cave stream is recharged by surface streams that dry up after spring snowmelt. Use of the Cave by small mammals is common in part because its nearness to the surface provides a wide variety of microclimates for bats and enough organics to support an invertebrate community attractive to insect-eaters. The Cave has eight bat species, the most abundant being the long-eared Myotis (*Myotis evotis*). Tree roots and root hairs are common in much of the Cave and may be a substantial food source for cave life. Root casts allow mole shrews, rapid waterflow, organics, etc., to enter the Cave (92-BIO.CUT).

Field Exercise: Using the cave inventory maps, map the distribution of roots, air flow, drip rates, speleothem colors, siltcicles, packrat middens, and relate to surface topography maps and vertical cave profiles. **Answers**: Roots, brownish speleothems and packrat middens occur close to the surface. Drip rates decrease sooner in the summer near the surface as that storage of water is exhausted earlier than deeper in the cave. Airflow is highest in passage constrictions and between high and low cave entrances. Silticicles occur near argillite and silt deposits. White speleothems occur deep in the cave, especially on ceiling out of reach of humans.

CONCEPT: Caves go beyond the twilight zone.

Summary: Zonation of formations and lifeforms occur near entrances and with depth and thus dynamically changes with continued erosion and rainfall.

Examples: Moonmilk looks like cottage cheese when wet and powdered milk when dry. Moonmilk with more than 90% calcite is called Mundmilch. It is commonly associated with portions of caves where a lot of air flows between the cave and the surface. Organics could be supplied by water filtering through rock and blowing in from the surface. Both would be high near entrances and could be further concentrated in water through evaporation. Warm, dry air appears to move into this area during summer from the surface.

An inventory of algae-shaped speleothems has detailed the size of the Cave's prehistoric entrances. These cave formations are coralloids shaped like popcorn and oriented toward entrances past or present. Cyanobacteria (blue-green algae) may shape them towards light by binding calcite particles (Viles, 1984). Photosynthetic use of carbon dioxide may cause calcite to crystallize as well (Jones & Motyka, 1987).

Directional popcorn is greatest near cave entrances because this is where drying winds from the surface are greatest and therefore can evaporate more water and deposit calcite. However, right at the entrance there is little popcorn, presumably because frost wedging destroys it faster than it can form.

The number of species is greatest near the entrances except when drying air moves in. Then many cave-adapted species move further into the cave or small cracks where the relative humidity is higher.

Examples: Zonation occurs above caves as well. Dead leaves at the top host small globular springtails, oribatid mites, harvestmaen, jumping spider, centipedes and ground beetles. Further down can be found sprintails, mites, pseudoscorpions and crane fly larvae. Deeper still are earthworms.

Field or Lab Exercise: Map zonation of lifeforms and cave formations in a cave entrance with outgoing air. Using directional popcorn, map past opening to the cave, as in the dome pit just before the River Styx Bridge. Explain how this may change over time. **Source**: Computer Filename is 93-GUIDE, section on 110 Exit.

CONCEPT: Air affects caves.

Summary: Air transports water, organics, and carbon dioxide, all critical to caves. Changing the air quality affects this delivery system.

Example: Volcanic ash has been detected in water-deposited clays above the stairs. Wind blows ash from Cascade volcanoes mostly to the east during the present time but, during the last Ice Age, winds blew off Canadian glaciers in a southwest direction and so may have carried volcanic ash from the Cascades to southwestern Oregon.

Example: A low pressure system over the Pacific Ocean during winter generates storms that are moved to the Monument by prevailing winds of the jet stream. Thus, most precipitation occurs during winter and therefore affects vegetation patterns, such as the predominance of conifers. A high pressure system over the Northwest in summer prevents storms from moving in and so this is a dry time of year.

Example: A storm moving in drops the air pressure so much that air blows out of the cave. When high pressure returns air blows into the cave. This affects movement of cave life, directional cave popcorn, etc.

Slide Show Presentation: Weather or Not: Sky folklore that predicts the weather.

Lab Exercise: Choose three folklore sayings and explain why they might be valid scientifically.

Lab Exercise: Use the Monument's weather station box to show weather measurements and show relationship to local ecology. How many fog days does Oregon Caves have to Cave Junction. Does this effect the concentration of tree lichens? **Answer**: Although some fog and storms are channeled up the canyon to the Caves (resulting in more precipitation than in nearby stations with similar elevations), there are more fog days in Cave Junction than at Oregon Caves. Lichens should be more common in the Cave Junction Area, as at Illinois River Park.

CONCEPT: Tectonics and astronomy affect climate.
Example: Astronomical cycles (tilt of earth, shape of orbit) tend to control the medium range glacial periods while earth movement affect longer trends. The rate of change of the Moon's orbit, of the Earth's spin rate, and the tilt of the Earth's axis is dependent on the location of continents and on sea level. The length of day is controlled by how close the moon is to EARTH and the rate of change depends on how much of the spin is dissipated by tidal friction, in turn dependent on sea level.

Example: Mountain building tends to cool continental climates because general elevations are raised. But the process of mountain building often involves volcanic action which through reflection of sunlight by volcanic dust may cool the climate temporarily but in the longer run may warm it by increasing global carbon dioxide.

Lab Exercise: After being given some basic information on global weather (much of which is affected by the shape and spin of the earth), describe the climatic effects of the continents being 1) mostly oriented east and west and 2) being welded together into a supercontinent. **Answer**: Rainfall would be more evenly distributed with few mountain ranges in an east-west continental configuration to block air masses. There might be fewer deserts. There would be stronger continental climate if there was only one supercontinent. Some paleontologists believe that deserts in the interior of the supercontinent sent few nutrients to the rivers that fed the oceans. Since there was unrestricted ocean circulation and no land masses on the poles, there was less of a north-south temperature gradient and this in turn reduced vertical ocean circulation that would have provided nutrients through upwelling. This lack of nutrients in both cases may have helped cause the great Permian extinctions.

CONCEPT: Rocks affect water above and below.

Examples: Rock types and their structures affect water above and below. Geologic structure in Oregon Caves includes breccias, dikes, faults, slickensides, joints, sills, tilted bedding, and soft sediment deformation from chert growth. Contacts between rock types is important above and below ground. Crossing the small creek by the Big Tree, one passes into quartz diorite from the argillites of the past half mile. Quartz diorite looks lighter than the argillite and has tiny black dots. The drainage probably occurs here because of the geologic contact between the diorite and argillite. Water flowing through the porous sandy soils of the quartz diorite reach the impermeable, water-proof argillites and is forced to the surface as a stream. Faults and contacts between different rock types may control the direction of most drainages.

Contacts control most springs. Five small springs begin and flow all year in the Monument. The first becomes Upper Cave Creek. It sinks into its bed and emerges as Cave Creek from the Cave's main entrance. The second become Waterwelt Creek and joins Panther Creek outside the monument. A third comes from above the main parking lot. A fourth soon enters Cave Creek and the last one begins No Name Creek. Most of the springs occur where geologic contacts with relatively impermeable strata forces water to the surface. Two intermittent streams draining snowmelt from the monument's largest upper meadow sink into the Cave before reaching Upper Cave Creek.

Lab exercise: Compare the hydrologic map (streams, intermittent streams, springs, drainages) with the geologic map of Monument to explain distribution of at least three hydrologic features (springs, direction of streamflow, number of tributaries, and steepness of stream profile). **Answer**: The fault running through the marble mass has largely determine where Cave Creek lies. See above examples.

*<u>Climate, astronomy, and humans as geo-forces</u>

CONCEPT: Water/air interactions govern caves.

Oregon Curriculum: 1.2 Demonstrate Change

Summary: Water is one of the few substances that can exist as a gas, liquid and solid at temperatures normally found on the surface and subsurface of the earth. Because of its chemical and physical versatility it is essential to all life and the creation and decoration of caves. Its interaction with air determines where most life in caves live and where most formations form.

Examples: Water's high heat capacity helps to stabilize temperatures in the cave. In its liquid form, it is essential in dissolving out and decorating the cave. Depending on how and where liquid water flows and what the relative humidity of the cave is determines for the most part what type of formations grow and where cave species live. Without evaporation most directional cave popcorn would not grow.

In its gaseous form, water maintains the high humidity in the cave essential for the survival of many cave species. In order to save on energy in such a food-poor area, many cave animals have lost most of their waxy cuticles that protect against water loss. In its solid form, water is stored until spring and summer when it passes into the Cave and keeps it wet. Warming from the greenhouse effect (aided by water vapor), however, may reduce this storage capability.

How air and water interact, especially the number of freeze/thaw cycles, often determine the size and shape of cave entrances.

Demonstration: **Limits of Water** - Introduction to the water of Oregon Caves both on the surface and in the cave. Demonstration of instruments that measure Ph, temperature, total dissolved solids, and water speed and volume.

Lab Exercise: List at least five ways each of the three forms of water (liquid, ice, vapor) has affected Monument biology or geology.

Lab Exercise: Run River Run
Objective: Use toy boats or balls to measure flow rate of River Styx. Estimate cross-section area of the stream and calculate the flow rate. Compare this to the weir measurements.

Background: A stream's velocity directly affects the sediment load the stream can carry as well as its ability to erode its channel. Large amounts of suspended particles in the water can tax the current's energy and actually reduce the rate of flow. Sediments accumulate wherever the water is slower e.g. in depressions, where the stream widens, or on the inside of bends.

Velocity itself is affected by various characteristics of a stream's channel. The same amount of water will flow faster in a narrow, deep channel than in a wide, shallow one because of differential friction. Streams also run faster if the channel is straight and smooth as opposed to crooked and rough (so large rivers in lowlands often run faster than mountain streams). As a stream flows over a rocky bed, different parts move at different speeds. Steep gradients will result in higher speeds, other factors being equal. A river's speed will also vary with its depth. Flow is fastest just below the water surface and slowest near the bed where friction acts as a brake.

Procedure: Divide the students into groups of five. Have each group stretch a 50 foot string between two students. Have another student then roll a ball from one end of the string to the other, calling out "start" and "stop." Have the fourth student stand with a stopwatch and measure how long it takes the ball to go from the student at one end of the string to the student at the other end of the string. The fifth student will be the recorder and will write down the number of seconds the ball took. The next step is to determine the ball's velocity or speed per second by dividing the distance traveled by the time it took in seconds. V = D/T (sec). Compare the findings of each group. Explain to the students that at Oregon Caves they will be measuring the velocity of the River Styx current instead of the velocity of a ball.

Extensions: Have students create a simulation of a river channel, with curves, obstacles, etc. then measure the differences in velocity. After completing this activity on land, use the method to measure a nearby stream.

CONCEPT: Climate rates affects diversity.

Summary: Through climate shifts, for example, changes in temperature and precipitation modulated by landforms and other environmental constraints, different patterns of suitable habitats at the landscape level are produced. Each resulting landscape pattern, in turn, provides a different environment for species. Some species may find more suitable habitats following climate change, while others have less or none at all.

Example: The speed or frequency of climate changes will determine whether an organism might be carried over from an unfavorable cycle to a favorable one. If the lifespan of a species is much longer than the frequency of climate change, it can become established as its range expands during one climatic regime, and merely survive during a succeeding regime. Time changes superimposed upon space changes shapes the observed patterns of diversity. A human-caused decrease in climate cycle time and a decrease in available habitat is a double whammy and likely will increase extinctions.

CONCEPT: Drainages change with depth.

Summary: Surface and subsurface drainages aren't the same. Because the geology is different on the surface and subsurface, what provides water for a cave may not be the same as what is on the surface. Caves and the surface are interconnected but they usually don't evolve at the same rate or extent.

Example: Stream piracy of a surface stream occurred in the lower part of the cave because surface and subsurface streams enlarged at different rates.

Lab Exercise: Use the two transparencies and superimpose surface and subsurface drainages of Oregon Caves. What is the relationship of the surface streams to the underground River Styx and the orientation of cave passages? Why are most of the streams on the surface intermittent, meaning they only flow at certain times of the year? **Answer**: There flow becomes so low in summer that it is all subsurface; much of it in the caves. Why is Waterwelt Creek not intermittent? **Answer**: It does not flow over cavernous rock and begins at a higher elevation that the other streams.

*<u>Ecosystem similarities and contrasts</u>

CONCEPT: Death births life and ecosystems.

Summary: By accepting death and change as the basis of life, the Monument provides us with renewal.

Example: Acceptance can overcome a biased and negative attitude towards death reflected in Bakker's comment that "It is hard to accept dinosaurs as a success when they are all dead."

Examples: The Takelma Indians saw death as a continuation of life, ghosts living much the same as did living people. Native Americans in general saw themselves as a integral part of the cycles of nature. As a Lakota Indian explained, "You may have noticed that everything that the Indian does is in a circle, for the power of the World works in circles and everything tries to be round. The wind in its greatest power whirls. Birds build their nest in circles, for theirs is the same religion as ours."

Example: With death comes new life; a five hundred year tree may last another half a millennium as a food source for cave critters. A live tree with its thin cambium layer may have 5-10% living tissue while a dead tree is about half living matter.

Example: Alone in a cave with pits and tight passages we do feel closer to the natural boundaries set by death. We feel closer to the mystery of life and death than when actually at risk crossing the street or riding in a fast car, when death may be literally just around the corner. Then we feel fear and panic but not mystery. So we go to nature, the cave, the mountain, to feel more alive by feeling the death that nature insists we not forget. Nature seems to want us to remember death; for diversity and kinship of life not only include the fact of death but require it. **Source**: Computer Filename is DEATH - Natural and Native American Views

Lab Exercise: Soil in the Making
Objective: Through studying a rotting log, students will learn about the process of decay and the role of dead trees in a cave.

Background: Rotting logs and other plant debris are a vital nutrient source in the cave and are one of the hallmarks of old growth forests. As trees, branches or leaves fall to the ground, they are attacked by bacteria, fungi, insects, slugs and other organisms that begin to feed on and break down the dead plant material. Once these organisms have begun the decay process, other animals move in and continue, often creating holes and tunnels in the wood that form homes for still other creatures. Eventually, after countless animals have lived and fed on the dead log, it decays to the point of becoming a mound of rich soil.

Materials: Magnifying glasses or hand lenses, at least one for every two children. Pans to put pieces of wood into for close examination. Aluminum pie pans work well.

Procedure: Before visiting the Monument, call the chief of interpretation for advice on where to find a rotting log. Then on your park visit, bring the students to a fallen, rotting log near the trail. Remind the children that the log is home to many animals, so they need to be especially considerate of them. Also caution them to always look before they put their hand anywhere. Some log dwelling insects can bite! Warm days are best, as many insects become dormant in cold weather. If possible, divide your class into several smaller groups, having each group take turns at the log, or visit different logs.

Have each group kneel around the log with their eyes closed. Ask them to use their other senses to explore the log. What does it feel like? (soft, hard, wet, dry, spongy?) What does it smell like? Does it smell like anything they've smelled before, or is it different? Then ask the children to listen carefully to the log. Can they hear anything? (Sometimes the sound of chewing insects can be heard.) Have them tap the log in different areas. Does it sound hollow or solid?

After the children have opened their eyes again, have them look carefully at the log, gently and carefully pulling pieces of it apart. What's inside? Have them use their hand lenses or magnifying glasses to get a closer look. You may be able to see the thin threads or *mycelia*, of fungus, or the discoloration that comes from the presence of bacteria or algae living in the wood. Or perhaps a variety of insects and beetles. Chunks of wood with their inhabitants can be put in the pie pans for passing around and easier inspection. When the students are done, have them carefully return the log and its inhabitants to their original places.

Have the children discuss the role of rotting logs in the cave. What will their log look like in another five years? Will it be the same then as it is today? What would happen in a cave if we took all the dead logs away? Would it have any effect on animals?

Slide Show Presentation: Death like a wheel: Native attitudes towards death and extinction.

CONCEPT: Energy can neither be created nor destroyed.

Lab Exercise: Trace on a cave map the energy path from sunlight to the cave. This could be leaf to root to root exudate to fungi to fungus gnat to cave cricket to egg to beetle to cave cricket to ringtail to surface. Is there more than one path? How about paths that do not use sunlight? **Answer**: Some cave bacteria break down minerals for use as energy.

CONCEPT: Ecosystems rarely stagnate.

Summary: Ecosystems are characterized by constant flow and change in their components.

Examples: Movement may be geographic, as with movements of wildlife (bear, mountain lion, marten) and shifts in the ranges of animal species (climate change), or through the ecosystem, as with the flow of energy, carbon, calcium, and other matter. Flows and changes may occur in space or time. They may be cyclic, over short or long periods; they may represent trends; they may reflect changes in larger systems; or they may be seemingly random. At the same time, the mere fact that we can classify ecosystems means that they have some stability and bounce back (resilience). They may change but often within a range that we would define as the same ecosystem.

CONCEPT: We evolved in environs different than those we make.

Summary: Humans produce early successional ecosystems with lower productivity, recycling, connectedness, diversity, and stability than most ecosystems. Yet, based on reproduction rates and fossil evidence, we probably have evolved in and adapted to more mature ecosystems than those we make.

Example: One of the basic prerequisites of health is that one "we must not depart radically from the pattern of personal behavior under which man evolved, for example, by smoking, overeating, or sedentary living." -- Thomas McKeown, "The Role of Medicine: Dream, Mirage, or Nemesis?," 1976

Example: Among hunter-gatherers, like the Takilma, wild foods were harvested from a wide range of areas. When one area failed to produce its usual yield of berries, for example, another place would. Or, at worst, the gatherer didn't eat berries that year but found another food to replace them. In this system, the pressure on one area to yield a certain volume of food was not great.

With the advent of farming and sedentary lifeways, all this changed. Unlike hunter-gatherers, the farmer must rely on a particular piece of land planted with one or two crops. Consequently, the farmer's fate if far more vulnerable to the changes of weather, crop diseases, and predation by wild creatures. Its more likely to be boom or bust, a dualism that helps cause a good village/bad wilderness mentality. This leads to the necessity for control. Wild things become adversaries; they either take up space, sunlight, or water that the farmer needs for the crops or they directly invade the crops, eating or infecting them with diseases.

r-selection is selection for maximizing the intrinsic rate of increase (r) of an organism so that when favorable conditions occur, e. g. in a newly formed habitat, the species concerned can rapidly colonize the area. Such species are opportunists and often include weeds, parasites, and pests associated with humans (dandelions, rats, lice, roaches, tapeworms, etc.). r-selection is advantageous in unpredictable and rapidly changing environments, as in parasitism or the early stages of a succession. A mature tapeworm, living in a human gut and needing to get its larvae into the flesh of a pig in order that another pork-eating human being will be infected may shed a million eggs a day and over its lifetime produce as many as seven thousand million of them. Producing eggs which develop without any contact with sperm is of particular value when an animal needs to generate a large work-force in order to take swift advantage of a fleeting opportunity. So a single aphid can cause a plant shoot to be infested by a "thousand carbon-copies of itself within a few hours: a mite can duplicate itself to forma solid carpet covering all the available space on an insect host. Many weeds, such as dandelions, produce thousands of seeds without the need for pollination

In contrast, K-selection is selection for maximizing competitive ability or living in physically stressful environments, the strategy of equilibrium species such as humans. Most typically this is a response to stable environments as in caves or to physically stressful environments like most caves. This implies selection for low birth rates, high survival rates among offspring, and prolonged development. Some of the oldest trees in the Siskiyous are on serpentine.

Neoteny helps achieve K-selection. Neoteny is the retention of juvenile traits in a sexually mature organism. Herb, human, and some cave-life evolution is neotenic. Neoteny results in distinctive human traits of face-to-face mating, head aligned with the spine, large brains at birth, reduced hairiness, prolonged playfulness and social assistance at birth, traits that favor humans' migratory habits. Prolonged childhood also extends the spacing of births. The number of brain cells are switched off later in humans, resulting in more nerve connections needed for increaed sociability and adaptation to new areas humans migrate to.

Neoteny makes adult humans more like flat-faced, large-headed babies than like other adult mammals. Some studies say we picture our own bodies as having larger-than-life heads, although not as extreme as the child-like animals in many cartoons. The original trigger for the evolution of human neoteny may have been a need for bipedalism, which neoteny favors with straight spines, forward pointing big toes, hair loss to lose heat, and childhoods long enough to learn how not to fall down on our flat, neotenic faces. Other benefits came later, including tools, language, communal carrying of food, bigger brains, and a child-like adaptability when moving to new lands. Neotenic births got big-brained heads through the birth canal before heads got too large. In turn, walking upright and changes in blood flow to the brain prevented large brains from overheating.

The down side of neoteny was that humans may have become more gullible, more likely to be imprinted to follow leaders, just as puppies and ducklings follow whoever appears after birth. By relying on neoteny, industrialism can stagnate its servants in the insecurity and gullibility of adolescence (Shepard, 1982, Berry, 1990:165). But some believe there is hope. "The global environmental crisis will improve our lives by offering us a planet-wide crisis of the soul, an opportunity to mature as a species. We are, as these things go, a fairly adolescent creature, with prowess all out of proportion to our wisdom." -- Stephanie Mills in Utne Reader, Nov.-Dec. 1989

Other neotenous species live in harsh environments. Some Pacific giant salamanders (which are often found in caves) never leave the water after their larval stage. These individuals retain such larval characteristics as small legs, a flat tail, and external gills. Yet they are sexually mature. Bats appear neotenous as most live long lives compared to their body weight. Their relatively slow metabolism may be connected to their hibernating habits.

If humans were originally an equilibrium tending species they seem to be no longer. We now seem to be somewhere at the extreme end of an exaggerated oscillation called urban-industrialism, the willful withdrawal of our species from the natural habitat in which it evolved. Some scientists believe that the more extreme we become in our alienation the sicker we become since we evolved as healthy humans intimately connected with natural systems and modes of thought. There has been virtually no change in the human brain since the advent of agriculture.

Lab Exercise: Research the characteristics of ten mammals from the park mammal list. Categorize them as either K- or r-selection. Why are carnivores and others near the top of the food web mostly K-selection? **Answer**: Predators lead a more stressful existence than their prey as their food supply is more limited.

Lab Exercise: Compress human existence into 30 minutes and point out significant events. **Answer**: One would have to spend 29 minutes and 51 seconds on gathering and hunting groups, a little more than 8 seconds describing settled agricultural societies, and a fraction of a second of industrialism.

CONCEPT: There's no such thing as a free lunch.

Summary: Not only that but, in terms of non-renewable and degraded renewable resources, each lunch costs more than the last. "In nature there are neither rewards nor punishments--there are consequences." -- Robert G. Ingersoll, Some Reasons Why, 1896. All our actions have consequences.

CONCEPT: Most ecosystems balance between order and disorder.

Examples: Ecosystems can respond to environmental changes in quite different ways. In the course of undergoing change, ecological systems may follow different pathways. Eventually, the processes that result in changes balance the processes that lead to ecological organization. Such a state is called an optimal operating point. An optimal operating point defines the limit of ecosystem development along one pathway, as in natural succession or human-caused degradation. Ecosystems may have more than one such point. The idea has been enlarged and described as evolution at the edge of chaos".

Example: Balance even suggests that humans, with all their power, order, and <u>Big</u> brains, have their own great weaknesses: pride and narrow-mindedness. In our self-righteousness, we mistake natural silence and simplicity for stupidity. We fail to see that nature often says so little because it know so much beyond words.

Example: Two opposing forces operate in the growth and development of a population; the first is the inherent ability to reproduce at a given rate (biotic potential). The second is the opposition to growth from all the forces of the physical and biological environment in which the organism exists (environmental resistance). Often changes in populations balance between order and disorder. Even a disorderly sequence of change might be described in terms of chaos theory, fractuals, etc.

Question: The second law of thermodynamics says that overall the order of an a system should decrease. How then is it possible for both ecosystems and evolution to produce increasing order and complexity? **Answer**: Life increases order at the expense of decreasing order outside the living systems. This is why life is dependent of outside sources of energy such as the sun or hydrothermal vents.

*<u>Process, relations, timing, and cycles rather than objects, black/white divisions, hierarchies, power, or endpoints</u>

CONCEPT: The meek shall inherit the earth.

Summary: Timing and precision equal power and strength in survival. The smallest, least powerful species are often those that give rise to evolutionary lineages. Predators tend to have a higher extinction rate than do plant eaters.

Example: Survival of the fittest refers to those organisms that can fit into the exhibiting coherence of interacting life systems within the community. Fitness cannot be reduced to strength or power alone. They are but two aspects of many that are involved when a species confronts a community. Natural selection is a holistic phenomenon that amounts to a test for each new species, and determines if it is able to fit into the existing patterns of life within the community.

Example: The smallest, least powerful species are often those that give rise to evolutionary lineages. The largest animals, like dinosaurs and large mammals have among the shortest species life-spans. Humans have already exceeded their average species life span of about two million years. The largest, most powerful species are often among the most specialized and with the smallest populations, both of which increases their risk of extinction. We consider plants and microbes to be meek yet they can for the most part fend for themselves while we need them. They and insects tend to do better during mass extinctions than do large animals.

CONCEPT: Many gray areas occur in classification.

Summary: Rigid classifications can blind us to diversity in nature.

Examples: Not all greens are of the same color. "Gray" areas include viruses, trees/shrubs, parasites (orchid-fungi relationships), protists, spectrums, and metamorphic/sedimentary (cherts and metacherts).

Examples: Daddy longlegs found in Oregon Caves are not true spiders, they only have some of their characteristics. They do not spin silk. Viruses have some attributes of living organisms (they reproduce) and some of inorganic substances (they crystallize). How about certain proteins that cause disease? We arbitrarily divide the rainbow and electromagnetic spectrum into different colors and groups (infrared, ultraviolet, x-ray, etc.). There are many cave formation colors of brown, reds, yellows that are caused by a complex combination of rust and organic material.

When the wallrock limestone of cave was forming, there was no or only a small Atlantic Ocean. It was a time when the reptiles were turning into mammals. There are no sharp lines between the evolutionary transitions between fish and amphibians, amphibians and reptiles, reptiles and birds and reptiles and mammals. There is no sharp line between our own species and our ancestors.

The creatures that produced the limestone and chert found in the cave were neither animals or plants. There were single-celled creatures. Like animals, they moved around. But, like plants, many produced their own food using sunlight.

Lab Exercise: Research specific relationships or processes in Oregon Caves and describe how some things have characteristics of two "opposing" categories. **Answer**: The parasitism/symbiosis of orchids, the seasonal solution/deposition cycle of calcite, the order/disorder of ecosystems, the predator/prey relationship, shrubs/herbs, and sedimentary/metamorphic rocks.

Example: Grey areas and transitions have their uses. Humans exist ever more in a structured, (b)right design -- security at the cost of material bondage. This ordering of our world lessens fears but thickens boundaries between us and nature. Twilight is neither day nor its opposite and thus stands above the bonds of division. Dreams, waking, dying, (re)birth, crossroads, midnight, noonday, and solstices also are when traffic between human and other worlds is easiest because boundaries are then thin. Boundaries need both sides, there being no life without death, no winter without summer, no dawn without dusk. In between day and night, shine and shadow arise from the same root word. Straddling boundaries can cause us to see ourselves in a new light and mirror. "The poetic images lead us to insights along curved paths rather than through direct answers." (Conway, 1993:153). Night rounds and softens edges while day sharpens them. Twilight does both. All this ambiguity unnerves humans used to pat answers either black or white but not both. Nature tends to avoid clear-cut forests and terms. Humans are sharper than round stones -- sharper but perhaps no wiser.

Without some uncertainty, life becomes boring and the ability to change is lost. Ambiguity destroys our old rigid creeds and opens us up to multiple dimensions of experience.

CONCEPT: Cycles can predominate in geology, birth, and simple food-webs.

Oregon Curriculum: 1.3 Demonstrate Cycle

Summary: Cycles have no beginnings or ends. The further back in time we go, the more we find the circles in time that we call cycles. The caves record climate, life, and rock cycles, such as glaciation, relic species, and ashfall -- the evidence for which has been erased aboveground by erosion.
Example: A natural oscillation shows a peak concentration of carbon dioxide during late winter or spring. The carbon dioxide in our atmosphere is renewed once every 300 years.

Example: Large magma plumes add great amounts of carbon dioxide to the air and also drown continental shelves by displacing water with lava. This results in a great accumulation of oil, as happened during the mid-Cretaceous.

Example: Parks give us the quality and amount of change, as in a cycle, that produces continuity for without change we have stagnation. Illustrating relationships rather than treating nature as things assures continuity and being able to deal with change.

Example: Mankind has recently been producing byproducts in such large quantities that natural cycles are often overwhelmed. Carbon dioxide produced as a result of the burning of fossil fuels appear to be altering the climate around the world. Global levels of carbon dioxide now appear to be increasing tens of thousands of times faster than the geological normal, increasing yearly by one or a few percent. Carbon dioxide in the atmosphere has increased at least 25% within the last two hundred years due to fossil fuel burning and forest reduction. It is expected to double within 60 years. This increase will exceed the amount presently found in much of the Caves and may dissolve formations in the upper part of the cave and increase their growth in the lower parts. Due to the higher concentrations of carbon dioxide, non-native plant growth above and in the Caves would probably alter calcite precipitation.

Because modern cultures rarely recycle most of their own wastes, these wastes do not become part of natural cycles. Hydroflorocarbons released from refrigerators, air conditioners and styrofoam are causing destruction of the planet's life-saving ozone. With all the added carbon dioxide in the air, will the cave formations continue to form?

A more important consequence of carbon dioxide and particulates may be to increase precipitation. Computer modeling and historical records from the 1930s indicate that climatic warming may increase precipitation in southern Oregon and northern California. This may cause loss of some drought and cave adapted species due to acid rain or competition with species adapted to more wetness or rich foods. Increased rainfall, combined with acid rain and higher amounts of carbon dioxide, may directly or indirectly decrease endemic habitat through faster plant growth, competition, and soil formation.

Daily pressure variations are, after synoptic cycles (seasonal patterns) the most significant affect on airflow in the Cave.

Cycles helped create the cave in the first place. Larger and older cycles are partly responsible for where Oregon Cave is located today. Heat released from the decay of radioactive particles heats up deeply buried rock enough for it to become plastic, like play dough. The heated, lighter rock oozes upward to form large plates of rock in the middle of the oceans. These ocean rock plates push against and sink beneath the continents when the ocean plates cool off.

Cave ghosts are white, rounded masses on the ceiling, the remains of formations partly dissolved away by acidic dew. Cave ghosts and the boxwork found in the Wedding Cake Room occur in the upper parts of the cave because warm air rises and condenses on the cold ceilings. Heat from tidal friction and radioactive decay deep inside the Earth warms up the bottom part of the cave two degrees F. warmer than it is four hundred feet higher up in the cave. The warm air brings up from the bottom of the cave so much carbon dioxide that condensation can form carbonic acid to eat away calcite.

The cause of medium-term glaciation is cycles on an astronomical scale. Five thousand years ago, the earth was closer to the sun in June and the tilt of the earth was slightly greater. Both added to summer heat in the northern hemisphere. These cycles of earth tilting and the shape of our planet's orbit around the sun help cause the Ice Ages. Changes in tilt is caused in part by axial precession, a 26,000 year cycle of a wobbling of the Earth's axis. It is caused by the gravitation pull of the sun and moon on the earth's equatorial bulge.

When Cave Creek finally cut down into the cave, cold, dry, dense air from the surface flowed into the cave and evaporated cave water, leaving behind many delicate formations on the floors and lower walls. This air flow cycle continues today and causes another cycle in cavern pools. Cold air flowing into the cave during winter cools the surface waters of the cavern pools and causes the water to sink, bringing dissolved oxygen to the pool bottoms. This is especially important now because oxygen is needed to get rid of human caused organic material that is getting into the pools.

Extinctions during the formation of the wallrock limestone in the cave and associated meteorite impact cycles may be caused by a twin star of the sun which throws chunks of rock out of the comet "cloud" that hovers beyond the orbit of Jupiter. Or the disturbance of the comet "cloud" could be from passage of the solar system through galactic dust clouds. Meteor bombardments during the Cretaceous may have killed off most nanoplankton and the light reflecting compounds they produce, thus reducing the Earth's albedo, warming the climate and killing off the dinosaurs. The dust cloud generated would have blocked sunlight, reduced atmospheric and ocean circulation and thus reduced the nutrient supply from upwelling currents. Present oceanic pollution may cause similar effects.

Equally controversial is an apparent relationship between the meteor bombardments, mountain building and lava flows on earth, a time when the huge rock plates are moving faster than usual. Normally the heat in the earth caused by the decay of radioactive material slowly leaks to the surface. This leakage may not be enough to let all of the heat escape. Instead there seem to be a cycle in which every so often the inside of the earth "boils" over, releasing heat in a geological hurry through rising molten rock that pushes the continents around. Crashing continents, rising mountains and increased sulfur and carbon dioxide from the lava flows could then alter the climate and cause extinctions.

A meteoric impact may trigger this cycle by cooling the climate and causing glaciers. The glaciers in turn may alter the earth's rotation and change the cycles of rock flow deep within the planet. An alternative is that a meteoric strike transmitted earthquake energy through the earth and focused them on the antipode, the opposite side of the earth from where the meteorites truck. The earthquake waves would have been converted into heat and this may have softened and weakened the crust enough for mantle magma upwelling to begin. **Source**: Computer Filename is CYCLE - Cycles at ORCA

Examples: "The energy industry is not a cycle but only a short arc between an empty hole and poisoned air." - Wendel Berry in Gift of Good Land, p. 117. "We have broken out of the circle of life, converting its endless cycles into man-made, linear events." -- Barry Commoner, The Closing Circle, 1971

We shall not cease from exploring
And the end of all our exploring
Shall be to arrive where we started
and see the place for the first time
- C.S. Lewis

CONCEPT: (Non)life controls on ecosystems merge.

Summary: All of the chemical-physical factors of the environment are called abiotic factors. Yet abiotic and biologic factors that control the composition and location of ecosystems often are not clearly separate.

CONCEPT: The carbon cycle affects many processes.

Summary: The carbon cycle affects tectonics, climate, caves, and us. Calcite was crucial in the explosion of life 600 million years ago. It served to detoxify the oceans, as an armor, and as a place to attach muscles.

Example: A drop in global carbon dioxide 7 to five million years ago may have favored CO_2 efficient grasses. The resultant spread of grasslands helped in the evolution of species that led to us.

Example: Several tens of thousands of years ago, there may have been no large entrances to Oregon Cave. Warm, moist air rising from deep within the cave carried a lot of the same gas that we breathe out, carbon dioxide. Moisture condensed on the colder ceilings, much like water condensing on the outside of a glass of ice water on a hot, muggy day. Some of the carbon dioxide gas dissolved into the water to form carbonic acid, what we find in a soft drinks. That weak acid ate away the ceilings.

Lab Exercise: Imagine yourself as a carbon atom. Draw and label the components of two carbon cycles in which you participate. Label how long you think you spend in each component (seawater, limestone, carbon dioxide gas, etc.). **Answer**: You would spend about a 1,000 years in the ocean, 10 million years in limestones, and about 30 days in freshwater.
CONCEPT: Little lasts forever.

Summary: All things change. Oregon Cave a hundred years from now will be different from what it is today although the changes may be so slow that we do not notice them. The National Park Service does not attempt to keep Oregon Cave in a museum where time is frozen, where nothing changes. This is not part of the natural processes and cycles of nature.

But the Park Service is committed to preserve cycles in a age where many natural cycles have been destroyed, modified or ignored. Preserving cycles and living them in our own daily lives follows a path of growth between stagnation and chaos.

Example: The Park Service has not been destroyed but it has changed. The history of the Park Service reflects both changing viewpoints of the American public and the founding fathers of the Service and country, men of vision who saw far ahead of their time. This Monument is a microcosm of those changes, such as:

1. The Park Service change from encouraging people to visit parks (commercialization of cave, many dirt and asphalt trails, transformers in cave, buildings, water lines and sewage lines over cave), in part to serve the public and build up political support and appropriations for parks, to the protection of increasingly scarce resources under increasingly greater human impact (cave restoration, law enforcement, resources management).

2. The public and political change of viewing parks as lands worthless for commercial uses to areas of high value because parks fulfill certain needs increasingly recognized as important by Americans. Oregon Caves was established at a time when some of these needs were already recognized. Many of these values cannot be brought or sold.

3. The American democratic emphasis on increasing rights, starting with landless, adult males and progressively extended to blacks, children, women, Hispanics, Native Americans, cavers and other special populations, including non-human animals and just now touching on "non-living" resources. (Conflicts of Park Service with animal rights advocates, cessation of live animal demonstrations in parks, use of insecticides, protection of poisonous animals, meeting the needs of special populations, "problem" animals, reintroduction of native species).

Lab exercise: Describe two possible conditions of Oregon Caves 5,000 years from now.

Lab Exercise: The Monument has perhaps NPS's best recorded sequence of cave exploration, development, and restoration. Extensive CCC projects were completed in the 1930s, the last period of major development. By the 1980s, resources management, oversight over concession operations, and interagency cooperation became increasingly important.

Use the park's history files to show five changes in Park Service attitudes among the 1930s, 1960s, and 1990s. Exploration and development of Oregon Caves is recorded by about 1,200 letters, reports, etc. in vertical files (HIST.FIL), about 20 artifacts and approximately 500 photographs in the park museum, and in the 30 artifacts, the 55 arrow and 120 rock writing sites in the Cave.

CONCEPT: Everything is on its way to becoming something else.

Summary: Change tends to blur distinctions in nature. The cave is turning into a grotto. The qualities of ecosystem components change in time and space. These include changes in air temperature, water quality and flow rate, soil moisture, shape and genetics of flora and fauna, and the aging of individuals.

Examples: Change may not be slow or uniform. Evolution, for example, is often episodic. Otherwise, we would see a lot more transitional forms between species. There have been very high periods of speciation (early Cambrian, late Cenozoic) as well as high periods of extinction (end of Cretaceous and Permian). Some change is chaotic but even this change may have some order to it.

Caves go through succession. Rotting logs go through a animal and fungi succession. The fungi that break down the more soluble parts of the cell wall are usually followed by those that digest cellulose and finally by lignin-attacking species.

Examples: At least moderate change favors biodiversity. One of the reasons insects are so diverse is that metamorphosis (from larva or nymph to adult) allows the penetration of more than one habitat and tends to make more niches.

Lab Exercise: Choose what you consider to be transitional animals from the drawings of Monument animals past and present provided for you. Defend your choices. Why might transitional animals be so rare? **Answer**: Most speciation occurs relatively fast, in upland tropics, and in small populations and therefore would unlikely be preserved as fossils.

CONCEPT: Everything goes somewhere.

Summary: Matter/energy is neither created nor destroyed. For earth's ecosystems both energy and matter go somewhere.

Example: Air pollution may be diluted but it is still present.

Lab Exercise: From the Monument history files, find out what happened to: **1)** Monument garbage (much was thrown downslope in years past, now it goes to a soon-to-be-closed landfill, **2)** cave construction rubble (two piles on USFS land), **3)** unused lumber (mostly burned).

CONCEPT: Some cycles may self-regulate up to a point.

Oregon Curriculum: 1.3 Demonstrate Cycle

Summary: The constancy of certain cycles and conditions suggest some sort of feedback and regulation. Natural thermostats control and usually moderate air and water cycles but excessive impacts (human or geologic) can override such safety mechanisms and affect climate and caves.

Example: The salinity of the oceans has not changed substantially in a billion years. The global air temperature hovers over a narrow range. As the sun has become warmer in the last billion years, the amount of carbon dioxide in the air has decreased (increased absorption by clays from increased weathering from organisms?) proportionately.

Example: Certain marine algae produce compounds that enter the atmosphere. Once there, they serve as particles around which clouds form. In warm temperatures, the algae bloom, causing more clouds. The increasing clouds reflect the sun's light and warmth back up into the atmosphere, causing cooler temperatures and fewer algae. Fewer algae means fewer clouds, and fewer clouds mean a rise in temperature. With that the cycle begins again. The net result is temperature regulation. However, human-caused warming could overwhelm this thermostat.

Too rapid a warming could cause a runaway effect by increasing oxidation of peat deposits and thus releasing more carbon dioxide and methane. Global methane in the atmosphere may have doubled within the last 150 years. Methane in turn increases the greenhouse effect and chemically removes oxygen from the atmosphere. Termites are important worldwide in removing excess oxygen in the atmosphere due to production of methane by gut (protozoans) which break down wood into usable food for the termite. They too are increasing due to the cutting down of old-growth forests. Cutting forests absorbs oxygen because the lumber produced tends to decompose much faster than it would in a forest. Increased carbon dioxide may increase wetlands which in turn would increase methane production.

Example: The ozone layer in our atmosphere was made by life's first oxidizing species. This layer, which undergoes seasonal and geologic cycles, prevents the loss of water to the upper atmosphere. That's one way life might be regulating the retention of water, but there are other ways, too. For example, the scum that grows over the surface of pond and lakes helps to prevent evaporation.

Ozone changes are not yet a major concern at this latitude although many species may already be at their limit of ultraviolet tolerance. Cave species that wander out into daylight are perhaps most at risk. Daylight is deadly to some cave copepods. Dark skin on people helps protect us. Recent studies in nearby areas document an unexplained loss of the tailed frog and several salamanders. The loss may be due to ozone depletion in the upper atmosphere.

Since car exhaust helps increase ozone concentrations, the presence of approximately 40,000 cars on the monument per year has probably increased ozone slightly near the ground in the last 20 years. This may cause leaf death by interacting with ethylene production, both of which produce leaky cell membranes in leaves. However, indicator species, such as various conifers, at present show little or no signs of damage from ozone, sulfur dioxide, etc.

Example: Sea level is fairly constant over the short run although it can change over the long run due to withdrawal of water by glaciation and displacement of water by rising mid-ocean ridges. Sea level, especially in the northern hemisphere, is rising very fast not only from deglaciation but apparently from the withdrawal by humans of stored water underground.

Lab Exercise: Negative feedback can destroy a cycle by the snowball effect. List three examples of possible runaway negative feedback. **Answers**: Global warming would cause decomposition of organic matter in the arctic which would release more carbon dioxide which would cause further warming through the greenhouse effect. Extinctions of keystone species could destroy succession cycles by further increasing extinctions and other cascading effects. What positive feedback mechanism might stop such processes? **Answers**: Warming could increase cloud cover would would reflect sunlight and cause cooling. Vegetation could soak up excess carbon dioxide.

*<u>Sums and patterns greater than parts in a multipath way</u>

Summary: Since life expressed through ecology manifests more than the sum of its parts, it cannot be understood using solely analytical and reductionist modes of thought. Life in its natural setting inspires us to develop modes of thinking and acting that are holistic, systemic, symbiotic, connective, and participatory. We learn to see the world in terms of patterns and not just positions and points, in terms of networks and lattices, not just centers and peripheries, in terms of processes, not just objects and things.It inspires us to act toward each other as well as toward the environment in ways that serve and nourish the whole of which we are all participants, and in ways that are compassionate, co-creative, and cooperative.

CONCEPT: An ecosystem and its parts alter each other and form new levels.

Summary: A system is more than a simple aggregation of its component parts. As a result of its linkages, interrelationships, and interactions, new properties emerge in the system that are not characteristic of its component parts.

Example: An organism is more than simply an aggregation of body parts. Properties of complex systems include the properties of diversity, pattern, and structure. They also include self-organization, resilience and persistence, and capacity for self-renewal. Just as system components are characterized by flow and change, the emergent properties of the system also change, as in the process of community succession. Other emergent properties include the "functions" of entire systems, such as the function of wetlands in removing contaminants from water and in moderating flow fluctuations in adjacent streams. Another function is climate regulation.

Complex systems, and the multitude of components and processes that form them, exist within a hierarchy. Multi-scaled systems can be viewed as systems of constraints in which the higher level of organization provides the environment in which lower levels evolve. Each level affects "lower" and "higher" levels so that an analogy of a controlled hierarchy where orders only come from above is incorrect. Ecosystems are not one-way or even two way streets.

One of the major consequences of the hierarchical organization of ecological systems is that nonequilibrium dynamics or spatial heterogeneity at one scale can be translated into equilibrium at a higher level. For example, patchiness of habitats may help stabilize populations of prey and predators. Pattern persists within a hierarchical framework; a pattern may be stable at one level and not at another. The reconstruction of time series to determine the long-term dynamics of an ecosystem (also called the historic range of variability) is crucial in relating the dynamics of ecosystems to pattern formation and persistence.

A critical characteristic of a hierarchical system is the whole/part duality of its components. Every level is a discrete functional entity and at the same time is part of a larger whole.

Example: Lichen acids, important as dyes and antibacterial agents, can be produced by certain fungi in very small amounts. But when those fungi are associated with alga as a lichen they can produce vastly larger amounts.

Lab Exercise: Study a list of cave species from the Monument.
Explain which species are at most risk from extinction as a result of habitat loss outside of the Monument. **Answer**: Those species with the smallest habitat and those species whose individuals have the greatest ranges.

<u>*Small cavess as wilderness</u>

CONCEPT: Small is wild.

Summary: Caves allow wilderness in a small area easily accessible to most visitors to a national park area. Wilderness can give us peace, identity, intensity, surprise, challenge, an extension of the senses, unity, and self-esteem. Wilderness provides a link with the natural order, of which we are part and from which we can draw inspiration and meaning.

Examples: In coping with a wilderness, the American people developed qualities, virtues and characteristics that set them apart from the more civilized and longer settled parts of the world. As in the cave tour experience, both self-reliance and the value of small communities are emphasized. The challenges of the wilderness poured strength and creative vitality into our country. Our national character was forged in the wilderness. Wilderness may well be necessary for our continued survival as a culture. All known past cultures that became greatly urbanized and lost touch with wilderness ultimately collapsed, such as the Mayans, Aztecs, Romans, Babylonians, etc.

The Wilderness Act of 1964 speaks of wilderness as land that "generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable." This fits most of Oregon Caves.

The experience of wilderness can involve hiking, climbing, caving, walking a 1/2 mile of cave trail or overcoming one's fears of bats, spiders, scorpions, or caves. On the other hand, industrial tourism, like Disney World or Coney Island, tend to provide more entertainment and less change, mystery, challenge than does wilderness in National Parks. Tourism processing can be an impediment to the intensity of experience, diverting us from coming at the experience in our own way and at our own pace.

Parks provide an alternative to industrial tourism. Parks can provide experiences that create a flow in which action and awareness merge, a state in between pervading uncertainty (anomie) and pervading certainty (alienation - where one's abilities are greater than one's responsibilities). For outcome certainty reduces challenge to drudgery and novelty to necessity. And the experience that requires little yields little.

For many years, black rock layers in Oregon Caves were thought to be slate, formed when muds in the marble were metamorphosed. We now know they probably were partly moved along bedding planes under high pressure but were not metamorphosed enough to become slate. Wilderness is full of surprises. This is in part because ecosystems provide emergent functions that cannot be predicted by analyzing the parts of an ecosystem. Surprises keep us alert and awake. Understanding by any means (nature activity, science, music, wonder, all that increases awareness), as opposed to a mere increase in knowledge, deepens our awareness of the mystery around us because the more we know the more we realize how little we know. For every question answered, a dozen more are raised. When you think you know all the answers you haven't asked all the questions. The greatest mysteries here are bats and caves; they are major, worldwide symbols for the mysterious. Caves are metaphors for the unexplored areas within our own heads.

At the same time, understanding increases our competence and thus our self-esteem and sense of identity. Understanding can include learning how to walk through a cave safely as well as knowing more about natural processes and relationships. The snowshoer who stays reasonably dry and comfortable after a long day's hike is apt to talk proudly of the accomplishment, finding in the competent performance of her activity the basis for enjoying it, even if the sun didn't shine on her. Competence also helps build membership in a community of like-minded and competent people.

Wilderness is a matter of degree. Each of us chooses the right amount of challenge and novelty to give us feelings of interdependence, creativity, play, enjoyment, wonder, provocation, self-reliance, self-restraint and self-actualization--of being in control and having the freedom to choose. For a claustrophobic person it may be looking into the Cave's entrance. For a person with low mobility, it may be getting to the first room. For a different person it may be simply walking through Oregon Cave on the tour route. For another it may be caving in the "outer limits" of the Cave, perhaps where no person has ever gone before. Personal growth depends on the right degree of stress from a wilderness experience--physically and emotionally--and this threshold will vary with the physical condition and previous experience of each individual.

Wilderness, especially caves, are where we began, both as a species and as a culture. There are large areas of wilderness left: the bottom of the oceans, most of the Antarctic, the surface of the moon. But these are not "meaningful" wildernesses in terms of accessibility by single individuals. Like heaven, it is nice to know it exists, but many of us may never get there. In contrast, caves preserve a sense of individual discovery and exploration no longer present elsewhere in our extensively explored world. Except in caves, one can explore today only as part of a large team financed by governments or large corporations.

In a wilderness you can learn about yourself, your companions and nature. In wilderness, away from the social intensity and distractions of daily life, participants test themselves, heighten self-confidence and esteem, clarify their identity and personal values and address the central issues in their lives. Studies indicate that many wilderness programs yield small but significant increases in self-esteem, improved self-concept, a shift in locus of control from external to internal and heightened self-awareness among some participants.

Wilderness must be in four dimensions or there is no or little wilderness at all. There must be wilderness above us, wilderness below us, wilderness behind us and wilderness before us to feel that one is truly in wilderness. This is best seen in a cave because what happens to the atmosphere and the surface and once-molten rocks deep down affects the cave. A wilderness on the surface is not much of a wilderness if mining is going on underneath us. Our wilderness experience is lessened by seeing aircraft vapor trails overhead. Knowing that the cave was wilderness before and after we come here enhances the wilderness experience. This geological history can easily be seen in the wallrock and formations of Oregon Caves.

Wilderness extends the senses. Wilderness requires not only a depth of character but an extension of the senses as well, a presence, a pre-sense, before and beyond our five ordinary senses. Jim Bridger, the famous mountain man, said, at the end of his life, "I wish I war back in the mountains. You can always see farthar there." Here we have an extension of the senses beyond that of mere sight.

Unlike humans, nature isn't bound by the daylight of distinct and separate things. Many animals see more at night and in caves, when, as with smells and sounds, things flow together as a seamless process rather than being viewed as discrete objects. As mediators and tokens of unity-in-diversity, the sensory powers of wildlife seem more balanced and extensive than those of humans.
Source: Computer Filename is WILD-ORC - Wilderness qualities of small caves.

Lab Exercise: List, in priority order, human impacts that lessen the wilderness qualities of an area. Understanding of human impacts can alter that priority order as the full impacts of less visible changes are realized. Discuss the implications of some of the low priority impacts. Would this change anybody's priorities?

CONCEPT: Cave wilderness illustrates harmony.

Summary: Wilderness appeals as a place to knot together the unity that civilization tends to fragment. Contact with the natural world shows man his place in systems that transcend civilization and fosters reverence for those systems. The result can be a feeling of peace and harmony. Caves well emphasize the peaceful aspect of wilderness.

Examples: Forster, EM - How can man get into harmony with his surroundings when he is constantly altering them?

Aldo Leopold - "Harmony with the land is like harmony with a friend. You cannot cherish his right hand and chop off his left. The land is one organism."

Sigurd Olson - "The most important function of the wilderness for modern man is the opportunity of glimpsing for a moment what harmony really means. Harmony of knowledge, will and feeling toward the earth is wisdom, for it has to do with living at peace with other forms of life. Harmony is the musical flow of environmental awareness."

Lab Exercise: List examples of harmony in caves and old growth. **Answers**: Symbiosis, interconnected food webs, species adaptations, balance between decay and growth, succession.

CONCEPT: There is more than meets the eye.

Summary: What is happening high up in the cave and deeper below are both important in understanding caves. What is missing is as important as what is present, as in speleogens. Clues can help us expand beyond our narrow slice of sensory input, time, and space.

Example: Exceptions to our ordinary life make us look beyond the obvious. The novelty, expansiveness, and great beauty of scenic sites in parks reverses the ordinary, bridges dualities, and allows access to extraordinary experiences. Ecology helps us see the im-mediate coherence of our world -- acting as a lens through which we can sense worlds beyond linear sight and time.

Examples: Gas exchange between the photosynthetic cells of leaves and the atmosphere occurs at the walls of tortuous internal passages, so the functional surface area is from ten to over thirty times greater than meets the eye. For a tree with 2000 leaves, the internal surface for gas exchange is 1.5 acres.
The electric potential of some trees peaks during the full moon.

Example: Over 30 bone sites exist in the Cave although nearly all the bones are buried. Animals in nature usually can only be seen indirectly. The indirectness of animal viewing reinforces the belief that there is more in nature than meets the casual eye.

Demonstration: **Tracking**: Learn the most common tracks and how to track them. 30 minutes

Lab Exercises: Study different types of simulated or real tracks and list two characteristics that can be gleaned from them. Why are tracks often broader in winter?

Answers: Many animals such as the marten and snowshoe hare grow extra hairs on their feet during winter so as to be better support on the snow. Greater distance between tracks indicate greater speed. Distortion in tracks may indicate acceleration.
Scat Chat: Students dissect sanitized owl pellets following an general introduction to cycles and predator/prey relationships. 30 minutes.

Materials: Bags or sock boxes. (Sock boxes are useful for small or delicate objects that could be crushed if simply put into a bag. You can make sock boxes by first collecting several pint-sized plastic yogurt or ice cream containers and several old socks. Then put the plastic container inside the sock, with the open end of the container facing towards the open end of the sock. Now put the cave object into the container and you're ready.)

Procedure: Before beginning this activity, put the various cave objects into separate bags or sock boxes (one object per bag). Pass the bags, one at a time, halfway around a circle of children. Each child feels the object and gives an adjective to describe how it feels. The other half of the circle tries to guess the object. After making guesses, pass the bag or sock box the rest of the way around the circle. Have the last child reveal the object. Reverse the order with each new object so everyone has a chance to guess and to feel.

The discussion following this activity can focus on the questions: Where are these objects from? Are some of these objects in the process of decomposing/turning into soil?
Would you expect to find these things in a field, your lawn, the playground? Why or why not?
What else would you expect to find in a cave?

*Adaptations of animals and microbes

CONCEPT: Adaptations and beauty confer survival.

Summary: We may see an ecosystem as beautiful because all its parts fit together and those are the ecosystems where we may most likely survive in. Thus the ability to see beauty may confer a survival advantage in evolution.

Example: Beauty often is a gestalt, a total-field of interacting processes. When all the parts harmonize, we say it is beautiful. This longing for the beautiful may well reflect a yearning for healthy environments in which we prefer to live.

Examples: Females often choose mates depending on how symmetrical they are. The high symmetry of spider webs is needed for maximum strength as well as non-sticky pathways to catch their prey.

Example: The only shapes that fit together so close that all their walls are common with those of their neighbors are triangles, squares and hexagons. Of these three, the hexagon has the shortest total length of wall for a given enclosed area. So building cells as hexagons saves building materials for the honey bee.

Example: People can live in harmony with the natural world by understanding how life adapts. In the late 1800's the California citrus industry would have become extinct through infestation of trees by scale insects but the ladybird beetle (Vedalia cardinalis) brought the scale insects under control. Nature may be saying to go green or die.

Example: Native Adaptations to local environments included plank houses, wealth displays, warfare, myths, trading, and use of river and plant resources. **Source**: Computer Filename is INDIAN - Summary of Lowland Takelma and Galice Indians (groups that probably used the monument).

Lab Exercise: Comb INDEX-A and INDEX-L-Z for five examples of adaptations of Monument species. **Source**: Computer Filename is INDEX-A - Similar to park glossary but contains more in-depth information. First half; finishes with letter L. **Source**: Computer Filename is INDEX-M - Similar to park glossary but contains more in-depth information. Second half; finishes with letter Z.

Lab Exercise: Characteristics of animals reveal their adaptations which are related but different from our own. Complete the following list and explain the differences between other animals and us in term of adaptations:

A mountain lion can jump as far as 30 feet. I can jump ____ feet.

A flea can jump 130 to 150 times its body length. I can jump ____ times my body length.

A black bear can weigh up to 500 pounds. I weigh ___ pounds.

A hawk, if she knew how to read, could read a newspaper 1/4 of a mile away. I can read a newspaper ___ of a mile away.

The booming of a blue grouse can be heard 5,000 feet away. I can be heard ___ feet away.

Lab Exercise: Examine skulls of common mammals at Oregon Caves. Try to guess what each animal ate. Which teeth are closest to our own? **Answer**: Omnivores like those of bears. Discuss the difference in the teeth of carnivores, herbivores, and omnivores.
Source: Computer Filename is MAMMAL.LIS - List of mammal species at ORCA

Example: Advertisement help species blend in or stand out. The monarch stands out to warn birds of its milkweed poisons. The viceroy mimics the monarch and thus gains protection but itself is quite tasty. Hover-flies mimic bees. Tiger beetles, with red and black stripes, which have formidable jaws and readily use them, are mimicked by grasshoppers. Bright colors in male birds is an advertisement of the males that they are fit to mate with females.

Lab Exercise: Find Me If You Can!
Objective: Children will be able to explain the value of camouflage.

Materials: A copy of the "Find Me If You Can" handout for each child.

Procedure: Give each student a copy of the handout and ask them to find and color in the hidden animals. This drawing will show a cave and will have a number of animals hidden there. They should all be in their correct niches, and the sheet should show accurate habitat features.

Example: Seeds mostly depend on animals or wind for dispersal.

Lab Exercise: Seed Race
Objective: Students will list four ways that seeds get to new places.

CONCEPT: Home often depends on microclimate.

Examples: Snail shells found here harmonize with the surrounding marble. One layer of the shell is made of calcite while another layer is made of a very similar mineral called aragonite. Since the two minerals break in different ways, the layers acts like plywood for a much stronger shell.

Examples: In all ecosystems the species-rich arthropods regulate numerous critical biologic changes and confer stability on the total system. A cave ecosystem has "structure" and animal and microbe species respond to this structure spatially and seasonally. This "structure" changes geographically as well as with succession. Invertebrates function in the food webs that involve every microbe and animal in the cave. Soil arthropods play important roles in the breakdown of litter, cycling of nutrients, and dispersal of microbial inocula. There may be ten thousand species of organisms in one cubic meter of cave soil in the Pacific Northwest. Pacific Northwest old-growth soils typically maintain nearly 200 arthropod species per square foot at any time of the year. Five to eight-year-old clearcuts have yet to recover to 1/10 of that diversity.

Field Exercise: Sample square 1/3 meter plots down to 1/3 meter in cave soil. Use Burlese filters. Determine number of different types of visible arthropods in each sample. **Extension**: Use a binocular microscope to find additional species. Draw a graph of size versus number of species. Are there any species you might not see even with the aid of the binocular microscope? **Answer**: Yes, although there is an optimum size for most arthropods that is within the range of the unaided eye and binocular microscope.

CONCEPT: Species extend/maintain their habitat up to a point.

Summary: Animals often use behavior to extend/maintain their habitat. Humans have carried this to an extreme but it may only be temporary as most examples from other species would indicate.

Lab Exercise: Habitat Classifieds

Objective: Students will be able to make associations between several different animals and their habitats.

Background: Real estate classified ads are one tool that realtors use to match customers to their "dream houses". Just as people have preferences for homes, so does wildlife. This activity uses "classified ads" for wildlife homes to illustrate specific needs for habitat.

Method: Students match animals to their habitats as advertised in the "Habitat Classifieds."

Procedure: As an introduction to this activity, you may ask the students to bring in the classified section of a newspaper. Have them read over the real estate ads and decide which houses they would like to live in. Point out that they each have individual preferences for the types of home they would like to have.
Have the students complete the Habitat Classified worksheet. If your class has not had enough background in the species featured in this handout, list the animals on the blackboard for the children to choose from.

Lab Exercise: Cave Homes, Houses and Habitats
Objectives: Students will be able to explain the meaning of the term "habitat". They will be able identify their own needs for food, water, shelter and space and explain that animals have similar needs.

Notes: All animals, including people, need homes or habitats. We usually think of our home as a house, but if we consider our need for food and water, our home extends far beyond our house. Animals' homes are also bigger than their shelters, as they often venture out to find food and water. A black bears finds winter shelter in a den just slightly bigger than its body, but in summer will typically range over thousands of acres of habitat to find enough food. Warblers who use the Monument in the summer may winter in South America.

Materials: Drawing paper and crayons.

Procedure: Ask each student to draw a picture of where he or she lives, being sure to include all the things they need to live, such a place to cook and store food, places to get food and water, a place to sleep, etc. When the drawings are finished, discuss them with students. Ask them to point out the survival needs like food and water that they included in their drawings.
Have the children hang up their drawings where everyone can see them. Point out that although each home is different, they are all homes and include similar basic things. Using the drawings as a reference, discuss the question, "what do people need to survive?". On the blackboard, make a list of the students' ideas under the heading "people". Do the same for wildlife.

After both lists are complete, ask the students to see if they can group together some of their ideas into larger headings. (For example, warmth might be combined with a place to sleep or a place to keep dry, and all three can fit within the heading of "shelter") See if the students can narrow down the two lists and come up with the basic survival needs for both animals and people.

Talk about how homes are different for different kinds of animals. Ask the students to imagine a bear's home, or an ant's home, or an elk's home. Where do these creatures sleep, where do they find food and water? How do they satisfy their basic survival needs? How far does a bear travel to find its food or its winter shelter? How does that compare to the amount of travelling an ant does? What would happen if an ant had to go as far as a bear (or a salmon!) to find its food? (It probably would not survive, since the distances are too great for an ant to travel.) Would we be able to survive in a home where the bedroom was ten miles from the bathroom and fourteen miles from the kitchen? (Probably not; this would not be a usable home or habitat for us.)

All animals, including people, need usable homes, where they can find the basic things they need to survive. For animals, these homes are called "habitats". They are usually much bigger than the animal's den or burrow, since most animals need to leave their shelter in order to get food or water. Point out that our homes are really quite similar - we need to go outside the house to get food and to buy extra "cover", such as clothing and blankets. Like animal homes, our homes are much bigger than our houses.

Once the students have an understanding of "habitat", write a few sentences on the chalkboard to define it. As much as possible, make use of the ideas that the students suggested. For example, habitat is a place with food, water, shelter and space. Habitat has the things that animals need to live. The students may write these sentences at the bottom of their home drawing. They may also write their own sentence about what habitat is, perhaps drawing a new picture to illustrate their words.

Extensions:
1. Discuss the differences in habitat between young and old caves, large and small ones. (See the Introduction for more information.) Ask the students if they think they would find the same animals living in a young cave as in an ancient one. The answer is often "no", since the habitats are so different that animals whose habitat is the ancient cave often cannot satisfy their basic needs in a younger cave. There are also some species that live in either habitat. This points out the fact that some animals, such as polar bears are very specific in their habitat requirements, while others like black bears, can live in a wide variety of situations, including caves.

2. Go outside and look for animal homes. Be sure not to bother the animals or their home in the process! Discuss the idea that they are probably only seeing one part of the animal's home, since the animal probably uses a much larger area for finding food and water. This activity can be easily incorporated into your park visit.

Lab Exercise: Habitat Rummy
Objectives: Students will be able to identify components of habitat as food, water, shelter and space and apply knowledge of these components to habitat requirements of various species of animals. Each animal has its own specific requirements for food, types of water sources, shelter and space. This activity will reinforce this concept for your students, as well introduce habitat requirements for several residents of caves.

Materials: Chalkboard and playing cards (masters for the playing cards have been included)

Procedure: Draw the Habitat Information Chart on the chalkboard. Review with your students that each type of animal has its own specific habitat needs and point out that the chart shows the needs of five different cave animals. Review the idea of ecosystem: a broad type of habitat, such as the cave, or the ocean. Explain that the playing cards for habitat rummy will be similar to the blocks shown on the chart and that each student will be given habitat cards with which to play.

Divide the class into small groups of two or three children and discuss the object and rules of the game as follows. The object of the game is to get a complete set of habitat cards for an animal, (or all five cards from one vertical column on the Habitat Information Chart). The game ends when complete sets have been made for each of the five animals, with the student having the most complete sets the winner of the game. Every playing group will use one complete set of habitat cards and each group will have a winner. For now, the game is based on luck, but students will become familiar with the habitat needs for each of the five animals. For the first round, make sure that the Habitat Information Chart in plain sight of all players. The game begins as one students in each group deals five cards to each of the players in his or her group, leaving the leftover cards in the center of the playing area. After dealing is complete, the first player may discard an unwanted card and select another from the remaining deck. Play progresses around the circle with discards being added to the leftover cards in the center (either face-up or face-down) and new cards being drawn, until one player gets a complete set of five habitat cards. When a player does get a complete set, he or she yells "habitat!". This process continues until all habitat sets are complete. The student in each group with the most complete sets is the winner. Winners from each group can then play each other until a final winner is declared. After the game is complete, lead a class discussion so that everyone has a chance to review the habitat requirements for each animal. Ask the class if they think they're ready to try Habitat Rummy without the Information Chart. Playing the game without the chart will help reinforce the different needs of various cave animals. If they're ready, remove the chart and have them play again. This time the game depends on knowledge as well as luck!

Extension: Have the class research the habitat needs of five different animals and make their own playing cards and Habitat Information Chart.

CONCEPT: Species adapt to energy levels.

Summary: Low energy includes low light, little or low energy food, low temperatures. High energy includes ultraviolet radiation, high air temperatures, fires, and swift water.

Examples: Darkness transforms the life of caves. Some cave crickets, mites and spiders have lost dark skin pigments either because such change saves energy or because isolation of small cave populations has caused random changes in the animals over generations, what is called genetic drift. **Source**: Computer Filename is CAVE-BIO - Article on cave life in ORCA

A number of fleas are highly host-specific. Fleas parasitic on subterranean hosts such as moles, shrews, and mountain beavers usually have very reduced eyes. Owl vision is 35 to 100 times more sensitive to light than that of humans. Nocturnal flying squirrels are distinguished by their very large eyes.

Development of larger "claws" in cave-adapted springtails helps movement on slippery mud and thus saves energy in an energy-poor habitat. Cave springtails often have longer antennae and legs, a flattened outermost antennal segment and a large body size than the ancestors they evolved from. All these are likely responses to low energy levels.

Orb-web spiders are particularly sensitive to vibrations. When a female detects the struggles of an insect caught in her silken trap, she immediately rushes across and sinks her fangs in it. Many females spend all their time sitting on the web so the male strums on the outer strands of the web, using a special regular rhythm, clearly different from the irregular shakes caused by a struggling insect, He then clambers gingerly towards her. But he trails a safety rope behind him so that if she does not recognize him and attack, he can swing swiftly out of danger.

Bears are active in the Monument from early spring through mid-autumn and are found throughout much of the park. In fall, they find or create a den and enter a dormant state for most of the winter. A bear's winter sleep is much lighter than the true hibernation of chipmunks and golden mantled ground squirrels. When disturbed by melting snow during warm spells bears often wake up, leave the den and explore for several days before returning to the den for the rest of the winter.

Some wrens may use natural degradation of the song to determine how far away the singer is. Most mammals and birds communicate from 1 to 5 Hz because higher frequencies are more attenuated in the air and absorbed.

In low light levels, some species, such as glow-worms, produce their own light, as in the case of New Zealand caves. A complex protein called luciferaze combines with oxygen and in the process give off a brief glow.

Ecosystems with high biomass often have substances that are resistant to breakdown for use as food. Bacteria and fungi have developed enzymes to decompose lignin in wood. The saliva of shrew have an enzyme that decomposes the chitin in insects.

Field Exercise: Matching Mates
Objective: Students will play a physical game using noise/light makers which portray animal behaviors. Students will explain the key concept listed above.

Procedure: Have blindfolded students stand in a circle facing outward with their hands behind their backs. Hand out one noise (if during day) or one light-make (if at night). Distributed duplicate devices to each side of the circle. have participants scatter outward from the circle (and find a place to hide if they are playing without blindfolds). When all students have scattered, the leader gives the signal to begin. The participants attempt to find their mate by using the noise/light makers. Discuss. The next time introduce predators.

Examples: The low light and poor transmission of sounds in subsurface habitat and old-growth favors other forms of communication than that of visual signals or high pitched sounds. As the high humidity of these areas can readily transmit odors, this fosters the use of chemical communication.

The skunk is not the only animal to defend itself mostly with smell. Eschscholtz's Salamander exudes a milky, sticky, astringent fluid from its tail. When frightened, ringtails secrete a sweet and musky odor from its anal glands. The most commonly seen millipede on the Monument is black with yellow markings. Picking up this millipede releases a cherry-like odor of hydrocyanic acid, given off so as to prevent it from being eaten by predators. Hydrocyanic acid can poison animals because it blocks enzyme metabolism in muscles. The same substance is found in cherry leaves and probably for the same reason. Eating a small leave sometimes can sooth a cough but eating too many leaves could relax more than just chest muscles; it can stop the heart. The sawfly caterpillar puts tree sap on ants who are then attacked by other ants because of the unfamiliar smell. Ants themselves release alarm odors that can galvanize an entire nest to attack an intruder.

When in danger, slugs in caves produce especially thick mucus or slime. The smell of the mucus may deter predators. The mucus also may make slugs too slippery for predators to grab and hold. The mucus is such a good lubricant that slugs can slide over broken glass or an upended razor blade without being cut. In addition, a thick coating of slime helps to protect the slug from dehydration. Bacteria competing with scavengers for dead meat produce toxins and smells that deter scavengers. Those scavengers whose found the smells offensive were the ones more likely to survive, such as ourselves. This is why rotting meat stinks.

Species use smells for other reasons than just defense. Woodrats establish scent trails in Oregon Caves. Black tailed deer in the Monument produce a smelly paste from glands on their foreheads and under their eyes. This they smear on tree trunks or leaves. Other scents are found in feces, urine, tarsal and metatarsal glands from two places on their hind legs and glands between their toes and near their tails. Male crickets chirp when they smell chemicals discharged by the females. Salamanders release sex attractants in water. The molecules are heavier and more numerous compared to chemical messengers used in air. Ant chemicals that distort communication in rival ants also have high molecular weight, and thus last longer than those used in finding food sources. The evolution of ants has seen increasing use of chemicals to lead ants to food, defense, etc. Red-backed voles rely heavily on the fragrant underground fruits of truffles, a type of fungus prized even by humans as a delicacy. Like flying squirrels, red-backed voles locate their food by smell.

To prevent winter freezing, some insects purge themselves of nucleators, mostly by emptying their guts. Others concentrate natural antifreeze chemicals in their bodies, like glycerol. Daddy longlegs may crowd together to conserve body heat. If you put your warm hand near them they will crowd around it. Hollow guard hairs keep ungulates warm in winter. Mammals in colder climates tend to have larger bodies and shorter appendages (legs, ears, noses) than their closest relatives further south. Compare the snowshoe hare with jackrabbits further south. Which is bigger, the timber wolf or the Mexican wolf?

Example: The size of warm-blooded animals in a single, closely-related, evolutionary line increases from warm to cold climates. Dire wolves, for example, were larger than timber wolves.
Demonstration: **Hair Today** - An introduction to mammal hair and pelts and how they allow each animal to adapt its environment. 30 minutes.

Example: Darkness heightens our use of other senses. As his last match flickered out, 24-year-old hunter Elijah Davidson found himself in the absolute blackness of a cave in 1874. Davidson was chasing after his dog Bruno, who in turn was pursuing a bear. Dog and bear entered a dark hole high on the mountainside. Davidson stopped at the mysterious entrance. He could see nothing; but an agonizing howl pulled him into the cave to save his dog. Now the matches were gone and Davidson had a problem. Fortunately, he was able to hear a stream. He waded down a gurgling, ice-cold stream and found his way back into daylight. Bruno soon followed.
Demonstration: **Night Walk** - Explore neglected senses on this short walk at Grayback Campground.

Lab Exercise: Use various spice smells for a blindfolded student to locate her or his baby bat silhouette in a cluster of other baby bats with different smells. How might a mother bat get close enough to smell her baby? **Answer**: Usually through distinctive calls by their baby.

Lab Exercise: Grylloblattid Tag
Objective: Students will appreciate the role of sound and vibration in cave life.

Procedure: Create a circle of students. The blindfolded "springtail" in the middle listens for the approach of a "grylloblattid." If the springtail points in the direction of the stalking grylloblattid before being tagged, the springtail survives.

Extensions: Try this on the cave trail where vibrations from the trail are important as well in locating predators before it is too late.

Examples: High energy adaptations are many although not as numerous as low energy adaptations.

In Cave Creek can be found a few red-bellied newts. Their flattened egg clusters are probably adaptations to turbulent stream life. Likewise, internal fertilization in cold, swift streams insures new offspring for the tailed frog each year. The boneless tail-like appendage, more prominent in the male tailed frog, is really an extension of the skin, not a true tail. The frogs use the tail for internal fertilization, essential in the fast water where the frogs live. The female uses her tail to deposit her eggs under river rocks. They are the largest eggs of any native frog in the US; their size may help prevent them from being washed away. Likewise, small lungs makes the tailed frog less buoyant and therefore less likely to be swept away. The swift water provides plenty of oxygen even for small lungs. Lack of ear, reduced dorsal fins and balancers, and a small tail fin helps the muscular larvae adapt to swift water. Larvae often face upstream, clinging by suction-cup-like mouths to stones in waterfalls. Both male and female lack eardrums, and the male lacks a vocal sac, found in most other frogs. Attracting mates by calling would be useless in the roar of rushing water. The toes show partial webbing, but the flexible fingers, which cling to boulders in the rushing water, are unwebbed. Tailed frog tadpoles cling to rocks in the swift current with a unique sucker mount. Equipped with a small larval tail fin, the muscular larvae swim well.

Elongation of appendages helps springtails to walk on the surface tension film of cave pools instead of being trapped by it.

Energy: As energy flow rose in human history, the percentage spent on system maintenance and waste increased (Beckerman, 1975:188). Greater use of energy, especially of non-renewable types, made all cultrues more centralized, costly, and polluting and less democratic. As such societies expanded and reached the limit of suitable land, disgruntled servants could no longer flee to greener pastures. Overpopulation increased competition for resources which in turn led to the rise of patriarcal cultures (Martin & Voorhies, 1975). Men's greater strength compared to women proved crucial in war and plowing. Overpopulation also may have denigrated the role of women as child bearers and helped give rise to patriarchal and militant societies.

Lab Exercise: Compare habitat of reptiles and amphibians and explain the main difference and how the animals have adapted. Research at least two each of the following Monument herps:

ORCA reptiles
Northern Alligator Lizard (*Elegaria coerulea*)
Western Skink (*Eumeces skiltonianus*)
Rubber boa (*Charina bottae*)
Common Garter Snake (*Thamnophis sirtalis*)

ORCA amphibians
Pacific Giant Salamander (*Ambystoma macrodactylum*)
Clouded Salamander (*Aneides ferreus*)
Eschscholtz's Salamander (*Ensatina eschscholtzi*)
Pacific Tree Frog (*Hyla regilla*)
Western Toad (*Bufo boreas*)
Tailed Frog (*Ascaphus truei*)

Answer: Reptiles, with their relatively waterproof skins, tend to inhabit the drier parts of the Monument. Amphibians with their moist skins and need to lay their eggs in water, seek out damper areas.

CONCEPT: Interfaces respond quickly.

Summary: Skin and hair often have the greatest response to the environment, such as climate change, since they are its interface. Camouflage and warning colors are other interfaces that change quickly both in evolutionary time, in growth, and seasonally (See CONCEPT: There is more than meets the eye). Interactions between species also change rapidly.

Example: Water moves in and out of a Giant Pacific Salamander's skin. This makes it susceptible to drought and toxins.

Example: Book lungs are the original respiratory organ found in spiders. They may have evolved when land plants were more common than animals in the Devonian and the oxygen content of the air may have been higher. Some tiny & fast moving spiders have evolved a tracheal spiracle, which is more efficient at obtaining oxygen.

Field Exercise: Lesson Plan #1 in Teacher's Guide for Caves and Serpentine Plants). **Source**: Computer Filename is **TEACHGUI.1-3** - Teacher's Guide

Lab Exercise: Give a card to each student describing the behavior and food habits of the Ice Age animals that each student is role playing. Develop a food web using string to tie each food web interaction between each student. Have one animal become extinct. What happens to the rest of the web? Lay the web down and then try to pick it up again. Is it the same? **Source**: Computer Filename is MAMMAL.ICE - Pleistocene animals near ORCA

Lab Exercise: Each student should choose animals specific to the present-day Oregon Caves community. Use a sign up sheet to ensure that most species are represented and that some are not over-represented. What you are after is a diverse and accurate representation of a cave community. Assist the students in researching assigned animals of the cave community. Have students locate information describing what those organisms look like and how they function in the community.

Following their research, students may wish to "picture" their organism. Students amy draw an outline of the species they choose on a sheet of paper. Instruct students to then attach another piece of paper behind the first and cut out the shape. When the shape is cut out, they will have two identical halves. Instruct students to detail their drawing on both sides. The two piece may then be sealed with glue, leaving only a small section unattached. before the last one or two openings are closed, stuff the organism with crumpled paper. To populate the room, use string to suspend the organism from the ceiling or along the wall. Hang them at appropriate heights relative to their trophic level (predators would hang higher than herbivores or chemotrophs).

Summarize project by asking students: Can you show me some examples of producers? Consumers" Decomposers? What would be the effect of removing a particular organism from the community? What would happen if the entire population of these organism was removed? What could cause the decline of organism in this community? How is this community important to us?

Lab Exercise: Food Chain Tag
Objective: Students will be able to describe a simple food chain. Natural systems are constantly changing, with some animals more plentiful one year and fewer the next. If a system becomes too far out of balance, with too many predators, for example, the population of prey may crash, ultimately decreasing the number of predators as well. Although actual systems are much more complex (ecologists usually speak of food webs, rather than chains), this game uses a simple three-link food chain to illustrate the constant adjustment within a natural system.

Materials: A large field or play area. This activity works best with 20 - 40 people.

Procedure: Divide the students into three groups, representing detritus, a detritus-eater and a predator. In a group of twenty-five to forty, choose three to five students to be predators, seven to ten to be detritus and microbe eaters, with the remaining fifteen to twenty students to be microbes. Explain that in most food chains, detritus is more plentiful than detritus-eaters, and detritus-eaters more plentiful than predators. Once the groups are chosen, have them choose a particular hand-signal that will differentiate them from the other groups. For example, the microbes may want to simply hold their arms out from their sides like amoeboid limbs, the snail to form a shell with their hands and the pseudoscorpions to hold their hands like pincers, with claws showing. Make sure to define the playing area, so that everyone knows how far they can chase one another. Now, when everyone is ready to play, the game begins. The pseudoscorpions try to tag the millipedes and springtails, the springtails try to tag the detritus and the detritus try to tag the pseudoscorpions and spiders. (When spiders die, their bodies decompose, acting like fertilizer for the fungis.) Once a person has been tagged, s/he turns into whatever type of creature tagged him and continues the game.

After several minutes, stop the game and count how many microbes, predators and detritovores there are. Point the numbers out to the students and have them resume the chase. After another few minutes, stop them again and recount. What patterns have emerged? Have the spiders all been caught? If so, what has happened to the numbers of springtails and detritus?

After the basic game has been played for several rounds, you might add another element to the game by having one of the microbes re-enter the game as a human. To illustrate the tremendous impact that humans can have, explain to the group that the human can tag everyone, transforming them into more humans, but that no one can tag the human. Play another round of the game, seeing how long it takes before all the players have been changed into humans.
Summarize the activity by discussing the changes and relationships that the game illustrates. What happens if there is an overpopulation of springtails or spiders? How does the system adjust to the overabundance? What happens when humans use too much of the food chain? How can we keep that from happening?

CONCEPT: Scat chats.

Summary: Feces tells about the condition, food habits, and habitats of animals.

Examples: Predators usually have hairy or scaly scat with a tweak or twist at the end caused by a sphincter muscle. Herbivore scat can be hard or soft depending on season and food available. In the winter it is mostly hard, relatively undigestible material.

Look for scat near eating areas.

Field Exercise: Identify latex scat from various animals based on general characteristics between predators and herbivores. Describe seasonal changes. **Answer**: Herbivore scat often varies greatly depending on the season. Scat helps tell what has been absorbed and discarded. Lots of hair or fruit skins probably indicates that lots of meat or fruit, respectively, have been digested.

CONCEPT: Adaptation has limits.

Summary: You can't go back unless you never left. There are limits to adaptations, resilience and persistence, such as the prior history of an animal, microbe, or ecosystem. Because environments change, species are forever catching up. This is especially true for species that have low generation turnover and that are greatly changing their environments, such as ourselves. It's hard to be in harmony with your environment when you are forever changing it. No two forms of life can occupy permanently the same ecological niche; eventually one form will replace the other.

Example: Living organisms, microbe or animal, have a range of tolerance to certain environmental factors. Values below a critical minimum or a quantity or factor in excess of the critical maximum will exclude certain organism from a specific environment. The range of tolerance and optimal conditions will vary for geographical or physiological races of the same species.

Examples: A cave shows the harmony of the earliest mammals with their environment. The large dinosaurs forced our remote ancestors into caves and other dark, cold places, forcing them to become more warm-blooded and hairier. Birds have hollow bones that lighten weight and serve as part of a circulation system. Bats never developed hollow bones (thinning them instead) and so the never developed the speed that many birds have. At the same time they can survive a broken leg while birds usually cannnot.
Cyanobacteria (blue-green algae) found at cave entrances best utilize the red end of the spectrum, closer to what the sun was giving off 3.5 billion years ago when the first plants evolved.
Example: Ecology teaches that everything has limits, including
human numbers, perception, consumption, and effects on a limited planet. Twice as many people doesn't necessarily result in doubling happiness. No relation is linear for long. Everything taken to excess destroys itself, including materialism, competition, growth, domination, individualism, hierarchy, and exploitation. Ecology teaches that much of the universe lies beyond our understanding or control.

Example: Mammals like ourselves and the skunk who died in the cave remind us we and bats cannot live all the time in a cave. There is not enough food here to keep a warm blooded creature alive. That is why there are no mammal or birds adapted solely for living in caves. Each animal harmonizes with its own environment.

Lab Exercise: From a list of vertebrates at Oregon Caves (both present and no longer present), list five species with habits most similar to those of humans. Why are some of these species most in danger of being lost from the monument? **Answer**: Those that have very long ranges (mountain lion, bear, fisher) and those that have very short ranges (endemic insects in cave).
Source: Computer Filename is FAUNA.ORC - Vertebrate species at ORCA

Example: Each species has an optimum clumping value; overcrowding beyond the density or undercrowding below it will tend to act as a limiting factor in population regulation.

Lab Exercise: Explain why once a population falls below a certain limit, further declines can set in and cause extinction. **Answer**: Mates may have trouble finding each other. There may be inbreeding. There may be local events such as icestorms that could wipe out the whole remaining population.

Example: Ecosystems may have multiple limits, some more stable than others. For example, the climax community, as the end-point of ecological succession, is an example of an optimum operating point. However, after a disturbance, succession may proceed along multiple pathways, and a given pathway may stop before the end-point of succession is reached. Furthermore, if there is a large-scale change in the climate or in the regional pool of species, new species may enter the system, resulting in new system organization.

Resilience is the ability of an ecosystem to bounce back to its original state. One type of stability is not necessarily a characteristic of resilience. For example, caves that undergo pest outbreaks as part of their natural cycle may be unstable (populations oscillate strongly), but resilient (they bounce back).

Related to resilience is regenerative capacity. Following some disturbances that result in loss of species or other change to system components, processes, linkages, and organization, the system may be able to recover on its own. Especially important is whether sources are available from which species can reinvade, the rate at which habitat becomes suitable for the variety of species, the capability of the various species to disperse into unoccupied habitats, and the sequence and process by which critical linkages among ecosystem components and processes can become reestablished.

Lab Exercise: Describe five cases where prior evolutionary history has limited the usefulness/efficiency of adaptation.
Answer: Humans, bats with delicate wing membranes, bears with highly prized gall bladders, mountain beavers with inefficient kidneys.

Slide Presentation: **Bats and Flying Squirrels** - Focuses on their unusual abilities and benefits to humans. 20 minutes

Lab exercise: Study skeletons of bats and flying squirrels and explain why flying squirrels are not true fliers. **Answer**: There is no great modification of the flying squirrel from other squirrel that would indicate adaptation to true flight. Unlike the bat or bird, there is no keel for the attachment of muscles and no thining of the skull or leg bones to reduce weight.

CONCEPT: Cooperation, interdependence, and community surpass win/lose competition.

Summary: Life complements itself. Competition tends to decrease in a community with high diversity because it forces species to evolve into different niches that are mutually compatible. Direct fighting is avoided among many species, including the wolf. How about our own species? Even parasitism tends to evolve into symbiosis.

Examples: The bats in the Cave, have varied feeding habits. Some eat beetles, others eat only moths. Some bats spin webs near cave entrances, others hunt their prey. This reduces competition.
Flying squirrels prefer standing dead or hollow trees for nesting and often nest in old woodpecker holes.

Foraminifera probably made up part of the original Applegate limestone and radiolarians made up part of the chert. When necessary, both can use food produced by tiny algae that live in their protoplasm. They in turn utilize carbon dioxide and nitrogen-bearing wastes that are given off by these tiny protists.

A restricted symbiosis can be too much of a good thing. It is estimated that within 30 years humans and a few domesticated animals and plants will comprise over half of the mass of all living things living on land. The harmony of human-livestock-agricultural plants conflicts with the greater harmony of life on planet earth.

Tree root fungi seen in near the Doug Fir roots in the cave probably have a symbiotic relationship with their host. Roots provide a home and food while fungi assist in water and mineral transfer. During times of stress, resources are more evenly allocated between trees. In primeval caves, the roots of trees have been found to naturally graft to one another. Roots of one tree can join with roots from the same tree, to roots of another tree of the same species and even to the roots of different species of trees. Scientists are increasing seeing forests as much more than collections of individual trees. With the roots of hundreds of trees fused together, a forest of "individuals" can be seen in some ways as one giant organism!

Blue-green algae seen near light bulbs in the cave all lack a nucleus. They are considered among the earliest forms of life on this planet. Through a process that took a billion years or more, independent bacteria invaded cells but ultimately became part of it in the form of nuclei, mitochondria, chloroplasts, etc. We are the fruit of that ancient union. Predations and parasitism often evolve into mutualism.

Physarum polycephalum is a yellow slime mold sometimes seen in caves.. Slime molds are fungi that move together as a plasmodium and engulf food. When the woods dry out in summer, the plasmodium may produce a resistant structure that has a hard outer cover. Or the plasmodium may creep to an exposed spot and form a stalk and a round tip in which spores form. How cells are chosen to become these reproductive structures remains unknown.

Examples: From predator protection and food sharing, bringing food to a homebase is inseparable from the ability to share. Dominance in humans is for organizing for food gathering; in baboons it is for defense. Birth assistance is unique in humans. As among the Athabaskans, men had to marry the widow of a deceased brother. If no brothers were available, Athabaskans designated a husband. "When the (West) fully learns that cooperation, not rugged individualism is the quality that most characterizes and preserves it then it will have achieved itself and outlived its origins. Then it has a chance to create a society to match its scenery." - Wallace Stegner

"All ethics so far evolved rest on a single premise: that the individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in that community but his ethics prompt him also to cooperate perhaps in order that there be a place to compete for" - Aldo Leopold.
Conflict is not the only response to a situation; other metaphors include resisting, outwitting, skipping, and subverting. Amphibians may have invaded the land in order to escape hungry and competitive fish.

Lab or Field Exercise: Pollination of serpentine plants (Lesson Plan #1 in Teacher's Guide for Caves and Serpentine Plants).
Source: Computer Filename is **TEACHGUI.1-3** - Teacher's Guide

CONCEPTS: Specialization is risky yet can increase diversity and efficiency.

Summary: Specialization ranges from herbivore defenses, to pollination, to vertebrate evolution, to the human brain.

Example: Human brains have specialized in that each side of the brain performs different functions. The left hemisphere tends to be better in non-sequential processes, spatial relationships and perception of music while the right hemisphere deals with language and linear processing.

Such specialization and their associated left/right handedness appears a recent evolutionary/cultural event in humans and only may have become prominent in adults about 10,000 years ago. The left brain may not have become dominant until Cro-Magnon in Europe acquired grammar. Increasing complexity and left/right brain specialization from weapon and agrarian tool use and left-minded writing may have severed direct auditory communication between left and right brains.

Such specialization seems most pronounced in males. They tend to think in certain situations only with one side of their brain. That may be why they have a harder time with speech defects or from recovering from brain damage than do women, being unable to compensate by using the other half of the brain.

Children may reflect a more ancient handedness. By 16 weeks of age, most American babies tend to favor their left hand. From 24 to 28 weeks they may be ambidexterous but after that time most right hands become dominant.

Our slander of nature also reflects a bias towards the left side of our brain and its emphasis on mathematics, time, maleness, language, and the superego emotions of shame, guilt and embarrassment. We ignore right-minded alpha waves and magic that enhances dancing, drumming, esp, and harmony. Our right hemisphere emphasizes spatial skills, imagination, innovation, strong holistic and primal emotions, creativity, and intuition more than does the left brain.

In a similar way to human females and children, salamanders are among the less specialized of any of the vertebrates (in part because they are among the earliest) and consequently have the greatest regenerative capability of any vertebrate. They are able to regrow tails, digits, limbs, snouts, eye lenses, some internal organs, and even entire embryos. Salamanders share with lizards the ability to detach their tails as a defense. The self-amputated tail writhes, distracting the predator while the salamander escapes.

Example: Specialists tend to have small populations at risk from extinction. With their populations prone to fragmentation, specialists are more likely to generate new specees, and thus they gain and lose species more rapidly than generalists.

Lab Exercise: Tree and Cave Rings
Objective: Students will compare a diagram of tree rings from Monument with stalagmite rings and list at least three characteristics that point to those changes in the speleothem and the tree as occurring at the same time.
Background: Tree rings are caused by greater production of large size vessels during early spring to allow for greater water flow during spring and summer.
Answers: Similarities are differential growth, effects of drought and changes in temperature

*<u>Interactions affecting biodiversity</u>

CONCEPT: Place is central to diversity.

Summary: The Siskiyou's location has helped make it a diverse place cave animals and salamanders.

Example: Southwestern Oregon has the highest salamander diversity in state, probably due to this area being the wettest/warmest part of state and a refuge from recent glaciation in Oregon.

Lab Exercise: Compare maps (state and US) of amphibian distributions with precipitation and temperature maps and explain correlation. **Answer**: Amphibians prefer warm, wet places, including caves.

Example: The low elevation and east-west trending Siskiyou Mountains don't stop migrating salamanders or cave species as do the Cascades further east. So it is in this area that cave species and salamanders from east, north, and south intermingle, resulting in a great variety.

Example: Humans produce early successional ecosystems with lower productivity, recycling, connectedness, diversity, and stability than caves.

Example: How much diversity is preserved by humans may be determined by what level diversity we value the most. Genetic diversity, the most basic level in the biodiversity hierarchy, refers to the variability between individuals or populations of the same species. Genetic variation determines a population's physical characteristics, environmental tolerance range and evolutionary potential, and is therefore fundamental to maintaining the variety of life. Above genetic diversity is species diversity, what we are most likely to preserve because it is most visible. But above species diversity is community and ecosystem diversity.

Lab Exercise: Draw a graph showing changes in cultural diversity since 1850. Why did it decrease in the late 1800s? Is it increasing now? **Answer**: It decreased in the late 1800s because of genocide. It probably is increasing now because people are attracted to low taxes, a low cost of living, and a diverse and beautiful natural environment. Could the migration change the very reasons that people migrate here?

CONCEPT: Moderate disturbances and changes in time and space favor biodiversity.

Summary: Moderate physical disturbance allows species to move in that normally would be excluded by dominant, late successional species. In contrast, large disturbances can reduce diversity because it increases extinctions and favors the low diversity of early successional ecosystems.

Example: Only when disturbances are widespread and fast, as in meteor strikes or many human impacts, do extinction rates rapidly increase. Species simply don't have enough time to evolve in order to adapt to these changes. A large disturbance would be the loss of an old growth ecosystem's area of greater than 50%.

Examples: Storms blow down trees, usually a moderate disturbance. The Takelma believed that the winter-storm was a supernatural woman going out with her children to dig up plants, digging up trees instead of roots as the Takelma did. Only when edges have been greatly increased through clearcuts can blowdowns become a major disturbance.

In 1964, a 100 to 200 year rain event moved a debris flow into the gift shop and the lodge and significantly damaged the lodge. A 1962 project that removed hazard trees within the monument upslope from the gift shop probably augmented the debris flow. However, such flows are normal processes that periodically remove soil creep material clogging drainages here. The flows may even result from slopes steepened by glacial deposition. This latest debris flow disturbance appears to have increased biodiversity by creating or enlarging an alder community near the Big Tree. The effects on the cave are unknown.

Moderate disturbances are those that are local and rapid or widespread and slow. A landslide is local and rapid. The uplift of mountains and continental drift are widespread and slow. Such disturbances produce isolation of populations and subsequent speciation. The movement of continents in the last 150 million years has aligned them mostly north and south, put Antarctica at the South Pole, and isolated the Arctic Sea, thus increasing temperature gradients and subsequent diversity.

Lab Exercise: Describe the difference between a small disturbance
(glaciers, fires, landslides, floods, rodent burrows, most plant eating, etc.) and a large one in terms of migration, colonization, biodiversity, and productivity. **Answer**: Large disturbed areas are harder to colonize and are more likely to have wiped out species than small disturbances.

Example: Sexual competition leads to increased diversity. However, in stable circumstances, some scientists say, the benefits of sexual reproduction are not much compared to the difficulties and dangers that animals must endure to find a mate. However, few circumstances may be truly stable. Everywhere there are microscopic disease-causing organisms. These, because they reproduce at very great speed, are continuously evolving and diversifying and so are able to exploit weaknesses and vulnerabilities in their potential hosts. The animals they infect must therefore themselves be changing their genetic make-up if they are not all to succumb.

Example: Ecosystem properties such as patchiness and heterogeneity can be found at a broad range of scales. The spatial and temporal variability in the environment at various scales gives ecosystems with a diversity of resources, allowing the coexistence of species that would not coexist in a non-hierarchical environment (Levin 1992). Therefore, space/time variability of the environment affects the persistence and coexistence of species, creating various biotic communities and increasing biodiversity.

Moderate disturbance create patchiness, where there may be refuges where the prey are relatively invulnerable, while in other places the predators may quickly eliminate them. In such patchy environments efficient predators can reduce their prey to the number the refuges can hold. This tends to prevent extinctions and thus maintain biodiversity.

Patchiness increases the amount of edges where, for instance, cave and surface meet. Species who utilize both habitats concentrate here because both habitats are close at hand. When disturbances become too widespread, species may be lost. The amount of edge decreases as small patches of disturbance coalesce into clearcuts, etc.

CONCEPT: In-place speciation increases diversity.

Examples: The great age of the Siskiyous has allowed many species to evolve here. As the Siskiyou mountains came closer to the Pacific coast, as fast as fingernails grow, they became part of a vast forest stretching from Asia to eastern North America. But the last uplift of the Rocky Mountains severed this great forest. We now have only a few connections between cave species on the East and West Coast, especially spiders, mites and millipedes.

Lab Exercise: List three ways that diversity gives rise to further diversity. **Answer**: With more species there is a greater likelyhood of new symbiotic partnerships that can help the partners expand their range and thus speciate. More species often means more competition and predation, resulting in speciation to avoid competition and a less likelihood of the paradox of enrichment.
CONCEPT: Caves are a fragile refuge.

Stressful, small refuges like caves areas can be fragile. They tend to have low populations with a few large seeds or other offspring that have trouble colonizing other areas. Migrating to less stressful environments puts them at a numerical disadvantage to species with faster individual growth rates. They are "stuck" and therefore vulnerable to loss of their habitat, climate change, or bioconcentration of pollutants during their long lives. For example, dumps of calcium carbide from carbide lamps are toxic to cave life.

Examples: Refuges often hold many living fossils. A living fossil is a present-day species that has certain characteristics only found elsewhere in extinct groups of organisms. They include boas, opossums, grylloblatids, horsetails, etc. Ginkos and metasequoias were probably once found here but now only occur naturally in China. Since competition and predation is less in stressful environments, such as island-like environments like caves, they tend to be good refuges for living fossils.

Some cave invertebrates may be living fossils that escaped increasing drought or competition on the surface after the Pleistocene. Two species of a primitive insect called a grylloblatid are only found in Oregon Caves and nowhere else in the world. They are usually found in glaciated or formerly glaciated areas. Around 12,000 years ago, glaciers were on the move within 2,000 meters (about one mile) of Oregon Caves. Thus, the grylloblatid, like some springtails, may be a glacial relict who retreated to the cold and wet cave when the climate above ground became warmer and drier. Even though they occur in the deepest parts of the Cave, grylloblatids still find their way to surface snow on winter nights to feed on insects killed or made lethargic by the cold.

Springtails are probably the most common insect in Oregon Caves. They are among the most primitive of insects and one of the first to invade dry land about 430 million years ago. Silverfish occur in old-growth logs and represent an even less specialized insect. Like the silverfish, the earliest insects lacked wings.

The Pacific Giant Salamander is found in Oregon Caves most often during the driest, warmest summer months and the coldest winter months, both times when there is little food available outside. The salamander may be using the caves as a moist refuge from the heat, dryness , or cold outside. In summer, the cave temperatures lowers the salamander's metabolism so it doesn't have to eat as often.

Resorts are human refuges. The Chateau was one of the first resort hotels established in southern Oregon. It has been in almost continuous summer operation since 1934.

Lab Exercise: Using the list of living fossils found in the Monument, draw a list of two common characteristics of the species and their environment. **Answer**: Usually wet habitats, usually slow reproduction, shaded areas, non-specialized, poor competitors.

CONCEPT: The "paradox of enrichment" can reduce biodiversity.

Summary: Increase in all or multiple resources, such as oceanic upwelling or biomass, tends to increase diversity but an increase in only one (such as certain organics or nutrients) tends to lower diversity. This is the paradox of enrichment.

The lint deposited by visitors in Oregon Caves may cause the paradox of enrichment, where one species adapted to food-rich area outcompetes cave adapted species.

Increased consumption usually decreases diversity both in animal communities and in cultures. Before Euro-American settlement here, there was a much greater diversity of cultures even though consumption and use of natural resources was much less. The same thing is happening worldwide as most societies become more consumptive, they begin to look more and more alike, especially in cities. As cultures become homogenized, we are narrowing our options, putting all of our eggs in one basket. Richness of culture-- literature, art, music, compassionate human relationships also do not require a large population. Most of the most cultured cultures in the world (ancient Greek, Renaissance, Hopi, etc.) have been small in population.

Lab Exercise: List three examples of rich (nutrients, food, sunlight) where biodiversity is low. Explain why. **Answer**: extremely dry deserts (diversity restricted because of lack of water), glacial deposits recently left by melting glaciers (early succession has low diversity), lake rich with phosphates from agricultural runoff (paradox of enrichment), and boiling hot springs (near temperature limit for most organisms). Caves can have low biodiversity and it is usually the result of low nutrients and/or relative humidity.

CONCEPT: Structure diversity increases biodiversity in old-growth.

Example: Competition between individuals of the same species causes expansion of a niche or habitat; two species can coexist when each species is more strongly limited by such competition.

Predation, which may be thought of as competition between (usually) different species also can increase diversity.
Some springtails in Oregon Cave, like other cave-adapted springtails, have elongated antennae and legs, increased body size and the ability to jump over 20 times their own length. Some springtails have evolved greater jumping abilities in caves to escape predators. Such an ability would be less needed in soil habitats.

Example: Much in the way that prey escapes predators by being unpredictable, so does nature reinforce diversity and creativity in us.

Example: A tenth of all species of animals in the world are parasitic insects, including a water mite from Oregon Caves. Since parasites often eat only one part of a host at a time; more parasites species can be supported. Methods to prevent animals from being parasitized has increased diversity. Some scientists believe that the diversity resulting from sexual reproduction was fueled by competition with microbic parasites.

Lab Exercise: List three advantages that competition or predation confers on prey species. **Answers**: Speciation, removal of sick or weak individuals, reduction of dominant prey species, development of symbiosis.

CONCEPT: Some species are more vital than others.

Summary: Simple ecosystems like caves and islands are more vulnerable to extinction through the loss of "keystone" species.
The small species usually are more important to ecosystem functioning than the large species. The species with the most biomass (such as Doug Fir trees and arthropods) often have more major effects on their ecosystems than species with low biomass.

Examples: Hawaii lost many species through the loss of keystone bird species now found only in caves as fossils. Yet the loss of the widespread chestnut in the eastern forests did not result in the loss of any recorded species.

Lab Exercise: List four possible "keystone" species at the Monument's cave and defend your choices. **Answers**: Doug Fir (dominant tree and supporter of symbiots as well as nutrients for the cave), bats (bring organics into cave, reduce dominant insects), tree fungi (most trees would die without aid in nutrient and water transfer in roots seen in the cave), humans (alien plant species may crowd out native species), microbes (supply nearly all acid for limestone solution to make caves),

CONCEPT: Extinction changes in time and space.

Summary: Extirpation and extinction occurs in the short term from being in the wrong place at the wrong time and from generalists being outcompeted. Extinction in the long term comes from widespread environmental changes that hit specialists the hardest.

In the very short term, it is demographic accidents that doom populations, being at the wrong place at the wrong time. What makes species vulnerable to this kind of extinction is their own life-history characteristics--for instance, their vulnerability to inbreeding or the small body size that goes hand in hand with short generation time. Species that live longer as individuals persist longer as populations. In contrast, when we see extinctions at longer time scales, it is environmental changes that are likely to be their cause, for more persistent populations typically tend to be larger-- and therefore less susceptible to demographic accidents--than are very small populations. What determines these longer-term extinctions is how variable the populations are from year to year, for this assays how vulnerable are populations to their varying environments. Diversity is high in the tropics and reefs in part because environmental changes and subsequent extinction rates were low there until now.

Current human-caused extinction is several million times faster than the geologic average and at least a thousand times faster than the fastest natural mass extinction.

*<u>Value of diversity to human and ecosystem health</u>

Summary: Diversity relieves boredom and fosters excitement, humility, imagination, creativity, mystery, understanding and caring. It increases our chances of seeing something rare or new. Diversity is important for itself. Caring for what has no material use for us enhances the diversity of people and our ability to care.

Examples: Diversity supplies future knowledge, symbolic values (language, expressions, images), beauty, drugs, foods, dyes, etc. Growing up with animals helps us understand the seemingly more complex emotions of humans. The speechless kind of companionship shared with animals may provide a sense of relaxation that humans, who demand talk as the price of companionship, may not provide. High diversity is more likely to supply enough lifeforms to act as reliable barometers of the state of the environment, supply enough species to repopulate an area, and provide ecosystem functions such as water retention, prevention of flooding, soil creation and retention, offsetting of summer droughts, maintenance of breathable air, decomposition, and climate stabilization. Ecosystem diversity promotes cultural diversity.

Examples: Successive migrations and transitional environments promoted extensive linguistic and cultural diversity in the Oregon Caves area.

Example: "It is often said that variety is the spice of life. No intelligent investor confines his money to one or two shares. No one can sit stably and comfortably on a chair with two legs. No one remains fully healthy on a restricted diet." - Prince Bernhard of the Netherlands, speech, at the Young Priseident's Oreganization, 6 May 1974

CONCEPT: Decreasing a habitat can lower its biodiversity.

Summary: The small a habitat the smaller its populations are likely to be. This makes it vulnerable to inbreeding and to extinction by local events, what otherwise would be moderate disturbances such as floods, storms, etc.

Lab Exercise: What Happens If We Run Out?
Objectives: Students will be able to describe the consequences of shrinking habitat and to describe the role of parks in preserving habitat. The students will be able to describe at least three ways that they can help preserve wildlife habitat.
As more and more land becomes habitat for humans, there is less and less room for wild animals. Nature reserves, wilderness areas and national park areas like Oregon Caves become increasingly important, not only for wild animals, but also for us - as living laboratories, as recreation spots and as sanctuaries from our own busy habitats. With increased development, parks become more and more isolated too, functioning like natural "islands" in a "sea" of human habitat. In recent years, scientists have become concerned that these islands of habitat

may not be enough for the survival of some species. Throughout the National Park System, parks are beginning to work with their neighbors to help protect wildlife habitat outside park boundaries.

Materials: One name tag for each child. Enough food, water and shelter cards to satisfy the following guidelines. You will be playing four rounds of this game. For the first round, make enough of each card for each child to get one of each. For each of the next three rounds, subtract six from the original numbers of cards. (If you start out with 26 of each color, make 20 for Round One, 14 for Round 2, 8 for Round 3 and 2 for round 4, giving a total of 70 of each color card.) Make your cards by photocopying the examples in this book onto three different colors of paper. At least xxx yards of yarn or twine. A large open area or playing field.

Procedure: Before going outside, have each student choose a cave animal that they'd like to be. Have them write the name of their animal on a name tag and tape it onto themselves.
Round One: 1. Find the center of your play area. Have the students stand in a large circle. Explain to them that they are cave animals, constantly searching for food, water and shelter for survival. Life is good though, and they have plenty of space in which to wander and find what they need.
2. Randomly scatter the Round One cards over a large area and tell the students they need to gather at least one of each color card in order to survive. Make sure they know that they must walk, not run and that pushing is not allowed.
3. After the students have gathered up all the cards, find out who has enough cards and who does not. Have the ■have nots• become spectators, explaining that every animal in the cave needs to work to finds its food and must compete with other animals to find enough.

Round Two: 1. Give the rope to the ■have nots• of Round One and have them form a large circle with it. The students who ■survived• Round One should stand inside the circle. Scatter the Round Two cards within the circle and repeat Round One's procedure. During the discussion, use the children's name tags to point out the species of animals that no longer live in the cave, like bears.

Round Three: Tighten the rope circle now, making the ■habitat area• smaller, barely large enough for the remaining students to stand in. (There will only be room for a few rope holders, so have the remaining spectators stand to one side where they still can see. Repeat the procedure, using the Round Three set of cards. Again briefly point out that as the habitat area decreases, so does the number of animals and the variety of animals.

Round Four: Make the circle even smaller, too small for the remaining students to all fit. Using the Round Four set of cards, play the game one more time. In your final discussion, point out that animals need habitat to survive. If there is not enough land to supply food, water and shelter for animals, their numbers will decline or disappear. National parks and wilderness are set aside as habitat preserves for wildlife. As development expands along park boundaries, the remaining habitat within parks becomes more and more valuable.

Scientists are now beginning to understand that the habitat areas protected within parks may not be enough for wildlife to survive. Throughout the National Park System, biologists are working with park neighbors to protect wildlife habitat outside parks.
Ask the students to think of ways that they can help preserve wildlife habitat outside of Oregon Caves. Some answers might include not littering, picking up litter when they find it (especially plastics that can kill birds), protecting wildlife habitat in their neighborhoods by

being careful along streams or forest groves, or writing letters to their congressmen and other decision-makers asking for their help in protecting wildlife habitat. The children will likely come up with many other ideas.

Extension: The protection of wildlife habitat can sometimes come in conflict with human needs and desires, often causing considerable controversy. For this extension, have your students look for news about habitat conservation on TV, radio, newspapers and magazines. Have them bring in articles to post on a bulletin board or hold a weekly discussion period to talk about these current events.

CONCEPT: Biodiversity has potential.

Summary: Some species are "babies" of little present use but with great potential. "For nought so vile on the earth doth live But to the earth some special good doth give." -- William Shakespeare, Romeo and Juliet

Examples: If we removed any species from Earth, we are in that act forever limiting the possibilities of the future. Remove all the species and there is no future. Remove a significant portion of them and the future possibilities are profoundly diminished.
Biodiversity is the ultimate source of the maintenance, regeneration, creativity, and evolution of the biosphere.

Maintaining the world's vast variety of plants and animals is essential for human health. A cure for a disease may lie in a plant threatened with extinction. The discovery of taxol for treating certain cancers highlights the hidden values of supposedly worthless species. A certain wasp uses a chemical to stop a caterpillar from turning into a moth. This could one day prove useful in the biological control of the Douglas-Fir tussock moth. Usnic acid found in some lichens has antibiotic value.

Species act as reliable barometers of the state of the environment, like the canary in the mine who dies of suffocation before we do. Species with permeable skins, such as most amphibians and cave macroinvertebrates, can respond quickly to air and water pollution and to ozone loss.

High biodiversity can help keep ecosystems stable in the presence of environmental changes such as drought caused by global warming. In one grassland study, a community with a higher biodiversity maintained a high productivity while the productivity of a less diverse community declined during drought.
Productivity drops as the channels of the nutrient cycles are clogged by losses in biodiversity. High diversity is an insurance that some species will fill in the gap if other species are lost through geologic changes. Diversity begets diversity; the same species on two species of plants may eventually speciate. A highly diverse reservoir of species is important in colonizing an area impoverished by a natural or human-caused process. Therefore, even if an animal has no direct use, it is of value in increasing diversity, of sustaining animals and plants that are of more direct value to people. A high biodiversity keeps our options open and is most likely to insure efficient use of available energy. Biodiversity yields much information. If every species had a page about itself, you would need a library bigger than the one in Grant's Pass.

Biodiversity yields benefits less tangible than economic or medical ones, but just as important. We are awed by the grizzly bear, excited by the flying spotted owl, humbled by the blue whale, and mystified by the miracle of life itself. Wild animals symbolize freedom. They encourage our creativity and imagination. And perhaps most important, having compassion for our fellow creatures enhances our care and love of one another.

Many cavers find cold symptoms alleviated in a cave. This may be because there are fewer allergens but something in the cave air may one day be found to be useful in treating common colds. Certain of the actinomycetes (moldlike bacteria), for example, may prove a potential source of new kinds of antibiotics. Sulfur bacteria found in caves produce vitamins of the B group.

We need animals to develop our ability to care for others. If we cannot find positive value in other lifeforms, we are less likely to find it in people. Chief Standing Bear of the Sioux has said that "The old Lakota was wise. He knew that man's heart away from nature becomes hard; he knew that lack of respect for growing, living things soon led to lack of respect for humans too."

The Park Service protects animals not only because they have value to people but because they have inherent worth. Inherent worth means that the value of a natural object is not dependent on a human observer of that object nor on the monetary value of the natural object to some human.

Indicator species are of narrow ecological amplitude with respect to one or more environmental factors and that is, when present, therefore indicative of a particular environmental condition or set of conditions. They are the "canary in the mine," warning of relatively slow metabolism species like ourselves that we may be next. Indicators species include salamanders, frogs, owls, and butterflies. Most have large areas of permeable skin that can absorb pollutants. Some, like owls and butterflies and easy to census.

Lab Exercise: List five ways that animals can detect pollution harmful to humans, i.e., the canary in the mine. **Answer**: These could include the analysis of bee honey for air pollution. Even humans can be "canaries." Once upon a time only farmers usually die of certain cancers such as brain, lymphoma and prostrate cancers. Now these diseases have spread to the general population. Mental illness may be another "canary." "Filthy environments may make us mentally ill before they make us physically sick." -- Athelstan Spilhaus, Daedalus, Fall 1967

Slide Presentation: **Endangered Species**: Their value and impact. 30 minutes

CONCEPT: High biomass favors high biodiversity and stability and vice versa.

Examples: An ecosystem is a grouping of plants, animals, and microbes interacting with each other and their environment. Biomass is the total combined weight of all individuals in an ecosystem. Pacific Northwest old-growth forests have the highest biomass of any forest in the world while caves have some of the lowest biomass of any ecosystem. The large biomass ties up most of the plant nutrients and therefore may prevent any one species from dominating through the paradox of enrichment. Carbon dioxide released by the biomass creates cave habitat and thus adds to biodiversity.

Areas without much biomass can have high biodiversity. In part because of rainfall leaching of nutrients and lack of abiotic fluctuations, tropical forests have high biodiversity even though rapid decomposition and low nutrients prevents much biomass from accumulating. Tropical plants do not store food for longer periods because insects or other predators are likely to find it.

A more important reason for short food chains is because of variable environments. Crashes in food supply causes top-predators to spend much of the time recovering slowly from population crashes. The longer the food chain is, the longer the time spent recovering; eventually, recovery time exceeds the interval of time between major population crashes. Food chains therefore should be shorter in unpredictable environments. Biomass is so low and variable in caves that it becomes an unpredictable factor that favors short food chains.

High biomass favors long food chains because the biomass promotes stability by tending to dampen temperature, wind, and humidity fluctuations. Large logs hold in moisture during the dry season.
A highly productive ecosystem with high biomass can still have a low biodiversity if environmental changes are great and the number of interactions between species (connectance) is great. This appears to be the case with salt marshes where changes in salinity are great and connectance is high.

High biodiversity can help keep ecosystems stable in the presence of environmental change such as drought caused by global warming. In one grassland study, a community with a higher biodiversity maintained a high productivity while the productivity of a less diverse community declined during drought. High diversity is an insurance that some species will fill in the gap if other species are lost through geologic changes.

Lab Exercise: Explain why most people in over-populated countries eat little meat. **Answer**: It takes more energy and money to raise and eat meat.

Field Exercise: Observe the living and non-living things on a large and small log and record their effects. Draw a simple cycle that is taking place on the log and explain what has been drawn. Convince the student to not tear the log apart.

Example: Caves are examples of systems with tight nutrient cycles. When systems of this type are disturbed, recovery may be slow because there is little through-flow of nutrients. A high degree of nutrient recycling allows an ecosystem to maintain a high level of biomass, even when the input from the physical environment is small. When a portion of the biomass is removed, it takes a long time for the system to recover, because the nutrient input is small compared with the stock of nutrient removed. Adding chemical fertilizers may only help temporarily and may hurt slow-growing nitrogen fixers and symbiosis between microbes and roots. The chemicals may soon be washed away.

CONCEPT: Life runs on limited resources.

Summary: Only about 10% of the energy from one trophic level makes it to the next trophic level, often through bottlenecks.

Example: The growth of an animal or plant is dependent upon the availability of a minimum amount of vital nutrients. Any nutrient deficiency will negatively affect growth and development. When a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of the slowest factor, what are called bottlenecks. The process of photosynthesis is conditioned by several factors: carbon dioxide availability, temperature, leaf surface, light intensity. If the temperature is cold, and all other factors are maximal, photosynthetic rate will be limited by the temperature; if on the other hand the temperature is warm and light intensity very low, the photosynthetic rate will be paced by the available light.

Lab Exercise: List the natural resources in shortest supply in your community. Defend your choices.

*Effects of animals on geology and vice versa

CONCEPT: Biology greatly affects geology.

Summary: Most erosional, depositional, hydrologic, and atmospheric geology, such as rates, composition, etc., is at least partly controlled organically.

Examples: Moonmilk is large organically produced and maintained. Notice the drip lines etched in solid white rock on the right side of the squeeze just before Petrified Gardens. This was once soft Mondmilch, a wet calcite mud that appears like cottage cheese when wet. Certain bacteria appear very common in these white muds of Oregon Caves. They may be eating organics dripping or blowing into the cave near entrances and then concentrated by evaporation. Eating these organics would reduce the acidity of the water and thus help form tiny crystals of Mondmilch. Organic films normally may keep Mondmilch from recrystallizing into solid rock. But as surface erosion came closer to this area, temperature changes may have killed the bacteria and dripping water may have washed away the organics and thus hardened the mud into rock. The name Mondmilch once meant "little earth man." Farmers in Europe cured livestock wounds with it, believing it came from magical gnomes. Indeed, some Mondmilch contains the same antibiotics used to cure people.

Example: The alteration of mica to clay minerals may supply energy to cave microbes.

Field Exercise: Map distribution of hard and soft moonmilk and explain distribution. **Results**: Hard moonmilk occurs close to entrances where it is wet. Soft moonmilk occurs further in the cave but still near entrances or areas with airflow.

Example: Meteor bombardments during the Cretaceous may have killed off most nanoplankton and the light reflecting compounds they produce, thus reducing the Earth's albedo, warming the climate and killing off the dinosaurs. Present oceanic pollution may cause similar effects. The movement of continents in the last 150 million years has aligned them mostly north and south, put Antarctica at the South Pole, and isolated the Arctic Sea, thus increasing temperature gradients and subsequent diversity.

Example: Some pigeons have magnetite crystals in their skulls and neck muscles that may be used to navigate by the Earth's magnetic field.

Example: Caves tend to have an predominance of negative ions. This attracts lightning strikes. A high negative/positive ionic ratio in the air may give a sense of well being and speed healing rates.

Example: People have affected the geology of Oregon Caves. Cave formations and other cave surfaces have been discolored from smoke (torches, candles and/or carbide lamps), lint, skin oils and flakes, exotic plants, and dust from cave trails and the outside. GIS data indicates areas near the developed trail in the Cave has significantly less white flowstone than areas further from the trail. Changes in soils from fire suppression, atmospheric CO2 increases affecting plant growth and patterns, and acid rain may alter organic acids that color cave formations.

Erosion of formations can occur by 1) freezing, dehydration and dissolving of formations from human-caused airflow changes and 2) touching and walking on the marble, and 3) acids produced by lint and living or decaying exotic plants. Trail erosion on the surface affects surface vegetation as well as probably affecting sedimentation rates, speleothem color changes, etc. in the caves.

Airflow changes result from barometric changes, chimney effects, and water flow changes. Most of the airflow change comes from exit and connecting tunnels constructed in the early 1930s. Any removal or addition of material from or to the Cave changes barometric airflow by changing the total volume of the Cave. Local additions or removal of material within the Cave also change airflow patterns within that area, especially if the passages are small. Changing the size and location of the entrances alters upward airflow in winter and downward airflow in summer. Air pollutants and radon may also increase or decrease in the Cave from airflow changes.

Temperature changes largely from airflow and, to a lesser extent, from water flow changes. Increased temperatures in cave water could reduce oxygen levels and spread diseases among the Cave's macroinvertebrates. If sufficient organics are present, Ph and oxygen levels would decrease and calcite solution would increase.

Carbon dioxide changes result from human-caused airflow changes, human breathing, and global increases in the last century. Much formation deposition and solution is controlled by a delicate carbon dioxide balance; such balances are disrupted by airflow changes. Increased carbon dioxide probably will favor increased exotic plant growth.

Lab Exercise: Discuss three ways to prevent soil erosion above the caves. **Answers**: Blockin off social trails, revegetate, install water bars, install signs rexplaining reason for staying on trails or warning of fines.

Field Exercise: Run three meter wide transects in marble and argillite areas of the Monument. Record number and variety of snails. **Results**: More snails and larger numbers occur on the marble area because of the abundance of calcium for their shells.

CONCEPT: We can never do just one thing.

Summary: Everything we do has consequences, some quite different from what was intended. Everything is connected to everything else, although not equally. The past guides the present and future. Science only works well in understanding ecosystems when it is interdisciplinary.

Examples: The more the number of interactions between species the more likely that community will lose additional species if a species is removed through extinction. The more connected a community the more persistent will be its composition and the more resistant will be its biomass if a species is removed.

Affecting keystone species can have cascading effects. For example, over 90% of all aphid species may be specific to a single species of plant. Eliminating that plant would eliminate its aphids as well.

Oregon Cave preserves important hibernation sites for a rare species of bat, the Townsend's Big-eared Bat. Managing the cave for this bat compensates for the loss of its habitat elsewhere.

"What is man without beasts? If all the beasts were gone, men would die from great loneliness of spirit, for whatever happens to the beasts also happens to man. All things are connected." - Seattle (Seathl), leader of the Duwamish and Squamish Indians,
letter to U.S. President Franklin Pierce, 1855

Ecosystem thinking is broader than traditional appproaches to preservation of nature or multiple-use management. It emphasizes a fuller integration of ecological, social, and economic goals at different temporal and spatial scales to maintain a diversity of life forms, ecological processes, and human cultures. An ecosystem perspective does not deny the importance of producing resources needed by people. Nor does it deny the need to protect certain places from human activities. But it focuses on sustaining desired ecosystem conditions of diversity, long term productivity and resilience, with yields of desired resources.

Lab Exercise: Explain why the terms pesticide, fungicide, algicide, and herbicide are not correct. **Answer**: All these chemical kill or otherwise harm type of life for which they are not directed against. List the non-specific actions of such substances. What are their effects on systems of life? Discuss biomagnification, concentration via food chains or long lives and their effects on human beings.

Lab Exercise: Web of Life Bulletin Board
Objective: The students will be able to explain how the different animals, plants and structural features of a cave are connected to one another.

Notes: A web of life is a good way to illustrate this concept, as it shows the many complex relationships within an ecosystem.

Materials: A classroom bulletin board, pictures of different components of a living, dynamic cave. These might be magazine pictures or drawings or construction paper cut-outs that the children make, or cut-outs from the pages of this book. Yarn or string, scissors and a stapler.

Procedure: Near the beginning of this unit, set aside one of the classroom bulletin boards as the Cave Web of Life board. Explain that they will be adding to the board as they learn more about webs in the cave. You might begin with a brainstorming discussion of what lives in the cave. Have the children draw, or cut-out the line drawings from this section. Put these on the bulletin board, along with pictures of rocks, formations, soils, water and other pieces of the cave. Then center a class discussion on how the pieces are connected or related to one another. Use yarn to connect the various cave pieces, showing how each creature or cave component relates to the others.

As the children learn more and more about the cave and its relationships, they will be able to add more ■pieces• to the bulletin board, and more yarn to show the connections. For example, when you discuss people's role and relationship to the cave, the students can add pictures of such things as homes, hikers, carpenters, etc. Remove one of the features and discuss how this change effects the rest of the cave. Since cave managers are trying to make decisions about caves, discuss with the students how land could be managed differently to protect the cave web.

Example: The magic some find in nature teaches a vital ecology -- how everything affects everything else; all is related. Magic of primeval religions draws power from nature as life-force, that from which all life comes. With its unpredictable and organic ways, magic threatens the modern abstraction of nature as law and order, as structure sans personality, as design devoid of deity. So industrialists often deny the life, reciprocity, and ecology of magic. Pushing things through mechanistic violence and much energy implies only the most limited, obvious, and time-bound links. The most human-centered culture ever, namely our high-tech one, relegates much, even Creation, to manufactured things subject to manipulation and control. Ultimately this backfires and all humans become objects of exploitation as well. Everybody is sacrificed for a technic and/or sky utopia that rejects all physical bodies as inconvenient encumbrances at best.

Example: Decomposition of iron carbonate by the iron bacterium Perabacterium spelei supplies the energy required for the bacterium's metabolism. This process liberates ferrous ions that are oxidized to produce the ferric mineral goethite ($FeO(OH)$, which is often the brown pigment of cave silt.

Example: Perhaps the essence of an ecosystem, as any other system, is the interrelationships among its component parts and processes. Ecological systems are considered to be "complex" systems, on the edge between ordered, stable systems and chaotic systems. They are characterized by strong interactions between components, complex feedback loops, and significant time and space lags, discontinuities, thresholds and limits (Costanza et al., 1993). It is through these interactions that biotic and abiotic components have ecosystem "functions," such as erosion and deposition, primary productivity or decomposition, or the effects of predators on prey movements.

Example: Ecosystems can be defined as groups of animals and plants that occur together, along with all the environmental factors that directly and indirectly influence them. With this definition, it becomes clear that ecosystems are enormous ... and enormously complex. For example, caves are known for their characteristic assortment of microbes and animals. But the ecosystem includes an array of inanimate environmental factors as well. Among these are elevation, levels of airflow (determined in part by whether a slope faces towards the south or another direction and whether there is more than one entrance), type of soil, proximity to a creek or river and a myriad of other factors. Doubtless the system is complex enough that many factors are as yet unseen and unknown.

People play a part in ecosystems as well. In towns and cities, human influence is obvious. In national parks, we strive to keep human impact at a minimum. Our presence in the cave always has an effect though, whether we inadvertently frighten a bug from its feeding or attract a curious bat with our footsteps and voices. National parks give us the chance to enter, experience and become part of a natural ecosystem ... and the responsibility to leave the same opportunity for others.
CONCEPT: Ecosystems transcend human-made boundaries.

Summary: In areas such as cities and farmland, people have drastically altered native ecosystems, often rearranging them beyond the point of recognition. Yet, despite the appearance of a totally human system, we are all part of the giant global ecosystem. We still require the life-links of food, water and clean air even if they no longer exist in our immediate environment. The ecosystem that supports us stretches far beyond the horizons of our daily lives.

Acid rain has only recently become a concern for this monument. An increase in particulates, such as from slash burning, increases acid rain. Limestone rapidly neutralizes most acid rain effects but lichens and mosses that live on limestone boulders at cave entrances may be adversely impacted.

Due to the low amount of present or near-future pollutants sources upwind, air quality near and within the monument and in the main cave remains good. As a result of fire suppression, there probably are fewer airborne particulates than existed before 1909. However, concentrations are abnormally high during spring slash and controlled burns conducted by the US Forest Service near the monument and slash burns on the monument conducted by park staff.

Protected areas like Oregon Caves generally are at high elevations where biodiversity is relatively low. The Monument depends on the high biodiversity from the lowlands in cases where species become extirpated in the Monument.

Example: Land assessments have typically divided large systems into smaller-scale units. In this reductionist approach, the linkages among units tends to be lost, or they are assumed to be linear, with effects on the system that are simply additive. Ecological processes and relationships change as spatial scale changes.

Example: Vertical boundaries of Oregon Cave's ecosystem extend out to infinity although the closest areas usually are the most important. Outward we encounter oxygen, weather, ozone protection, meteorite dust, asteroid or comet bombardments, and the death of stars being the building blocks of life (we are made of star dust).
Evening Walk: The connections between stars and ourselves.

Examples: If the Monument had no boundaries and no people, there would be no need for management. Preservation would be assured. But no park is an island cut off from the rest of the world. Human impacts are now global in extent and include invading weeds, changing climates and endangered animals who have vanished elsewhere. Park management now faces the challenge not only of promoting non-impacting recreational uses within its boundaries but also the challenge of countering and nullifying human impacts that occur across park borders. Park staff cannot completely restore the natural airflow in the Cave as this would constrict part of the tour route to less than two foot high, a true caving experience! However, restoration already completed has stopped frost damage and substantial evaporation of cave water.
To leave public lands unimpaired, ecosystems should normally be managed as a whole as managing for a particular plant or animal is often to the detriment of other species. However, habitats may have to be changed to protect specific endangered animals. Such management counteracts human-caused decline of a species outside the Monument.

Lab Exercise: List ten ways that ecological processes extend across the caves boundaries. How could changes in outside land use affect these processes within the Monument? **Answer**: See above examples.

CONCEPT: Geology largely determined the areas' history.

Example: Waterflow and airflow data suggest that unknown cave openings exist as well but none of these may be passable to
*Human high energy impacts on low energy systems

CONCEPT: Caves tend to low energy.

Examples: The low energy of ORCA heightens awareness of our high energy impacts. Careless cavers can damage a fragile ecosystem. Just walking on mud banks can increase the amount of organics available to cave microbes and thus may produce a "paradox of enrichment" in which the small, less active microbes are out-competed by the larger, more active species.

Lab Exercise: Describe five high-energy processes found on the surface that are not found in the cave or are greatly reduced in energy. **Answer**: streamflow, airflow, amount of organics, large mammal movement, sounds, etc.

CONCEPT: Restoration reduces high energy impacts.

Slide Presentation: **Cave Restoration**: Find out what to remove and what to protect. 30 minutes

Examples: Compared to most surface environments, most caves have little food or other types of energy. Caves usually lack much wind, light, freeze-thaws, or organics. Thus, fragile minerals and species with low metabolisms can thrive underground. Foot traffic, lights, clothing lint, tunnels, and vandalism are high energy/food impacts on caves. Visitors or altered
airflow bring in skin flakes, dust, spores, or detergent-rich lint, all of which foster plant growth not native to the cave. Alien animal communities have developed on lint deposits and exotic plants. Such an unnatural increase in food can cause the "paradox of enrichment," where surface-adapted insects move in and outcompete smaller and slower moving cave-adapted insects. Several species of cave-adapted insects and bacteria in Oregon Caves are more common further away from the trails.

The Park Service tries to restore the caves through mitigation of past and present human activities. This includes rubble and trash removal, airlocks, exotic plant control and the design, construction, maintenance of a low impact trail and lighting system, and protection of the Cave by way of high quality interpretation by park and concession tour guides. Any of mitigation actions will reflect informed analysis of any evidence of human activities that have historic or prehistoric value.

Park staff and volunteers restored the cave to its original beauty, removing the "noise" so you can hear the "music." In the 1920's and 1930's, many tons of rubble were created by the blasting of tunnels and other changes of the cave tour route. Instead of carrying all the rubble out of the cave, early workers stashed many of the rocks and loose fill in side passages, covering or blocking off many beautiful formations and changing the cave's natural airflow. Working in the cold, damp and cramped cave environment, the rubble crew concentrated on the first third of the cave tour route, where most of the rubble piles were deposited. After loading the debris into 5 gallon buckets, the workers moved it out of the cave with handcarts, small wagons, chutes and "elbow grease." No engines helped them because the exhaust would be hazardous to people and would affect the cave's wildlife and formations. Over 1200 tons have now been removed, the equivalent of over 81,600 bucket loads. Several thousand square feet of cave walls and formations have been uncovered. Visitors can see River Styx much as Elijah Davidson first saw it, but with better lighting! Crystal clear water once again cascades over white marble. Previously, the stream had been confined to a culvert and the creek bed was filled with rubble. Still, much work remains to be done.

By carefully controlling the location, duration, and intensity of cave lighting, unnatural plant growth can be substantially reduced. Permanent doors reduce the amount of spores entering the cave and also stop unnatural drying and freezing effects on cave formations. Household bleach is sprayed on plants that survive. Extensive tests show that bleach is the most effective known method of control with the fewest side effects on cave life and cave formations. Monitoring of Cave Creek and the River Styx show little change in water quality since the spraying started. Although occasionally a visitor might notice a faint chlorine odor, much like that encountered around a swimming pool, airflow quickly flushes most of the vapors out of the cave.

Slide Presentation: <u>**Life in the Slow Lane**</u>: The low energy of caves and the high energy of people.

Lab Exercise: Contrast number of trophic levels on surface with number in cave. At most three to four levels in Oregon Caves compared to many more on surface. One reason is that there is not enough energy to support more because so much energy is lost between levels.

Third Level - pseudoscorpions, beetles (eating cricket eggs?)
Second Level - Fungus gnats, springtails, cave crickets
First Level - actinomycetes, fungi
Source: Computer Filename is MACRO.INV - Summary of cave macroinvertebrate study incl. species list and effects of trail on cave adapted species/endemics.

3. <u>History</u> of the Monument shows that we can be a sustainable part of nature. Topics are:

CONCEPT: NPS balances historic and natural preservation.

Summary: The Park Service balances preserving historic objects and natural processes. The objectives of the resources management program are to 1) allow natural ecosystems both above and below the ground to function as they did when Oregon Caves was first discovered by European man in 1874 and 2) preserve cultural landscapes, ethnographic resources, and historical objects and structures.

Examples: Certain objects, such as an asphalt trail may be removed if it interferes with natural processes. Only those objects considered historically significant are preserved. An old asphalt trail in the Cave is not considered historically significant; the much older Lodge (Chateau) is. However the condition of the Caves when Davidson first discovered it is considered historically significant. Therefore, cave restoration not only restores the natural processes in the cave; it preserves the historical scene as well.

When preserving historic objects and natural processes conflict, the intent of the enabling legislation (why the Monument was established) must be taken into account.

As certain parts deteriorate in the Lodge, similar parts can be made to replace them. But only historical objects and natural processes can be repaired or restored, rarely can natural objects be repaired. As soon as vandalized cave formations are repaired, they lose some of their natural qualities.

Lab Exercise: Use historical records to identify two potential conflicts in historic/natural preservation. **Answers**: Cutting down trees that may fall on historic buildings. Tearing down cabins because of water from burst water line entering cave.

Field Exercise: Go through cave and name different rooms based on observation. Compare with the present-day names. Are there any similarities or differences? Explain them.
Lab Exercise: List five names that have been changed in the Cave and explain why they might have been changed. **Source**: Computer Filename is 93-NAMES - Explanations of names in the Monument and area, including the Cave.

*Caution, selection, science, feedback, predictions, ecosystems, democracy, types, interdisciplines, prevention, and the long term in management.

CONCEPT: Ignorance counsels caution.

Examples: Going slowly may be more prudent when little is known about ecosystems. The nonlinear dynamics, hierarchical structuring, complex linkages, and multiple optimum operating points, most far from equilibrium, raises important questions about our ability to separate cause from effect and predict ecosystem behavior. Most difficult to assess the impacts of its presence or absence in an ecosystem are those species that alter the physical environment over many years, such as trees and humans.

Both characterization and modeling are sensitive to resolution (spatial, temporal, and number of ecosystem components included). Costanza and Maxwell (1994) found that (1) increasing resolution provides more information about the patterns in data, but (2) also increases the difficulty of accurately modeling the patterns. Predictability was found to exhibit fractal-like characteristics with decreasing resolution.

In practice, the scaling properties of many ecological processes are poorly known, in part because these properties are usually location-specific and time-dependent, making it difficult to generalize from isolated studies.

Example: Because we are time, space, and sense limited we only sense only a tiny bit of all there is. Our slice in particular of geologic history and the electromagnetic spectrum is very small. We mostly focus only on those things near our own size, speed, shape, etc.

Example: Many processes occur so slowly that they can't be managed solely in the short term. For example, management must occur over periods of time long enough to maintain the evolutionary potential of species and ecosystems.

Examples: Humans are a biological component of most ecosystems. However, by virtue of new technologies, population growth, and increased use of lands and natural resources, humans have a unique capacity to alter ecosystems through activities that create sudden ecological stresses, profoundly affecting the integrity and functioning of ecosystems. "The major sources of our ecological disasters apart from ignorance are greed and short-sightedness which amount to much the same thing." (J. Passmore).

Example: Damage from human impacts often are hard to correct or mitigate because of time lag effects. For example, partly because cave animals are long-lived, declines in their populations have lagged behind the collapsing habitat. This indicates that much more population loss might occur than can be currently predicted, and that it will continue even after habitat losses have been arrested. difficulty in finding mates, loss of genetic potential for future change, continued loss of genetic variability via accelerated random drift, inbreeding, and the risk of mortality from minor local environmental reverses, compounded by whatever difficult conditions are responsible for reducing a population's size in the first place, may eventually drive a species past the point of no return, beyond which its demise is relatively swift and certain.

Lab Exercise: Using the TIMELINE, list five mistakes that were made in resources management at the Monument. With more information, how could these mistakes have been avoided? **Answer**: 1. Lack of early information gathering. 2. Cutting of all trees near historic buildings as opposed to only those that were likely to fall. 3. Not establishing carrying capacity of cave tours early on.

CONCEPT: Management includes conservation and preservation of resources.
Summary: Conservation is the sustainable utilization of resources. Sustainability is the capacity to satisfy current needs without jeopardizing the prospects of future generations. Preservation includes protecting resource from human impacts.

Lab Exercise: Who Owns the caves?
Objective: Students will understand that the caves of the US are owned or managed by different groups and individuals and are managed for various purposes. Students will research and present differences between BLM, USFS, NPS, state, and private land use and management.

Background: Caves are administered by several public and private groups, each with a different purpose or management strategy

OWNER MANAGEMENT STRATEGY
Public
* National Park Service Preservation - recreation, (Oregon Caves NM) research, wilderness, wildlife

* U.S. Forest Service Multiple Use - timber, range, & Bureau of Land wildlife, recreation, research, Management wilderness, mining

Oregon State Parks Recreation and wildlife

Private
* Private Industry Timber harvest, recreation, wildlife

* Private Individuals Individual choice

Other Cave Owners
County and City Parks

Most county and city parks are for day use only and have no charge. They range from high use playground an picnic facilities to undeveloped natural areas. Special public events are sometimes held at these parks.

Procedure: 1. Have a class discussion on what the students like to do in the cave. Then have each student draw a picture of the activity they enjoy doing in the cave (e.g. hiking, fishing, looking for signs of wildlife or downhill skiing). Have students share their pictures and discuss the differences in types of caves required for each activity.

2. Discuss the fact that many different groups, both private and public, administer the caves of the US. Show students the cave use picture cards and explain who each owner is and how each cave is managed (see information on back of pictures). Then ask students which cave would best suit the activity that they shared in their drawing. Conclude by having students write a caption to go with their pictures. For example: "I could go on a picnic in a national park and see some spectacular scenery" or "I could go skiing at a ski resort that leases land from the U.S. Forest Service."

3. Have students identify who owns the land between their school and caves. Devise a key with symbols for timber and mushroom harvesting, recreation, preservation, wildlife, cattle ranging, and other uses and draw or display appropriate symbols on the appropriate section of the map.

Extension: Take a field trip to Oregon Caves and on the way look for different uses of the cave. Discuss how they are managed for different purposes. Compare how they look and the types of jobs they provide. Compare what opportunities each area offers for people in the area.

Lab Exercise: Managing the Land
Objective: Students will be able to describe different philosophies of land management.

Procedure: Divide the class into six groups, one group for each of the following: National Park Service, U.S. Forest Service, Nature Conservancy, Rough and Ready Lumber Company, Mountain Ski Resort; Oregon Parks

1. Ask each group to devise a goal statement and five management guidelines for the same parcel of land from a different viewpoint. Explain to the students that a goal statement is what the group is trying to accomplish with the land, for example, preserving it for future generations, creating a commercial venture, developing a recreation area, or using it as an educational facility. Management guidelines, on the other hand, are the ways they are going to accomplish their goal and the regulations they will follow to do so, for example, to preserve the land for future generations they would not allow anyone to collect or remove any of the natural features and there would be restrictions on development. If the group wanted to use the land commercially they would set certain fees and develop the area. The parcel of land in question is a watershed the size of the city of Ashland. One third of the area has snow covered peaks and two thirds of its is covered with old-growth forest. There is a large river with several tributaries flowing through it both on the surface and in a cave.

3. To assist the students in understanding the goals of each interest group encourage them to read advertisements, brochures, magazine articles, and books related to their group. They may also wish to contact local representatives of similar businesses and agencies. Groups should

take into account economic and social aspects of their guidelines, as well as the impact on the resource as a result of their plan.

4. When the groups have completed their assignments, have them share their goal and guidelines with the class. Then discuss the following questions.

* How are the goals and guidelines of the various groups different? How are they similar?

* What other types of groups might represent different goals and guidelines?

* What values does each group attach to the land? How are these values reflected in their land management plan?

* What are the similarities and differences between publicly and privately managed land? Do they influence each other?

* How do your goals and guidelines affect the community at large?

Extensions: 1. Select a real parcel of land in your community and have students apply their group's guidelines to this area.

2. Have students select a government agency and research its goals and how it operates.

3. Have a discussion on the difference between preservation nd conservation. Both are concerned with the protecting the resource. The National Park Service practices preservation in that it attempts to keep the resources safe from any kind of abuse or damage through nonconsumptive uses and values. The U.S. Forest Service practices conservation which uses the resource in both nonconsumptive and consumptive ways, within limitations so that the resources will last for the future.

CONCEPT: Nature knows best.

Examples: NPS resource management concern itself mainly with reducing or preventing human impacts. The idea that we are "stewards of the earth" is viewed by some people as another sign of human arrogance. Imagine yourself with the task of overseeing your body's physiological processes. Do you understand the way it works well enough to keep all its systems in operation? We are unconscious of most of our body's processes because we'd mess it up it we weren't. The human body is so complex, with so many parts, yet it is only one tiny part of the Earth, a system form more complex than we can fully imagine. The idea that we are consciously caretaking such a large and mysterious system seems dubious at best. And those effects we are having seem the opposite of caretaking. In the loss of wetlands, for example, we seem to be "cutting out our kidneys to enlarge our stomachs" - -Erick Freyfogle, Baltimore Evening Sun, 12 Sept. 1991

Example: "We are like goldfish who have been living in an aquarium for as long as we can remember; and being clever goldfish, we have discovered how to manipulate the controls of the aquarium: put more oxygen in the water, get rid of the pesky turtle we never liked anyway, triple the supply of goldfish food. Only once we realize we're partly running the aquarium, it scares some of us. What if we make a mistake, and wreck the aqaurium entirely? We couldn't live outside it." -- Noel Perrin, In Daniel Halpern, On Nature, 1986.

Example: Use of natural energy like solar energy may be the most dependable and safest source of energy for man. We know more about it than human-made sources and therefore can predict consequences of its use better. Fossil fuels are natural but not the rapid burning of those fuels.

Lab Exercise: Compare the flow of energy through trophic levels and manmade systems. Entropy, energy-waste, and the problems relating to heat and the "disposal" of radioactive materials, can be compared in natural and human made systems. Pose the thought that the world might be geologically and sociologically too unstable for the safe propagation of nuclear energy and the storage of radioactive wastes.

Lab Exercise: Use trail game (Lesson Plan #4) in Oregon Cave's Teacher Guide to learn about the disadvantages of quick fixes.

CONCEPT: Prevention beats restoration or mitigation.

Summary: Nothing can be fully restored after it has been altered. The least expensive way to reach sustainability is through education that changes people's behavior.

Lab Exercise: List five processes in Oregon that will never be restored regardless of how much funding is available. **Answers**: 1. Complete restoration of airflow. 2. Changes on edges of Mounument from effects of clearcuts. 3. Changes in air quality. 4. Changes in water quality. 5. Speleothem growth. **Source**: Computer Filename is CRM-86-92 - Action plan and yearly summaries of cave restoration project. **Source**: Computer Filename is VC-REST **Source**: Computer Filename is **CRM-DEVL** - Commercial cave guidelines.

CONCEPT: Many impacts are unintended, unanticipated, fast, and irreversible.

Example: People always have impacts on caves they enter, especially caves that are "improved" for our safety, comfort and enjoyment. Artificial lighting invariably encourages the growth of plant life that will stain and actually dissolve cave formations. How do plants get hundreds of feet underground in the first place, often long distances from the nearest opening to the outside? Caves are most easily invaded by algae, mosses, and ferns. These plants reproduce by means of spores, tiny, numerous particles that float in the air. Spores may be drawn into caves by the natural flow of air, by airflow caused by artificial exit tunnels, or by people. Once inside, artificial lighting, moist conditions, and fertilization by detergent-bearing lint from visitors' clothing can together provide a hospitable place for plant growth. Some plants with spiny seeds like cleavers are unknowingly carried in by people on their clothing. Some of these seeds drop off and germinate in the cave.

Example: Because of modern technology, a new chemical or exotic species can be introduced worldwide without known what are its side effects. Unintended impacts include asbestos, electromagnetic fields, and CFCs.

CONCEPT: Long-range planning is essential to sustainability.

Summary: Without such planning man-caused changes like global warming will significantly impact the Monument. Plans must be put into place not only to slow down the warmup but to mitigate effects of the warmup that will now occur regardless of future human actions. How will the Park Service being able to keep the excess carbon dioxide and heat out of the Cave and still allow for natural airflow?

Lab Exercise: By looking at the TIMELINE computer file, list two human impacts each that were unintended, unanticipated or irreversible. Defend your choices. **Answers**: Frost damage to formations from changes in airflow. Edge effects from clearcuts. Water entering cave from burst water line. Algae growth from cave lights. Possible increase in debris flow from cutting trees.

Lab Exercise: Use **Source**: Computer Filename is CRM-PLAN - ORCA's Cave management plan. What five long-term (one whose major effect are likely to be at least ten years in the future) concerns are not currently funded? **Answer**: Acid rain, changes in global carbon dioxide, edge effects from clearcuts.

CONCEPT: Management should be ecosystem based.

Example: Concerns about predictability and scale include the problem of collecting data from the bottom up. A bottom-up approach rarely captures the important system properties that emerge at higher-level scales. On the other hand, with a top-down approach, the assessment can be designed to focus on the small-scale system components that are essential to high-level system properties that are defined as being of value.

Lab Exercise: By looking at the TIMELINE, list two examples
where not considering ecosystem management could result in substantial human impacts. Defend your choices. **Answers**: Clearcuts up to edge of Monument. Effect of altered airflow and carbond dioxide changes on cave insects.

Example: Ecology must embrace the human mind as an integral part of any ecosystem it would study fully, if only because the values that reside in that mind determine the relations between people and their environment.

CONCEPT: Management should be based on democratic science.

Summary: Science flourishes best in a democracy. Democratic debate helps society set the course because it "can provide ways to recognize errors, complementing and reinforcing the self-conscious learning of adaptive management." Conflict is inevitable but in a democracy is "bounded"--restrained by rules that keep it within safe limits-- so that all can take part and air their views without fear of physical retaliation. In a democracy, the energy generated by conflict can be harnessed for learning and ultimately for positive outcomes.

Example: "Science has the power to illuminate, but not to solve, the deeper problems of mankind. For always after knowledge come choice and action, both of them intensely personal and individual." -- Paul Sears, Deserts on the March, 1947

Examples: "An emphasis on learning is an unconventional way to think about public policy. Most policies hum with tension between efficiency and fairness--between maximizing some objective and sharing its benefits equitably. Learning may not lead to the most efficient or most equitable result, because fairness and efficiency are not enough to define good policy when knowledge is sparse." (Kai Lee in Compass and Gyroscope).

The simple yet profound truths of nature might be too non-verbal or threatening for people to remember or practice unless there is an infusion of science and community.

Science may be inherently schizoid. Its initial search for order, taxonomy, prediction, and control of objects parallels the search for immutable religious laws. Specialization and separation of the inner and the outer piles up much data but little meaning. However, with the advent of relativity, quantum mechanics, ecology, energy fields, and chaos theory, understanding of observer bias, the emphasis on relationships and process been more in tune with democracy and holistic thought.

"The more superficial--or artificial becomes a society's knowledge of the real dimensions of the land it occupies, the more vulnerable the land is to exploitation, to manipulation for short-term gain." -- Barry Lopez i Orion Nature Quarterly, Autumn 1989

Lab Exercise: Explain why the scientific method and science might flourish best in a democracy. What are the similarities
among these processes? **Answer**: See above examples.

CONCEPT: Management and science learn from feedback.

Summary: Predictive ability is the core of useable science.
Feedback is essential to understanding. However, correlation does not imply causation. If a cat has kittens in the oven, that doesn't make them biscuits. Yet correlations and other patterns can guide scientific research and predictions based on theory. Prediction in science rests on the controlled experiment, where only one variable is changed at a time. However, on the ecosystem scale, this is rarely possible. Comparison between similar ecosystems is done so as to try to isolate single variables and their effects on the ecosystem.

Lab Exercise: Take the amount of dissolved calcium coming out of Oregon Caves and calculate how long the cave took to dissolve. **Results**: Erosion probably exposed the Oregon Caves' marble near the end of the last Ice Age. Much of the enlargement of the cave then began. If the stream exiting the cave had the same amount of dissolved marble as it does today, it would have taken about 10,000 years to dissolve out most of the cave. Since solution is much slower at the birth of a cave, more time probably would have been needed for the cave to reach its present size. Also, the River Styx probably is not the only water to exit the cave.

Lab Exercise: Using the TIMELINE, list five examples of feedback that drive Monument management decisions. **Answers**: Number of visitors per year (initiate study of overcrowding). Complaints by visitors on poor quality tours (initiated changes in concessions operating plan). Hazard tree plan (trees cut if they exceed a certain probabilility on falling on a structure or person). Flooding (changes in drainage), certain number of yellow jackets as visitors exit cars (installing of traps).

CONCEPT: Management is selective.

Summary: Although the Cave is the prime resource through legislative intent, there are no primary or secondary resources from an ecologic standpoint. Natural systems are process-oriented rather than object-oriented. All parts in a process are significant. No individual resource or resource type is ecologically isolated from the others. This is especially true in the monument as caves lie under surface processes. All resources, biotic and abiotic, of the land, water, and air, within and affecting the monument, are values for which the monument has been designated and is legally responsible.

This does not mean that resource management attention should be spread evenly on all monument resources and processes. Human-caused impacts on points in a process can be more damaging and permanent than at other points. The monument also is more influenced by some processes than by others. Certain species such as endemics and disjuncts are more sensitive to human impacts or are better indicators of environmental problems than are others, and should be targeted in monitoring programs. Impacts on certain species such as keystone species may initiate cascading effects. Mitigation of impacts in the monument deals primarily with documented effects while present inventory and monitoring deals more with potential damage.

Example: Because cave life is sensitive to change in the amount of organics, algae growing near lights has a potential to disturb cave communities as well as destroy cave formations by dissolving them with organic acids. Therefore, the algae is a prime target for control in the Monument. Research conducted from 1988 to 1993 indicates that the most efficient and least impacting method of controlling cave exotics is by hand bottle spraying with household strength bleach (5.25% sodium hypochlorite) every two months in summer and every three

months in winter (ORCA-I-315.001). Complete spraying of nearly all algae occurs every three years. As the bleach is strongly alkaline, impacts from spraying should show up as Ph changes. The Ph of 1) a cave pool immediately adjacent to a sprayed area in the Imagination Room and 2) the River Styx exiting the cave is monitored 24 hours after each spraying. So far there are no detectable Ph changes on cave water aside from the wet cave surfaces that are sprayed.
Source: Computer Filename is RM-IPM - Integrated Pest Management Plan

Example: Monitoring is selective with less expensive methods used most of the time. Water is a driving force in cave dynamics. Therefore, it is the focus of research. A 1992-1993 project involved determining the 1) location of the surface and subsurface watershed for the Cave by ionic ratios and dilute non-visible dyes identified by ultraviolet fluorescence, 2) amount of both dissolved and coarse particulate organic matter in water entering, inside and exiting the Cave, and 3) major ions concentrations (WATER93) in the four main types of water in the Cave (stream, pool, dome pit, diffuse seepage), surface streams and infiltration through 30 centimeters (1 foot) of argillite, marble, quartz diorite, and serpentine soils overlying or adjacent to the Cave.

This ongoing study indicates that through all seasons cave stream water has moderate Ph and total dissolved solids (TDS), pool water has high Ph and high TDS, dome pits (vertical shafts) has low Ph and low TDS, diffuse seepage from stalactites has moderate Ph and high TDS.

The TDS and Ph of all four types of cave waters will be monitored during each season (August 20, one week after first rain in fall or early winter, one month after persistent winter snow is present over the Cave, and one week after there is less than 50% snow cover above the Cave). If any major deviation occurs, such as the Ph/TDS graph point of one type of cave water occurring in the point cluster of another water type, then a full analysis of major ions, total organic carbon, and long-chain hydrocarbons will be done to determine whether or not the deviation is human-caused.

Example: Radon daughter products may help establish baseline airflow patterns. Because of the relatively long (22 years) half-life of 210 Pb, measurement of its activity on cave surfaces may provide a means of assessing average radon levels in a cave over the past 100 years. Radon sampling is also an inexpensive way to assess the current amount of cave-surface air interchange.

Lab Exercise: What are five of the most important processes or objects at the Monument.
Answer: keystone species, controlling abiotic factors (water, carbon dioxide, etc.)

CONCEPT: Human impacts can be cumulative.

Example: Touching magnified over many years becomes damaging while a single touch causes little impact.

Example: Cumulative snow damage caused the replacement of wooden verandas in 1958 with steel catwalks and fire escape ladders on the northwest side of the 4th and 5th floors.

Examples: Cave species are most at risk from toxic pollutants because they are long lived (neoteny and slow metabolism). Toxins can build up in these individuals to levels that affect their reproductive and immune systems. There is virtually no filtration of pollutants in the concentrated discharges characteristic of carbonate systems. Pollutants can therefore originate a considerable distance from the monument. Some old-growth caves species are at risk because they are at the top of long food chains; toxins become progressively more concentrated as they move up food chains.

Examples: Of all human alterations, man-made tunnels have had the single biggest impact on the Cave. Connecting tunnels and enlargement of narrow passageways have further impacted the cave climate and the growth and destruction of limestone formations. As a result of artificial lighting, algae and some mosses grow near cave lights. Altered airflow patterns and visitors have introduced lint, skin flakes, dust, mud, spores and seeds, all of which encourage plant growth. Lint and exotic plants dissolve cave formations. Asphalt, temporary wooden structures, or otherwise modified trail surfaces cover parts of the tour route. They alter natural drainage patterns and further add organics to an ecosystem adapted to a low food state.

Example: Soil loss from human impacts is cumulative. The average soil depth in the US in 1776 was nine inches. It is now 5.9 inches.

Example: Animals may tolerate a given environmental stress until one factor overcomes this tolerance and triggers a response which leads to a decline of the species under stress. The added impact tips the balance towards decline such that the results are not additive; a one percent increase in organics may cause a 90% decline in a species.

Lab Exercise: Of the human impacts on the cave which three are cumulative impacts? Explain why. **Answers**: 1. Touching (accumulation of skin salts that oxidize railings and relatively non-soluble skin oils that increase organics). 2. Freeze-thaw cycles from alteration in airflow. 3. Suppression of natural fires (increase in downed wood, decrease in stream flow). 4. increases in carbon dioxide (changes in formation growth).

CONCEPT: Classification is essential for long-term management.

Examples: Many likenesses and differences occur among living and nonliving things. A variety of functions, sizes, and structures exist in plants and stars, rocks and animals, processes and people. Yet there are sufficient similarities to permit their classification into orderly patterns. These classifications increase one's understanding of her world. Without knowing which species or geologic features are present and where they are located, there can be little understanding of ecosystem processes and how to manage them.

Example: The beginning of wisdom is calling things by their right name - Chinese proverb. Species seem to be a real distinction in nature. Hybrids are rare and don't do well. Hybrids between the Indigo and Lazuli Buntings appear to have reduced viability.

Demonstration: **<u>Cave Inventory</u>** - How a cave's biologic and geologic resources are inventoried and how that information is interpreted and displayed on computers. 25 minutes

Lab and Field Exercises: Lesson Plans #2 (serpentine plants) and #5 (cave formations) in <u>Teacher's Guide for Caves and Serpentine Plants</u>.

Lab Exercise: Where Do I Fit?
Objective: The students will be able to identify, describe and categorize/classify animals that live in the Monument.

Background: One of the more categories with which to classify animals is habitat preference. It is relatively simple to separate those animals that require an ocean habitat from those that live in caves. A more challenging task is to differentiate animals that require caves from those that can survive in other areas.

Materials: Construction paper and crayons for students to make labels for themselves. Hole punch and string or tape to attach labels.
Procedure: Begin by discussing or brainstorming what animals might live in caves. Ask the students to imagine themselves as one of those creatures. If they could be any animal in the cave, what would they want to be? Have each student make a label showing what animal he/she has chosen to be. Now sort the students by a predetermined but unrevealed category, such as ■has wings/doesn't have wings• or ■has fur/doesn't have fur•. Make sure not to reveal the category to the students. Separate the children into groups according to the animal named on their label. Have the children compare the animals in each group and then try to guess the category . It's best to have several categories in mind before starting the game. **Note**: Older children may be challenged classifying animals by habitat and food preferences while the primary grades may do better with appearance and other more obvious characteristics.

Alternate Procedure: Begin the activity in the same way, but instead of silently sorting the children, call out a category, such as ■eats only detritus•, or ■has fur• and have the children sort themselves into the proper groups. Possible sorting categories include: physical attributes (color, size, wings, number of legs), where they live, (in the soil, in the treetops), what type of cave they inhabit (younger vs. ancient, wet versus dry, sulfur rich versus not) what they eat (only plants, only other animals) and many others.

Extensions: 1. Have the children find out more about the animal that they chose for this game. Ask them to consult several books and prepare a short written report on their animal.
2. When introducing this activity, focus on the difference between young and old caves, wet versus dry. Discuss the differences in light levels, type of cave habitat and the differences those factors make to the kinds of animals found. Then ask the children to choose the animal

that they'd most like to be, from either forest type. Use young vs. ancient caves as one of the sorting categories.

Lab Exercise: Cave Sharing/Show-And-Tell
Objective: Students will be able to identify and describe a variety of pieces of the cave ecosystem.

Background: People can relate to caves in many different ways. National parks offer special places in which to experience the natural world. Except for the suppression of natural fires, the caves of Oregon Caves are largely untouched and unchanged by human hands, allowing us to see a piece of the world that looks much the same to us as it did to people hundreds of years ago. A visit to the caves of Oregon Caves can almost be like a trip back in time.

Materials: Children will bring things in from home. If you plan to do the Extension, labels and a display table will be needed.

Procedure: Have the children each bring in something special from or about the cave to share with the class. These special things can be but don't need to be actual cave objects. They could be family photographs, pictures from old magazines of things they like, and/or stories about things they like to do in the cave. Have the students share their special things with the class via a Show and Tell session.

Extension: Have each child label his/her items and display them on a science table or in a nature corner of the classroom.

Lab Exercise: Gallery of Images
Objective: Students will identify various components of the cave ecosystem through the use of art and language skills.

Background: The caves are like giant galleries of art. The graceful curve of a snail shell, condensation on a spider's web, the craggy textures of an ancient tree root, the rich colors of a flowstone wall all combine with a wealth of other pieces to form one huge artist's canvas. This activity will help students see and identify the nearly infinite variety of cave forms.

Materials: Construction paper, scissors and glue. Old magazine or newspaper pictures of caves and cave animals.
NOTE: Please make sure that the children understand that they should only use old, ready-to-be-recycled newspapers and magazines. Procedure: Ask students to bring their family's old magazines and newspapers to class. (Or collect them yourself, keeping a classroom supply of old periodicals for the children to use for many different projects.) Once you have the papers, have the children find and cut out pictures of as many cave animals as they can. Have them each create their own collage with the pictures, perhaps adding some of their own drawings, words and/or sentences about the cave.

Extension: Have the children make their collages on strips of paper that will become the border for a short composition about cave. The composition could focus on one or more of the following questions, or any others that the students themselves raise: What is a cave? What lives in a cave? What does the cave mean to us? What good things or good experiences do we get from a cave?

CONCEPT: Science provides continuity in management

Summary: Science provides continuity with its communal process, repeatable experiments and knowledge built on the past. Its findings change but its methods remain essentially the same. That combination gives us continuity instead of stagnation, dogmatism or chaos. Science shows us that we are continuous or strongly affected by entities or processes, both very big and very small, outside our personal or park boundaries.

Example: Evolution, especially mammalian and primate, gives us a link with all earth's creatures and an antidote to excessive anthropomorphism. "And in his passing moments of strength, the white man thinks he is a god who already owns the earth. How can a man own his mother?" (Chief Seattle).

Lab Exercise: A culture can be defined as people who share a common language, ethnic background, set of values, and/or religion. By this definition, list four cultures that occur in Oregon. Discuss the concept that science is the only common culture that we have.

CONCEPT: Theory fuels research and favors wholeness.

Summary: If you don't know what you are looking for, you probably aren't going to find it. Theory and paradigms do bias scientific research but are crucial to progress in understanding this world. Competing theories provoke the necessary ego to spur research to prove or disprove these theories. The history of science shows that the scientific method can rise above the limitations of theory and paradigms and change or replace them. Theory expands one's horizons by uniting various investigations. Disciplines and discoveries converge. Science is the search for unifying and widespread guidelines in nature.

Example: Archeological surveys in adjacent USFS lands in the last ten years suggests that upland use was more extensive than previously recognized.

Lab Exercise: Using the TIMELINE and the RMP-Plan, list four important scientific theories that drive Monument resources management. **Answers**: Smaller species are usually of greater importance to ecosystem processes than larger ones. Water and air flow are the main controls on cave geology and biology. Decreasing habitat tends to decrease biodiversity. Fire is an important element in Monument cave ecosystems.

Example: Physicists work on the Grand Unified Theory, a "theory of everything."

Example: One of the best tests as to whether a theory is based on good science is to see how much further research, testable predictions, and derivative theories have been generated by that theory.

Lab Exercise: Analyze astrology and flat earth theories. Are they good science? How would you tell? **Answer**: No, because they have been tested and been found to be false. Correlations between human personality and astrological conjunctions have been put forth but none have been repeated by other researchers. Neither theory has generated much additional scientific research.

CONCEPT: Understanding behavior is essential to management.

Summary: Management cannot succeed unless behavior is understood.

Lab Exercise: Construct a bat gate (Lesson Plan #6 in <u>Teacher's Guide for Caves and Serpentine Plants</u>. **Source**: Computer Filename is BAT-<u>PAMP</u> - Condensation of Bat House Management book.

Lab Exercise: What is the best way to keep bats out of buildings?
Source: Computer Filename is **<u>TEACHGUI.1-3</u>** - Teacher's Guide

*<u>Healthy ecosystems needed for human health and fun</u>

CONCEPT: Many uses agree with healthy, long-term sustainability.

Summary: People living outside Oregon Caves make extensive use of its resources for recreation and water. But if people are to continue to enjoy and benefit from these natural resources, we must be careful not disrupt the processes that sustain them. We are integral parks of the ecosystems on which all living things depend, and our actions are critical factors in determining the health of those systems. As we make one connection after another we come to recognize that we cannot choose between our economy and our ecology. Indeed, both words are rooted in oikos meaning household, and both ecology and economy touch essential features of human well-being.

Example: In our society of complex divisions of labor, identity is hard to come by. The community as a whole is obscured from the individual's view by the complex network of tasks and social groupings, in which most persons occupy an obscure place, and by divisions of interest. Thus, in complex societies, individuals are confronted by many bases on which they can differentiate themselves, their interests, and their lifestyles from others, but with few grounds on which to identify and associate themselves with the community as a whole.

Park uses compatible with preservation help expand personal and collective identity and responsibilities. Mountain parks give us a sense of community to be found in their age, democratic origins, patriotic history, animals, extension of the senses, silence and above and beyond all these values, an in-depth appreciation. Caves perhaps best exemplify best the value of silence and solitude. Paradoxically to become part of a community, we must leave it and return. To be confronted by the real has more power and lasting impact when that experience is not mediated immediately by other people. Being part of nature both transcends and enlarges our humanity.

A common focus on nature as an ultimate and authentic reality provides for a sense of something firm and unquestioned in terms of which the self can be defined. For, to focus upon nature and its ways, believing in the ecological unity of all things, is to construct an account of the ultimate, to say that this is the world to which one must relate.

Preservation treats all users alike, gives vital information and preserves future options, giving our community future continuity and depth. Understanding park processes overcomes what may be felt as short-range ugliness, such as a predator-killed deer, or a temporary inconvenience, such as a small parking lot. We don't have to possess in order to enjoy.

Example: Activity in nature can be therapy; people return to nature for re-creation, for a time free period for healing the wounds of hectic society.

Example: NPS research indicates that at least 50% of the visibility impairing particles in the air at NPS units in the Northwest is manmade. Increased particles may increase radon risks in caves. Airlocks may now prevent some of those man-caused particles from entering.

Example: Not all uses are sustainable. Horses destroy trails not designed for their use. The most serious alien (non-native) plant threat to Oregon Caves National monument is the introduction of aliens via horse droppings in the upper meadows of the monument. The monument currently spends approximately $5,000 a year in controlling aliens in the monument. For the last three years intensive efforts have reduced and even reversed the spread of aliens. This is largely because most aliens are concentrated in about eight acres of disturbed areas in and around the developed area. The only documented case of aliens occurring in the other 470 acres of the monument has been from the illegal entry of horses in two of the largest upper meadows along the Big Tree Trail.

Lab Exercise: Draw lists of visitor uses compatible with conservation and long-term sustainability and those that are not.
Have other students critique some of the lists and argue why some conservation-oriented uses may not be sustainable in the long run.

Lab Exercise: List sustainable activities on the Monument that contribute to human health and fun. How could these activities be made more sustainable and less impacting.

Lab Exercise: The Giving Tree

Objective: After this activity, the students will be able to describe at least three ways that trees give to us and three ways that we can give to trees.

Background: This book tells the story of a boy's lifelong relationship with a tree. Throughout their lives, the tree gives many things to the boy, asking only in return that the boy be happy. The story encourages children to think of the benefits they receive from trees, and also stimulates them to consider how not to make their relationship with trees one-way.

Example: The park safety plan delineates cave rescue procedures that will keep impact to cave resources to a minimum during rescues. Prevention of accidents is essential and is addressed in the permitting process for off-trail use in monument caves.

The park service does not try to eliminate all risk and hazards; otherwise it would likely eliminate a lot of fun and enjoyment and well as destroy natural processes. Controlled risk is a major element in the satisfactions nature enthusiasts derive from their participation. The sense of risk, even if minimal, is a reminder that nature's way is her/his own. To the extent a sense of risk is created, nature as an object beyond the reach of human manipulation and domination is sustained. Risk provides a sense of excitement, energizing individuals. More crucially, it helps to maintain a definition of the natural world as a place where people enter in a established and self-sustaining system that may have little regard for people and their needs.

CONCEPT: Parks give us a template for survival.

Summary: Areas protected from human interference, especially caves, act as benchmarks by which we can understand the rapid human-caused changes occurring in the rest of the world. If disruptions of natural cycles can come into a park, understanding of these cycles can flow out.

Example: The relatively simple ecosystems in caves are easier to understand than more complex ones on the surface.

Example: Parks are ideal areas for research. But only if we protect these pristine areas can we know best how we affect the land around us. Since ecology knows little of political boundaries, no park is an island protected from the rest of the world. But parks are ripples of hope spreading out to all of us. To cure a sick Earth, we must know and experience the natural health within parks and within us all.

CONCEPT: Nature frees us from dualism.

Summary: Our involvement with nature can go beyond an observer/observed, subject/object dualism. "If we encounter nature as natural resources, then we deny it any of the character of worldhood. And we simultaneously deny ourselves access to it as home. It is characterized by space, not by place. There is no human involvement and therefore no sense of significance in such as nature." (Neil Evernden, The Natural Alien). In contrast, an ecstatic experience with nature transcends duality; it is simultaneously terrifying, hilarious, awe inspiring, familiar, and bizarre.

Example: Nature teaches us to sense the negative as well as the positive. The presence and distribution of speleogens (erosional features) tells us more about Oregon Caves than the speleothems.
Speleogens are outlined by space and shadows between them, of what they are not. Speleogens in Oregon Caves include anastomoses, arches, bevels, cave "ghosts," boxwork, canyons, domes, domepits, meanders, meander niches, natural bridges, vugs, pendants, pillars, potholes, rills, scallops, and vugs. The silence and solitude of caves can gives us more than the constant din of machines and noise we are bombarded with in everyday life. The spaces between leaves is as important in understanding how a tree absorbs sunlight as is where the leaves are located.
Peaks, cliffs, waterfalls, caves, speleogens, and springs
all these focus on fields, process, and relationships rather than on the materialism of the more solid objects that surround and define them. Space defines place as much as things.

Example: There are no "good" or "bad" animals in nature. Each species has its role (niche) and should be considered for the way it performs that role, and not judged on the basis of any fancied resemblance to humans.

Lab Exercise: Using INDEX files, list some of the benefits to humans of poisonous cave animals in the park.

Lab Exercise: Listen and compare sounds in the cave, on the surface, and in the coffee shop on the Monument. What is noise? **Answer**: Noise to some is either an intrusion, a distraction, and/or meaningless sounds. Some noise can be turned into meaning sounds by understanding more about nature. Can the same be said about machine sounds or noise? What are the effects of noise on people? **Answer**: Noise above 100 decibles can cause permanent ear damage. Noise can distract us from meaningful sound.

CONCEPT: Nature wastes little.

Examples: Originally an excretion, calcareous shells served as defense, offense and as an attachment for muscles, providing a rapid increase in species diversity during the early Cambrian. Oxygen was once a toxic waste product among earth's first lifeforms but now is essential for most ecosystems.
Evolution tends to drive species towards great use of natural products, processes, and habitats over geologic time.

Lab Exercise: When resources are seen as limited, certain human economics tend to increasing efficiency and less waste over time. Research the mining and timber industries in

Oregon and give examples of how more efficient processes have superseded more wasteful ones.

*Interdependence of people and nature

CONCEPT: Much of what we do to the environment we do to ourselves.

Summary: Unless the Earth can speak to us of our interdependence "in ways that engage the heart, what will all the knowledge of all the experts count for? It will remain a chaos of information without an integrating theme. That theme, if we have the courage to face it, is our entire way of life, the pattern and the power of an industrial culture that cuts us off from the natural continuum." (Roszak, 1993:308).

Example: "Man did not weave the web of life... he is merely a strand in it. Whatever he does to the web he does to himself." (Chief Seattle).

Lab Exercise: Humans are on the verge of being able to change, but not control the earth's climate. What are the benefits and dangers of this power? **Answers**: Some changes could snowball and result in unanticipated effects. Control of climate could increase food production.

CONCEPT: Humans depend on functioning ecosystems.

Example: Most or all of the bats presently in the cave eat insects harmful to human interests. Each bat can eat up to half their body weight in insects each night. Many plants, including guavas, avocados, cashews, sisal, manila, cloves, and balsa trees are pollinated by bats. Bats distribute the seeds of papayas and figs.

Lab Exercise: List human impacts on the caves that now affect humans.

*Carrying capacity, lifestyles, and technology

CONCEPT: Caves and old-growth are fragile.

Summary: Caves have low carrying capacities. Human-caused changes in biomass can radically change the community.

Example: The high number of interactions between species in a cave makes it susceptible to the loss of a single species. Its high diversity means that the change in composition and in biomass can be great if a species is removed.

Example: Within the monument, the Park Service attempts to establish resource standards and carrying capacities against which to monitor and measure impacts resulting from recreation, including activities such as collecting mushrooms and off-trail hiking both above and below ground. Interpretive programs are given to develop understanding and elicit cooperation by visitors and nearby residents in protecting park resources and values.

Lab Exercise: Define a carrying capacity and see whether Oregon Caves exceeds it. Use information sheets on natural and human-caused organic input in cave, vandalism rates, etc.

Lab Exercise: Play cave trail game (Lesson Plan # in Teacher's Guide for Caves and Serpentine Plants).
Source: Computer Filename is **TEACHGUI.1-3** - Teacher's Guide
Source: Computer Filename is EA - Environmental Assessment of new cave trail

Example: Populations have the potential to reproduce in excess of the carrying capacity of their environment. without adequate controls, the biotic potential to increase will exceed the productive capacity; of its environment to sustain further increases in population. Increases beyond this level can result in famine, disease, death and war.

CONCEPT: Lifestyles vary in sustainability.

Examples: Lifestyles that emphasize consumption of commodity resources tend to be less sustainable than those that emphasize more conceptual resources such as wilderness, personal growth, health, aesthetic appreciation, ecological stability, and future planning options. This is in part because the conceptual resources are more likely to be renewable. Lifestyles that emphasize dead things (timber, minerals, cars, etc.) tend to be less sustainable than those that emphasize life. This is because, up to a point, biological systems can repair damage to their communities as well as to individual organisms.

Lab Exercise: Slash and burn agriculture is very efficient and life based. For each unit of energy put into the system by humans and their domesticated animals, about one unit of energy is returned. The ratio of energy put out by humans versus energy returned in our present day agriculture is about 16 to 1. What allows for this inefficient use of energy? Is it sustainable? Discuss the concept that use of great amounts of energy threw us out of nature because reliance on fossil fuels helped us temporarily exceed our carrying capacity.

Example: A few agriculturalists are working to create systems that display all four of the things we want to learn from nature: energy efficiency, cyclicality, diversity, and self-regulation - Evan Eisenberg, New Republic, 30 April 1990

CONCEPT: Caves and mountains preserve and sustain the pioneer spirit.

Summary: Caves preserve a sense of individual discovery and exploration no longer present elsewhere in our extensively explored world.

Examples: Except in caves, one can explore today only as part of a large team financed by government or large corporations. Yet unlike the consumption and control of nature by the frontier, exploration of caves can be sustainable.

Exploration has a long history here. Hudson Bay Company exploration in the 1820 was the first record of non-native people in the Siskiyous. The HBC's interest in the area was related to possible fur trading with aborigines inhabiting the interior valleys. Because of the number of endemics and overall number of plant species, this area continues to be a mecca for plant explorers and other botanists.
Source: Computer Filename is BOTANISTS - Information on historical botanists

Lab Exercise: If you were a cave explorer in the early part of this century, what specific habitats would you look for in the attempt to find cave species unknown to science? Where do you think the current focus of cave exploration is?

*<u>Wildlife and what it can teach us about ourselves</u>

CONCEPT: Much in nature serves as symbols in language, mythology, legends, and literature.

Example: When we lose natural areas, we lose parts of our language. The French have no word for wilderness, perhaps because they have no wilderness left.

Lab Exercise: Chose an animal from Oregon Caves and report on its role in the above fields, and, if discernable, any changes in such perception and symbolism. **Source**: Computer Filename is 93-HIST - History, legends, resources management background data for Cave tours (excludes geology) but includes history

Source: Computer Filename is 93-HIST.CUT - Short version of history, legends, resources management background data for Cave tours (excludes geology) but includes history

Lab Exercise: Using an animal list from Oregon Caves, list at least ten language phrases that use animals found in the Monument.

CONCEPT: Animals help us grow up.

Summary: Growing up with animals and observing their emotions helps us understand the seemingly more complex emotions of humans.

Example: "One does not meet oneself until one catches the reflection from an eye other than human." - Loren Eisley.

Example: "Animals are among the first inhabitants of the mind's eye. They are basic to the development of speech and thought. Because of their part in the growth of consciousness, they are inseparable from a series of events in each human life, indispensable to our becoming human in the fullest sense." -- Paul Shepard, Thinking Animals, 1978

Lab Exercise: List three emotions observed in pets and three in wild animals. Describe the circumstances. Where there any differences between the emotions of pets and wild animals.?

*Respect, interest, empathy, and protection

CONCEPT: Parks help us expand and rediscover our identity.

Summary: Expansion or rediscovery of our identity includes values of "immortality" (being a part of something bigger than you are, leaving your non-destructive influence with the land and all you love (photography, shared memories), heritage (preserved for all future generations) and cycles of nature. Identification can range from associating cave formations with more familiar objects to finding oneself. The condition of the land as it was when we came to it, as in the caves of the Monument, is the best possible measure of our history and identity. Nature can satisfy our craving for specialness, distinction, and personal worth, needs currently met by overconsumption that destroys natural systems. "If there is any real hope for a transnational sense of the brotherhood of man, it may come from an environmental disaster that makes us feel we're all on the same side, fighting a common foe." - James Fallows, The Atlantic, July 1990

Lab Exercise: = Who Am I?
Objective: Through questioning and interacting with their classmates, students will be able to name at least three animals of Oregon Caves, as well as several characteristics of each one.

Each species of animal has its own special characteristics that make it different from any other. These variations allow animals to use different food sources and habitat niches within caves. For example, winter wrens are similar in many ways to woodpeckers. Both species use snags and fallen logs as sources of food and shelter. But differences in beaks, tails, bone structure and behavior allow them to find food without competing with one another. Even closely related species, such as different types of woodpeckers, are distinct enough to avoid using the same food sources.

Materials: Enough animal labels for each child in the class. Yarn or masking tape to hold the labels onto the children's backs. Animals found in the Monument include: black bear, raccoon, bobcat, woodpecker, wren, slug, butterfly, spider, squirrel, flying squirrel, owl or others that the children are familiar with. Duplicate animal tags are acceptable.

Procedure: Prepare a label for each student in your class. Without letting the children see their own nametags, attach a tag to each child's back. (Masking tape or clothes pins work well.) Make sure to instruct the children to not say the names of any of the animals out loud. The object of the game is to have each child ask his classmates yes or no questions until he can guess what animal is shown on his nametag. The students might ask questions like, ■Do I have fur?•, ■Can I fly?•, or ■Am I a reptile?• ■Do I eat only plants/other animals or both plants and animals?• Questions that ask for more information than a simple ■yes• or ■no• (for example, ■What do I look like?•) are not allowed. Once everyone has found his/her animal identity, discuss with the class how they figured out who they were. What traits do all the animals share? What traits are found in only a few or only one creature?

Extensions:

1. Have the children find out more about the animal that they played in this game. Ask them to consult several books and prepare a short written report on their animal. See the suggested reading list in the back of this book for possible sources.

2. Have students visit the library and find books that show a variety of similar animals. (Field guides to birds or animals would be a good choice. See the suggested reading list in the back of this book for titles.) Have them compare pictures of related animals, such as different species of birds, and then make a list of similarities and differences. This could be done as either a group activity, with you showing pictures to the class and creating a list on the blackboard, or as a quiet activity that each student works on individually. Make a table on Ventura with animal names: black bear, raccoon, bobcat, woodpecker, wren, slug, butterfly, flying squirrel, owl, salamander, spider, squirrel, Roosevelt elk, black-tailed deer, raven, salmon.

3. Expand the picture dictionary to include non-animal terms of old growth or caves.

These could include: biodiversity, biomass, canopy, community, decomposer, Douglas-Fir, ecosystem habitat, indicator, species, lichen, mycorrhizae, nitrogen fixing, nurse log, milliped, grylloblatid, spider, springtail, producer, red tree vole, snag, succession, detritivore, transpiration, understory, watershed, . Use some of the Monument's glossary for definitions.
Source: Computer Filename is GLOSS.A-Z.

Lab Exercise: Complete the "Cave Word Search" and the "Cave Puzzle." Copies are available from Oregon Caves.

CONCEPT: We protect what is rare and unique.

Summary: The Monument fulfills our need for rarity. Parks are special places requiring special behavior. We strive to protect what becomes increasingly rare but at the same time we are more likely to visit the rare, fondle it or collect it. Parks are places where one can still find rare:

Examples: Cave formations, including canopies, cave pearls, calcite & mud dripstone, coralloids, conulites, crystal-lined pools, hard & flexible flowstone, helictites, microgours,

Mundmilch, rimstone, and vermiculations (Hill & Forti, 1986). Rare cave animals include endemics and disjunct species.
Preliminary species lists indicates there are about nine endemic macroinvetebrates in the Caves, more than any other known cave in the US or Canada except perhaps for Malheur Cave in central Oregon.

The Pacific pallid bat (*Antrozous pallidus pacificus*), and the ringtail (*Bassariscus astutus*) occur in the monument and are state-listed as limited in abundance in Oregon or throughout their range. The Townsend Big Eared Bat (*Plecotus townsendii*) is state-listed as critical. The Tailed Frog (*Ascaphus truei*), Western Toad (*Bufo boreas*), and Fringed Myotis (*Myotis thysanodes*) are state-listed as vulnerable.

22% of all native US vertebrates range from being very rare to being critically imperiled, according to a 1995 Nature Conservancy and Natural Heritage Network report. The percentage is 31% for vascular plants and 33% for butterflies. A loss of 90% of an ecosystem may cause a loss of 10% of its species even in those areas relatively unaffected by human impacts. Those species most at risk include ones with very restricted ranges and species whose individual need very large ranges. Large predators like us are rare and therefore valued.

Example: Unless one knows that Oregon Caves is unique, one may not be so vigorous in its defense. Many cave decorations, like stalactites, grow here and in other caves. Others may be unique to ORCA, such as hard clay "worms" and moonmilk, flexible flowstone, and mosaic coralloids.
Source: Computer Filename is UNIQUE - What makes the Monument unique (geology and botany)

Lab Exercise: Using the following:
Source: Computer Filename is ANIMAL - Animal species at Oregon Caves
Identify common traits for rare species in the cave. Are there any difference between those species that are rare in the Monument but common elsewhere versus those species that are rare everywhere?

CONCEPT: We value that which is significant and superlative.

Lab Exercise: The Most .... Fieldtrip
Now that you've returned from your trip to Oregon Caves National Park, take some time to think over what you saw, heard, felt and experienced there. This worksheet will help you remember.

The most unusual thing I saw on our park visit was

The biggest tree I saw was how much bigger than me.

The thing I'll remember the most was
The most surprising thing I saw was

The smallest thing I saw was

It was HOW SMALL

The most interesting sound I heard was

The most unusual smell I smelled was

The smallest animal I saw was

The most beautiful color I saw was

The most fascinating thing I learned was

My favorite thing was

Lab Exercise: The Most Field Trip
Objective: Students will be able to list and describe a variety of things that were seen on the class trip.

Background: Our recollections often center around the superlative things that we've seen or experienced. This activity gives students the chance to remember and write down their day's highlights, and encourages them to consider highlights they might not have thought of before.

CONCEPT: We brake for nature.

Summary: Nature helps us slow down and appreciate more. Slow natural processes gives us perspective, a sense of permanence, and is an antidote to the increasingly rapid pace of our day-to-day lives.

Example: Many nature activities frees us of the tyranny of the past and the future. Much of the appeal of caving comes from the unity of body and mind that freedom entails. The coordination of attention, muscle and eye is so focused that they flow together deep in our brains and caves. You are so involved in what you are doing you may not separate yourself from the immediate action. Cave movement, whether vertical, swimming, or over uneven floors, needs balance, equilibrium, and concentration. The possibility of danger heightens one's senses and draws one closer, literally, to the earth. This intensifies both the challenge of cave wilderness and a nobility derived from the cave's independence of humans. It's a physical poem, an aesthetic dance, a rite of passage.

Hiking the narrow and low passages of Oregon Caves partakes of this motion. The National Park Service has spent almost two million dollars in the last decade to restore the cave to its prehistoric heritage. Over 1100 tons of blasted rubble has been removed, tuning out the static so we can hear the music of silence and peace. Now the cave trail looks more like a wilderness than a tunnel, much more what it looked like to its first explorers in 1874. And even greater wilderness is never farther away than the edge of our lights. At the edge we become primeval again, blind and wary as to what blackness may bring. Shadows as well as the shear mystery of caves makes them seem much less predictable than the surface, humanized world. Without timepieces or highways, duration and distance act strangely when freed from their cages. Caves remind us of the limits of perception yet also help expand our sense of space and time. This longterm view in turn makes us care for the future. So deep in the earth and in our heads lies both condensed freedom and responsibility. Keep on caving!

Lab Exercise: List ten of your most time consuming things you do each day and plot it on a graph with the x-axis showing % total time involved and the y-axis showing the average duration of the event. Compare this to what you consider to be the ten most important processes/cycles at Oregon Caves and things that you might do there. Discuss the differences

*<u>Local Native Americans' varied cultures</u>

CONCEPT: Natives reflect our own past.

Summary: Despite the variety, there are similarities between local tribal cultures and those from our past (European and Asian tribal cultures). These similarities include small, closely knit communities, few specialized occupations, close ties to the land, and the strong role of religion in everyday life. Many scientists believe this was the context in which most of the human brain evolved.

Example: Native American legends tell of the close affinity that they had for nature. According to Apache lore, humans originated from limestone. This is true scientifically if you take it back far enough. "I am trying to save the knowledge that the forests and this planet are alive, to give it back to you who have lost the understanding." -- Paulinho Paiakan, Kayapo Indian, in Julia Burger, <u>The Gaia Atlas of First Peoples</u>, 1990.

Lab exercise: Research local and European tribal cultures and draw up list of similarities. Have any problems resulted from departing from these cultural norms?
Source: Computer Filename is INDIAN - Summary of Lowland Takelma and Galice Indians (groups that probably used the monument).

CONCEPT: Native managed for sustainability

Example: The is no evidence that any native group overfished the salmon runs. Prohibitions on fishing, hunting, or gathering before special rituals were performed may have reduced the

possibility of overuse as well as preventing conflicts caused when gathering an initially scarce resource.
The California Kumeyaay never cut a living tree. Firewood was obtained from broken branches, dead trees, or from chaparral roots. Some California tribes specifically planted those plants which sprouted only in the unusually timed rainfalls of drought years. The Yokut-Mono in California never disturbed mushroom stems and living mycelium under the ground. They also only took large bulbs for eating.

The selective harvesting of larger bulbs, corms, and tubers for food may have had the practical effect of thinning the resource; the digging stick that was employed aerated the soil, separated and dispersed the smaller bulbs or corms, and activated their growth, thus essentially increasing the size of the tract and its potential productivity. Yokut-Mono broke off soaproot roots so that new plants would grow. Sedges and bracken roots were dug in such a way as to stimulate new growth. The extensive use of fire had similar effects.

Because natives utilized so many different habitats and species, they promoted the maintenance of nearly all habitats, from meadow, to forest, to riverine habitats. Although not known to be used by Takilma, small dams in California maintained wet habitats and grasslands. The Karuk, who probably were present in the Monument at one time, used fire to disease and pests of oaks. Without fire, a bumper crop of acorns produced many Filbert Weevils and Worms that would reduce the crop of acorns the following year unless fire was used. Fire was used by Takilma to increase deer food as well as to increase the number of basket fiber plants such as Beargrass.

Example: "Native Americans maintained a careful balance with their environment, not because of technological primitivism but because of complex social laws that regulated greed, wealth, and power. Material equality was the cornerstone of most tribes' social philosophy." -- Carl Gawboy, Harper's, July 1990

CONCEPT: Natives had a transactional bond with nature.

Summary: Native legends reinforced intelligent, reciprocal relationships, not stupidity or dead objects. Takilma regarded the land as a community. For the Takilma shamans, the cosmos is a tale that becomes true as it is told and as it tells itself. Freedom, personal responsibility, and a humbling awareness of the true size and intelligence of the world combine in this point of view. A reverence for and an immersion in the powers of language and interspecies communication are the basis of the shamanic path. To heal is to increase both inner and outer harmony and to grasp their basic unity. Both *heal* and *holy* derive from the Anglo-Saxon *haelen*, meaning "whole." Shamans cure through spirit journeys that map a sacredness once honored by most humans on Earth.

Example: Through hearing of trickster stories, natives both enjoy vicarious satisfactions and respect their consequences, a combined catharsis that moderates longing to remerge into nature. Several native tricksters try to fly but crash instead. Such stories warn that assuming abilities not our own can backfire. In defying the given natural order, tricksters suffer the results and thus teach the power and meaning of an ordered life. Innovation, appraisal, and self-awareness from tricksters paradoxically reinforces such a life. Living these experiences by way of imagination allows humans to both avoid them and strive for more appropriate abilities. Then we can enjoy natural limits as order and disciplines that enhance our total existence.

Examples: In contrast, many in our modern culture view much of nature as dead or at least stupid. This may be in part because so much of our modern technology and what we grow up surrounded by is not composed of living species. When one reacts to what is viewed as stupid, one often reacts in an ignorant and uncaring way. Aldo Leopold asserted that "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong we may begin to use it with love and respect."

The Takelma believed that if a rattlesnake bites your shadow, it is a sign that you will vomit. They also believed that if a black-striped snake crossed one's path, it should be killed. Otherwise, a relative would die.

The view of the world as transactional and endowed with mindful sentience is reborn in every child even in our own culture. It is a "habit of mind that has served our species well for a very long while, that communicates observations about the behavior of systems, especially biological systems, more clearly than any 'alternative mode of description, that appeals to common sense, that has yielded significant scientific findings in contemporary ethology (animal behavior), and that has produced a wealth of art and literature>" (Roszak, 1993:300).

Demonstration: **Shamans** - A reincarnated Takelma Indian shaman cures a patient. 20 minutes

Demonstration: **Indian Star Lore**: Native American and European stories and folklore. **Source**: Computer Filename is STAR - Star folklore

Examples: The Takelma Indians almost certainly passed through the monument yet they left no known impact of their passing. By treating the earth lightly through minimum impact recreation, modern visitors can do the same.

The many Native American groups in southwest Oregon made it one of the world's most diverse cultural areas. What often united these cultures was a belief in "supernatural" guardians that protected people and the land. Over 200 tribes in North America knew of "little people" or "dwarfs." The Hupa, Karok and Yurok near the coast believed in a bearded dwarf who gave out just enough food so people would have enough to eat. But if the Hupa dwarf saw wasted food, he produced a famine. Similar was Rock Old Woman, who punished selfish, greedy Takelma shamans, those who ignored the communal good. Some Tolowa and Shasta respected the power and privacy of "little people" and avoided areas where they were seen. As a result, such areas could recover from resource use. The land was to be used, but Tututni natives were cautioned by their Creator not to cut down more trees or kill more animals than were needed.

Nature guardians encouraged stable populations as well as frugal use of resources. "Little people" known to five western tribes were said to have started death or floods so people wouldn't overpopulate the Earth. This may be a reason why the social ideal of the Hupa and Yurok was to have few children!

The belief in "little people" formed part of a broader Native American view that saw the world as alive and conscious. In part because differences between humans and the rest of the world weren't felt to be great, actions by individuals had repercussions that reflected back on their community and
their world. It wasn't nice to fool Mother Nature or her guardians; retribution could be a swift "accident" or a lingering drought.

This contrasts with the attitude of most of us. Many in our culture feel we can do anything we want to nature without fear of punishment. Nature guardians don't limit our greed and selfishness. Nature has become an insignificant "other" that we exploit and no longer identify with.

It may be that few cultures ever completely halted population growth, a rise that eventually drove groups into agriculture and increasing exploitation, along with attitudes that justify such use. But this can change if an awareness of the results of our actions, combined with a love of nature, can replace or complement "supernatural" controls on human impacts.
Lab Exercise: Although little is known about Takilma resource management, data on nearby California groups can suggest some of the management actions that were performed. Use Before the Wilderness: Environmental Management by Native Californians as a source and list three sustainable resource management actions the Takilma probably undertook.

CONCEPT: Use can lead to closeness.

Summary: Takelma plant use illustrates closeness to nature.
Slide Program: **Indian Plant Lore**: Native American legends about plants.

Example: Native American used the resources extensively, so much that the population levels prior to European contact possibly may have been the highest to have ever characterized societies without a well-developed and relatively intensive agricultural subsistence base. Indeed, it was thought be at least some natives that without human use the land would deteriorate and become less productive. But it was a use practiced close to the land in a give and take transaction filled with courtesy and respect. People needed the plants in order to live, but it was thought the plants also needed the people; they needed the people to gather their seeds, and leaves and roots, and to talk and sing and pray to them. If the plants were not used by people, the spiritual relationship was broken and both plants and people no longer had a place to call home.

Many resource use were complementary. The high fat content in sugar pine seeds may have offset the use of lean salmon. Certain Indians were prized for their ability to climb 200 feet up a sugar pine. When Indian wives asked their white husbands for some sugar pine nuts, the settlers cut the pines down instead as they did not know how to climb the trees.

Lab Exercise: Approximately 65% of the material culture items utilized by one Californian tribes were made entirely or primarily from plant materials. What % of plant derived objects do you utilize in one day. Start early in the morning and maintained a record of plant, animal, plastic, and metallic objects you have used.

<u>*Appreciating smallness & simplicity in and out of caves</u>

CONCEPT: Smallness unlocks bigness.

Summary: The small is often a more understandable and accessible answer to the big. Nature is not just the seen world, but more importantly the unseen world that can only be experienced by coming close and through intimate contact.

Examples: Small folds easily seen in their entirety in the Monument are in the same orientation of folds much larger than the entire Monument. The direction of one small fault in Oregon Caves is the same orientation as the stresses on the entire back-arc basin in which the cave bedrock formed. A slight breeze reveals the prevailing wind that dropped dust and snow on the Monument's largest meadow, thus helping to create and maintain that meadow. A single drip in the cave, multiplied by millions of others, help decorate the cave.

Example: Just as one can speak of natural history as providing rules of composition in terms of which particular natural features can be appreciated, so too, the aesthetics of nature imply standards. Some caves, like Oregon Caves, are "better" than others for revealing the passage of geological time and for a certain "caveness" of tight, well decorated passages that most people expect a cave to be. A footpath detracts little from the aesthetic experience of the Big Tree Trail; a clear-cut or a four-lane highway destroys much of it. One of the aesthetic standards at the Monument is being able to see both detail and wholeness in the smallness parts, tiny holograms each of which help reveal the entire picture.

Examples: Caves are valuable to scientists because they harbor animal communities that are simpler to study than those on the surface. This is because there are often fewer types and numbers of animals in caves and so there are usually not as many types of possible interactions compared with animals communities on the surface.
Lab Exercise: Develop trophic levels for caves and old growth ecosystems.

CONCEPT: Smallness harmonizes us with nature.

Example: People can live in harmony by valuing smallness. The smaller we come to feel ourselves compared to the cave, the nearer we come to participating in its greatness.

Examples: Many of our inventions derive from small parts of nature. The gigantic hewletts, metal arms used to load and unload ships, are modeled after grasshopper legs. Velcro was patterned after the tiny hooked hairs of weeds that travel on animal hair.
Airplane designers have studied the mechanics of dragonfly flight, to determine how an insect whose wings are restricted to up-and-down movements, with no coupling device joining front and back wings, can hover in midair and fly both forward and backwards at speeds up to 60 miles an hour. Dragonfly wings have three times the lift, in proportion to weight, of the most advanced aircraft. Aeronautical engineers have reduced the noise of jet engines by studying the special construction of owl flight feathers with their extremely narrow outer vanes, softness, and loose fringes that prevent air turbulence.

Example: Studying sperm storage in bats has added valuable medical knowledge to fertility, birth control, and organ transplant studies. Understanding how a bat hibernates may help people to both slow down a patient's metabolism during surgery and an astronaut's metabolism during space flights. Because the relatively large size of most bats' hearts makes research easier and the translucent wings allow microscopic examination of living blood vessels, we are increasing our understanding of human circulatory disease. Bats may live over twenty years, a very long time considering their size. How they do this may provide clues for extending human longevity. Bats have been used in developing new vaccines.

Various insects have evolved ways to mimic bat echolocation. They thus avoid being eaten by confusing the bat with false echoes. Some bats have in turn evolved ways to circumvent such "jamming." Understanding how this occurs may help improve human sonar systems and navigational aids for the blind.

Example: Foraminifera probably made up part of the original Applegate limestone and radiolarians made up part of the chert. Both were mostly microscopic creatures yet are very important in rock formation. They and other microscopic sea animals are the main source of oil and gas that drives our cars. Bit by bit, the microscopic algae grows around the lights and builds up. Eventually they dissolve the underlying cave formations and add organics to a food-poor animal community, causing the paradox of enrichment in which animals adapted to food rich situations outcompete the cave adapted animals.

Example: The "Bigger Is Better" creed of large American societies crowds out values vital to small communities and our prehistoric heritage: restraint, respect, harmony, magic, honesty, mutual help, and the ability to change. In exchange for our freedom, Bigness grants us monotony, monoculture, intolerance, competition, specialization, and subsequent alienation from Earth and ourselves. Since freedom results from a mix of often conflicting controlling forces, Bigness monoculture lessens freedom, adaptation, and diversity. Varied worlds of spirits, animals, and imagination are removed or ignored to make way for things quantified, enlarged, and mechanized. The "paradox of enrichment" in biology operates on societies as well. Only one culture, the modern Western technological society, has been able to best absorb so much of Earth's resources, time, and energy so as to become the dominant culture.

Example: Large size, like specialization, means smaller populations, lower reproductive rates, and earlier extinction.

Field or Lab Exercise: Identify ten small things that probably have major impacts on Oregon Caves life or geology. Explain why.

CONCEPT: Smallness gives us in-depth appreciation.

Summary: Smallness in nature is like a nested series of Chinese boxes. For every one that is opened there is a smaller one inside. This can help us see, appreciate, and believe in greater realities behind and within nature, from the scientific to the artistic and spiritual.

Examples: Fleas carry their own parasitic mites in the spaces between their external cuticle plates. Wilderness in a small area requires us to look more closely, to expand our senses.

Example: As humans level out mountains, light up night, drain swamps, and fill in caves, so we become superficial ourselves. Wildness dies outside and within. Instead of growth on a deep past of organic cycles, we race towards an abstract and lonely future, a shaky culture because its roots lie so shallow. It is a future in which we weaken as we stray from our own evolution of small communities close to nature and her guardians. We all want to be Big individuals and so champion separateness instead of community. Energetic eruptions from a repressed unconscious become more common; Bigness makes them ever more deadly. As high tech, energy, and altitude religions reduce bio- and cultural diversity, so does Big hatred, fear, hubris, and greed drive out the more diverse emotions of empathy, humor, wonder, and ecstasy. Humans crave entertainment, power, and money for they often are quick, easy, and convenient. But they are so surficial that they don't satisfy for long. So consumption grows ever Bigger and chokes on its own waste.

CONCEPT: The small is many and vital.

Summary: Microbes (fungi, bacteria) drive the Oregon Caves ecosystem. Microbes play either central or crucial roles in most ecosystems, especially in caves where biomass and the number of levels in the food chain are both low. Microbes may be the first organisms in a cave to be affected by human impacts. Just walking through a cave can rearrange clay particles, increase accessibility to attached nutrients, and thus increase microbial activity.

Examples: Consider also the impact lint, skin flakes, hair, and other human deposits, up to a pound a year in the case of Oregon Caves. Although small compared by surface amounts, this organic input can be several orders of magnitude greater than what naturally occurs in caves and thus can have significant impacts on biological activity.

Humans have impacted some bacterial populations in Oregon Caves. An inventory done around every survey point in the Caves show a marked decrease in "cave slime" (mostly actinomycetes bacteria) growing on walls near the cave trail. Cave slime in Oregon Caves looks like white spots of very thin lichen. This reduction in cave slime could be the result of lint and other visitor organics that get on cave walls. A "paradox of enrichment" may ensue in which non-native bacteria adapted to a high energy food source outgrow and outcompete the slow growing cave slime adapted to low energy foods, an oligotrophic community. A similar situation may occur with the endemic/less cave-adapted ratio of invertebrates in the Caves (Crawford, 1994). In addition to the organic overload, touching of the cave walls by visitors and spraying with bleach to control exotic plants may have adversely affected the cave slime and macroinvertebrates near the paved trail.

An inventory of algae-shaped speleothems has detailed the size of the Cave's prehistoric entrances. These cave formations are coralloids shaped like popcorn and oriented toward entrances past or present. Cyanobacteria (blue-green algae) may shape them towards light by binding calcite particles (Viles, 1984). Photosynthetic use of carbon dioxide may cause calcite to crystallize as well (Jones & Motyka, 1987).

Lab Exercise: Use data on biological activity (amount of oxygen used) and bacterial abundances to explain distribution patterns and the effects of the human-made trail in the cave.
Source: Computer Filename is MICROBE - Summary of cave microbe study in ORCA

Example: Smallness favors biodiversity because habitats become grainier, they offer more niches for the smaller animals and plants. A single feather may house fifteen species of feather mites, each with its own preferred site and pattern of behavior.

CONCEPT: Small parks display speciation and extinction.

Examples: Based on studies in eastern North America, the isolation of the marble block in the Monument probably results in low diversity (because of lack of migration from other areas and high extinction rates) but high endemism; some species only occur in Oregon Cave and nowhere else in the world.

Speciation can be seen in the fact that about nine species are endemic to the Oregon Caves. About 1/4 of the state list of rare, endangered and threatened plants are in the Siskiyous. Due to genetic drift and high extinction rates, small, isolated carbonate areas tend to have a small number but high % of cave endemics. Larger carbonate areas tend to have a larger number but lower % of endemics. Larger populations and migrations tend to dampen genetic drift and so reduce the number of new/endemic species.

Cave communities are important as models for the establishment and management of nature preserves throughout the world. Like caves or islands, most nature preserves will likely be or already are surrounded by man-made environments unfavorable to most forms of life. It is vitally important to know how such relatively small communities can survive. Cave communities can give us important clues as to how to administer and protect these preserves.

But much of this valuable knowledge may soon be lost. People cause drastic changes in cave life that evolved in very stable environments. The few food chains are easily broken. Drying out of the cave from artificial entrances hurts creatures who have lost scales, hair or hard outer body covers, perhaps because they did not need them in the high humidity of caves. Coins and food thrown into cavern pools kill life through copper poisoning or loss of oxygen. Unnatural numbers of surface species thrive on human food in the cave and crowd out native species.

Example: Species are not the only things threatened in small areas. Genetics are too. Replanting of clearcuts with Doug-Fir affects the pollination of Doug-Firs within the Monument. The genetic pool of *Bassariscus astutus* (Ringtail) may have been human-impacted as gold prospectors may have brought some animals into the area. Saving outward forms will not save all of the genetic diversity that exists. Analysis of DNA from a 17 million old leaf in Idaho showed that since that time there had been 17 mutations in magnolias, five of them significant. Yet fossil imprints show the plants to have very similar outward forms to modern day magnolias.

CONCEPT: People can simplify their means or ecosystems.

Summary: A motto for the "deep ecology" movement is "simple in means, rich in ends." Simplicity and diversity can be compatible. But human simplification of ecosystems can result in pest outbreaks and other instability.

Examples: Food-web theory suggests that, the longer the food chain, the lower the resilience (bounceback) of the system's species will be. Consequently simplification, the human removing of trophic levels, may mean that pest outbreaks occur faster. This may be augmented because habitat fragmentation appears to hit parasites harder than their insect hosts.

<u>*Caves in dreams, mystery, and folklore</u>

CONCEPT: Caves fill our dreams and folklore.

Summary: Caves are central to the dreams, mystery and folklore of many cultures, including our own.

Example: Alone in a cave with pits and tight passages we do feel closer to the natural boundaries set by death. We feel closer to the mystery of life and death than when actually at risk crossing the street or riding in a fast car, when death may be literally just around the corner. Then we feel fear and panic but not mystery. Se we go to nature, the cave, the mountain, to feel more alive by feeling the death that nature insists we not forget. Nature seems to want us to remember death.

Example: Caves, especially "live" caves with running and dripping water and multiple entrances, seem as alive as geology can be. "For real company and friendship, there is nothing outside of the animal kingdom that is comparable to a river." -- Henry Van Dyke, <u>Little Rivers</u>, 1895. The active, relatively rapid deposition of formations suggests dynamism. Air blows in and out. Thus, the cave "breathes," grows and washes itself. Caves are born, become mature (well decorated), and grow old with breakdown and erosion. **Source**: Computer Filename is MYTH.CAV

Slide Program: **<u>Cave Folklore</u>** - Hodags, elves and things that go bump in the dark. 20 minutes
Lab exercise: Use descriptions of folklore beings in caves to deduce importance of caves in Euro-American and tribal. **Source**: Computer Filename is MYTH.CAV

CONCEPT: Folklore can be true or hurt out world.

Summary: Folklore reflects our fears, hopes, and loves. Myths and folklore may not have actually happened but believing them to be true has real consequences.

Slide Presentation: **<u>Bats</u>** - Focuses on their unusual abilities and benefits to humans. 20 minutes

Lab Exercise: Put the bat on trial. Are bats nasty "rats with wings" that get in your hair, are blind, and give you rabies? What is the best way to get rid of them? The lawyer defending the bat will discuss some of the science of bats and what benefits they have for humans. Use Appendix D in the Monument's <u>Teacher's Guide</u> for information supporting bats. **Source**: Computer Filename is **<u>TEACHGUI.1-3</u>** - Teacher's Guide

Examples: Many myths are true if not real. Belief in the cautionary tales of human arrogance, the spirituality of nature, etc. can shape behavior into being sustainable.

Lab Exercise: Comb examples of tree and weather folklore and present three that have some scientific basis.
Source: Computer Filename is TREE - Tree folklore

<u>*Wilderness as baselines to reduce human impacts</u>

CONCEPT: Caves, old growth, and mountains are templates.

Summary: Natural areas serve as a science baseline and benchmark with which we can find and allay harmful human impacts where we live. Relatively pristine caves in particular are good baselines because few surface impacts are present (increased carbon dioxide, ozone loss, human noise, etc.)

Lab Exercise: Describe some information caves could yield that could be used to reduce human impacts. These can include:

1. Temperature Recorders: Cave rock makes for very good insulation. Seasonal and even decades long temperature cycles rarely penetrate more than ten feet into rock. Consequently deep caves record temperatures changes over thousands of years.

2. Earthquake Recorders: Stalactites when broken may fall in the direction of the epicenter of an earthquake.

3. Sediment Recorders: The thicknesses of sediments in caves can record the amount of erosion on the surface. Highly erosion generally occurs where there are human impacts or in semi-arid climates where vegetation is too sparse to hold the soil but there is enough water to move soil.

Lab exercise: Explain how human impact could reduce or destroy such information.

*<u>Caves as a last frontier for private individuals</u>

CONCEPT: Caves free us.

Examples: Only in fairly pristine caves, like much of Oregon Caves, can we sense wilderness without noise, ozone loss, CO_2 gains, and other human impacts found all over earth's surface. Besides caves, the best wilderness still left can only by reached by large organizations or fortunes. Caves remain for most of us a last frontier, an in-depth appreciation of nature. Wilderness deepens us emotionally and spiritually, in its widest sense, by its challenges, peace, intensity, sense of renewal, and comparisons with our present life.

Tons of garbage ring the world's most remote islands. Trash mars the deepest lakes. Human wastes pile up on the tallest mountains. All earth's surface is subject to increased carbon dioxide, ultraviolet rays, airplane noise, acid rain, light pollution, and human-caused climate changes. In contrast, such impacts affect caves but little. Most caves naturally have more carbon dioxide than is found even now on the surface. Tens to thousands of feet of rock stop ultraviolet damage and human noise, and even retard the effects of global warming inside caves by decades or centuries. Tons of calcite buffer the effects of acid rain. And with the flick of a switch, the wilderness of night flowers once again. So caves beckon as the last best wild places left in earth's atmosphere.

Caves and caving harken back our origins, back to intertwined mental and physical aspects of wilderness. At one time wilderness covered the globe and surrounded small pockets of humanity. Now the only frontiers on the earth's surface or beyond are those reached by belonging to a huge organization, such a large country or corporation. Expeditions supported by hundreds or thousands of people replace individual exploration where no person has gone before. Consider the support for submarine exploration of the wilderness beneath Crater Lake. Only in caves may we mimic the small bands of prehistoric peoples and still find pristine renewal, where humans are but temporary visitors. Even with a small group, the freedom of wilderness may matter little without a blank spot on the map. Over 10,000 caves in the US alone have never been explored, quite a few blank spots. We often find mystery inside us only if we find it first without.

Example: "The forest is the poor man's overcoat." - New England Proverb

Lab Exercise: Contrast and compare exploration trips to caves as opposed to other wilderness areas such as Mount Everest, the bottom of a deep ocean trench, or the moon.

Lab Exercise: You are in charge of granting caving permits and backcountry trail permits in wilderness areas. How often should you grant permits and for how many people? **Answer**: Some surveys show that meeting more than one other group in a wilderness area detracts from the wilderness experience for a large percentage of wilderness users. Even encountering one other group in the cave may be too much for some cavers intent on a wilderness experience. Some cavers regard only unexplored cave passages as wilderness. Would you as a wilderness manager allow unrestricted access to unexplored caves?

*<u>In-depth exploration of caves and minds</u>

CONCEPT: Caves empower us in mind exploration

Summary: Caves are a powerful metaphor for mind exploration. Because many caves have little in the way of day/night, lunar, or seasonal, rhythms, caves provide laboratories to investigate the mystery of innate biological clocks.

Lab exercise: Suggest similarities between mental and physical exploration.

*<u>Challenge, peace, wonder, and growth from nature</u>

Summary: Oregon Caves' mix of huge tree and dark caves gives us the depth of awe, discovery, and mystery. The Monuments mix is a spiritual echo from our dim past and the hidden crevices of our modern minds. The Monument guides us away from our fixation on human-made things, an addiction divorced from nature. ORCA brings us down-to-earth again and reconnects us to our source, to what we never left. It gives us something easily lost after childhood, wonder.

Examples: Growing up and living in a city surrounded by human-made thing can cause us to identify creation and spirituality with human beings, an anthropic attitude that can lead to domination and control over nature. Close contact with natural beauty can do the reverse. Experiences of being near the source of our being can give us the passion to defend the natural world. Lovers always have energy and imagination. When you have energy and imagination you come up with ways to defend your beloved.

"Americans are still deeply touched by the sacredness in nature. The beauty of a place like Yosemite awakens something in our gut and in our heart. We are awed, and we fell small in the face of it. It's a great mystery. When we experience grief, we can go to the woods, to the ocean, or to the mountains for spiritual guidance. If we give of ourselves there, we remember that we are not alone" (Fox, 1994:199).

CONCEPT: Parks can help us reach valuable emotional/mental states.

Slide Presentation: **Does Nature Have Rights?**: The expansion of human rights to other species. **Source**: Computer Filename is RIGHTS - Slide program text entitled Does Nature Have Rights?
Example: "There was an inherent spirit to caves whether they were natural or manmade and that spirit had to be approached with respect. Crawling was the only way of showing that respect." - Carlos Castaneda in The Teachings of Don Juan.

Learning humility by contacts with the natural world can help us to live in harmony with it. Humans can redevelop the humility to obey nature's laws, instead of imposing man-made ideas on nature. The small numbers on a cave tour or caving trip makes us humble again, as in the Pleistocene when all of humanity was small in number. Nature has a way of reminding us that we are not in control, that we are not really on top, that we're going to feel pain, kill, and be killed, just like everything else.

Example: Challenge can involve hiking, climbing, caving, walking ta 1/2 miles of cave trails or 5 miles of surface trails or overcoming one's fears of bats or caves. On the other hand, industrial tourism, like Disney World or Coney Island, tend to provide more entertainment and less change, mystery, challenge than do National Parks. Tourism processing can be an impediment to the intensity of experience, diverting us from coming at the experience in our own way and at our own pace. The margin of error permitted is great enough to neutralize the importance of what we know. We need not notice a small spring or a cave rock overhang because we are not at the margin where water or safety counts.

The Park Service certainly does not label such industrial tourism as evil or even unhealthy, but suggests that parks do provide an alternative, an increase in diversity. Chosen carefully and sometimes with help from Park staff, challenges in Parks can be of just the right level to give us feelings of independence, provocation, self-reliance, self-restraint and self-actualization- of being in control and having the freedom to choose. Parks can provide experiences that create a flow in which action and awareness merge, a state in between

pervading uncertainty (anomie) and pervading certainty (alienation - where ones abilities are greater than ones responsibilities). For outcome certainty reduces challenge to drudgery and novelty to necessity. And the experience that requires little yields little.
Parks offer and tend to converge both physical and mental stimulation.

Example: Scarcity: Without some conflict and hardship, Americans can become lazy and rude, taking all for granted. To prevent this, a Cahuilla demon put tannin into acorns and drove away game animals in south California. Scarcity makes sacrifice meaningful. Nature teaches humans to sacrifice themselves and their possessions for their children and for the greater communal good. Scarcity increases empathy with the rest of creation now in agony from a mass extinction. Through various offerings, people transcend themselves and experience the original meaning of sacrifice, "to make sacred."

Example: Continuity and **connectiveness** includes values of immortality (being a part of something bigger than you are, leaving your non-destructive mark on the land and all you love, sharing with your children, photography), heritage (preserved for all future generations), cycles of nature, and identity. This can range from associating cave formations with more familiar objects to finding oneself. The major benefit of the study of history is the identify it gives us and the condition of the land as it was when we came to it is the best possible measure of our history. Parks give us the quality and amount of change, as in a cycle, that produces continuity for without change we have stagnation.
Participation in nature expands and deepens our identity and sense of belonging. Nature gives coherence, a sense of continuity and relatedness. We don't come into this world; we come out of it much as flowers unfold. The vine "grapes" and Earth "peoples."

Closely related to connectiveness is perspective, something that both mountains and caves give us. "Climb the mountains to see the lowlands." - Chinese saying.

Example: Pride: One of the best ways to find what people take pride in is to find what they preserve. And the person who may most acutely take pride in the symbols of his country's past is the person who can place them in the widest comparative perspective, something the Park Service help one to do. It is not an ambitious pride concerned with outward accomplishment but a pride of knowing and belonging linked to humility.

Creativity: Evolution shows us a creative path devoid of ego. People who seek out wilderness in the US may be more
creative than the general population. (Ward, 1977:212). Events of wildness in turn may help some people to at least briefly give up the need to control the environment and humans. This in turn can lead to greater creativity and openness.

Mystery and surprise keep us alert and awake. This is in part because ecosystems provide emergent functions that cannot be predicted by analyzing the parts of an ecosystem. Understanding by any means (science, music, wonder, all that increases awareness), as opposed to a mere increase in knowledge or facts, deepens our awareness of the mystery around us because the more we know the more we realize how little we know. We release about seven billion tons of carbon dioxide each year. Three tons go into the air, two in the ocean and the rest is mostly unaccounted for. Where does it go (some say into tropical grasses). For every question answered, a dozen more are raised. For when you know all the answers you haven't asked all the questions. Einstein said that "The greatest experience we can have is that of the mysterious." The greatest mysteries here are bats and caves; they are major, worldwide symbols for the mysterious. The word "nature" comes from the Latin "to be born," "which is fundamental enough, and puts it under the heading of abiding mystery." -- John Hay in David Halpern, ed., <u>On Nature</u>, 1986

Eisley - "It is the winter of the heedless ones. We had lost our way but we had kept, some of us, the memory of the perfect circle of compassion from life to death and back again to life, the completion of the rainbow of existence."

<u>Freedom</u> - In our encounters with the land, we find freedom. Each of us is enlarged by finding something larger than we are. Something that lasts longer than we do. We find ourselves in the land in a way that we can't find ourselves in a crowd of strangers.

Nature shows us the way. Evolution and migration are not tightly controlled and directed systems; many changes are fortuitous. For example, efficient jaws in mammals appears to be a sidproduct of better hearing. Only one primate made it through the end of the Cretaceous when all the last dinosaurs died out. Otherwise we wouldn't be here. How plants succession unfolds can depend on who got there first.

"The aim should be to obtain the maximum of well-being with the minimum of consumption. The cultivation and expansion of needs is the antithesis of wisdom. It is also the antithesis of freedom and peace - E. F. Schumacher in <u>Small is Beautiful</u>, 1973

<u>Peace</u> and <u>Silence</u>: "Climb the mountains and get their good tidings. Nature's peace will flow into you as sunshine flows into trees. The winds will blow their own freshness into you, and the storms their energy, while cares will drop off like summer leaves." - John Muir

<u>Humor</u>: The humor of trees is a droll, ironic, playful spirit that plays upon our combination of intimacy with trees and estrangement from them. The surprise and paradox of nature birth amusement. Nature pulls us out of our armored scars by uplifting us with laughter, for even mighty animals have their problems. How strong a bear is except if faced with a skunk. Nature helps keep human cultures sane. Surprised by paradox and unable to follow natural "logic," human emotions discharge into laughter instead of violence. Humor gets frontal lobes and the left hemisphere to work together. Mirth at nature's shapes, antics, and mimicry, all enhanced by mystery, help diffuse tensions and unite communities. In laughing at nature, people laugh at themselves. Making fun of life uplifts humans beyond pride.

Nature teaches people not to take themselves too seriously and not to be unduly tied to the past or concerned about the future. It shows that the world rarely meets human expectations but this need not result in sorrow, a withdrawing into oneself. Instead, life can become a laughing surprise, a feasting on the fullness of its weirdness. Illness-causing worries in one's stomach are then set free. This lowers epinephrine levels, blood pressure, and stress hormones. Pun activity in the right hemisphere suggests that humor can help balance right/left hemipheric disparities by increasing activity in the right hemisphere during depressions. Nature between absurdity and seriousness adds a degree of uncertainty to mundane lives. Its humor keeps humans out of the routine ruts of habit.

<u>Truthfulness</u> - Nature "can refuse to speak but she cannot give a wrong answer." -- Charles B. Huggins, <u>National Observer</u>, 21 November 1966

<u>Growth</u> and <u>Maturity</u>: See CONCEPT: Animals Help Us Grow UP

Lab exercise: Describe situations that evoked the followed responses in a area similar to the surface or subsurface of Oregon Caves. These include appreciation, awe, challenge, compassion, connectiveness, creativity, discovery, engrossment, freedom, gratitude, humility, humor, mystery, peace, pride, respect, reverence, silence, surprise, and wonder. Can you add others? **Source**: Computer Filename is PK-VALUE - Text for slide program on park values **Source**: Computer Filename is N-**<u>VALUE</u>** - Interpretive text on park values.

Lab Exercise: I'm a cave animal
Objective: Using the park visit, imagination, and language skills, each child will write a story from the standpoint of a living thing in the cave.

Background: This activity capitalizes on one of the most powerful learning tools available: imagination. By contemplating the life of another creature, students will be heighten their understanding of that creature, while honing their language skills.

Procedure: Discuss the park visit with the class. What do the children remember most clearly? Do they have favorite memories? Ask the children to think about the cave animal that they'd most like to be. Have each student write a story as if s/he were that being, describing his/her life.

Extension: Have each child illustrate his/her story and display these along with the stories, on a class bulletin board.

Lab Exercise: = Team Poetry
Objective: The students will work together in teams to create poems about the cave.

Background: The writing of simple poems is a good way to encourage students to reflect on and contemplate their new experiences. This activity brings several people together to share their reflections and thoughts in the writing of a poem.

Materials: A long, thin piece of paper (construction works well) that can be easily folded. 5" x 18" is a good size. Pencils.

Procedure: Find a quiet place to sit down. Divide the class into groups of six. (If your class isn't divisible by six, groups of seven will work well too.) Have each group sit together in a small circle. Explain that each group will be working together to write a poem. Choose someone to be the first contributor in each group, and give that person a sheet of paper. Either discuss a poem topic with the entire class, or have each group decide on a topic for itself. The topic should be related to the cave. It's especially valuable to choose a subject that everyone can see from where they are sitting, such as a nearby tree, rock, creek, or some other natural feature. After the topics are chosen, have the first person in each group write an adjective about the subject at the top of the paper strip. He/she then folds the paper over the word and passes it to the next person, who writes his/her line, folds the paper and passes it on. Following this pattern, use the format below to complete the poem. After the last line is written, have someone in each group read the poem aloud. Try several poems, starting with someone different each time so that people have a chance to contribute different lines to the poem.

Line 1 one word that describes the subject (adjective)
Line 2 another word that describes the subject (adjective)
Line 3 a word that describes something the subject is doing
Line 4 simple sentence or phrase an what the subject is doing
Line 5 verb
Line 6 a question you'd like to ask the subject
If you have groups of seven instead of six, add another adjective after the first two lines. Or create your own modification!

Lab Exercise: = Cave Poem
Objective: Students use a simple poem format called cinquain to express feelings about any aspect of their cave visit.

Background: The word ■cinquain• comes from the French word for five, cinque. This five-lined poem format is an easy way for students to express their experiences in a new way.

Materials: Pencils and the accompanying handout or plain paper. A hard surface to write on such a clipboard or piece of heavy cardboard.

Procedure: Have each student write a cinquain poem according to the following format. Explain that anyone can write a cinquian poem, as long as enough time is given to thinking and contemplating the subject. Just follow the formula!

Line 1: One word to name the subject
Line 2: Two words to describe it
Line 3: Three words of action about it

Line 4: Four-word phrase about it
Line 5: One word that names the subject in a new way.

Here is an example of cinquain.
Tree
Tall plant
Growing, reaching higher
Branches touching the clouds
Giant.

After the students finish, their cinquains can become part of their books, or can become part of a class bulletin board that illustrates their trip.

Demonstration: **<u>Clash of Cultures</u>**: Relations between Indian and Whites around the turn of the century. Points of contact are followed on a map. 20 minutes.

Lab Exercise: Sharing the Joy of Song
Objective: Students will discuss thoughts and feelings about the environment in music and express their personal ideas and feelings by creating their own songs/poems.

Subjects: Music, language arts

Skills: singing; discussion; sharing; artistic; interpretation; creative writing

Materials: Music, songs and poems about nature; musical instruments; paper and pencils

Background: Art reflects the artist. It may also influence the one who sees, hears, or feels the work of art. Social attitudes toward environmental issue are affected by the communications media, including the classical and popular arts. Historical and contemporary artists have expressed their views about issues, including environmental ones, and have influenced others in the process. Nineteenth century naturalists like Henry David Thoreau and John Muir influenced their generation through their teachings and writings and their influence continues today. Modern day songwriters and musicians express their viewpoints and feelings through the music they write and perform.

Procedure: Describe the ways in which music and other art forms influence peoples' attitudes toward the environment. Share examples of nature and environmental music with the class (some can be obtained from Oregon Caves or you may want to share your personal favorites). Look for ones with positive, hopeful messages as well as those with a "call to action". Discuss the lyrics and/or style. After spending time learning about Oregon Caves, have the students think about what they have experienced and how they feel about these areas. Then instruct the students to write down their ideas and feelings (if they kept a trip journal they may want to refer to it). Using these thoughts and feelings, have the children make up their own songs or verses. They could be about a specific place, animal, experience, or issue. Use an existing tune and put; new words to it or make up a new tune. Videotape and share the songs with others.

Extension: Use the written works of writers like Muir, Joaquin Miller, Thoreau, Aldo Leopold, and Sigurd Olson to encourage students to write personal stories or poetry about Oregon Caves. Illustrate with their own drawings or artwork.

TEACHER'S GUIDE FOR CAVES

Table of Contents

Lesson Plan #1 - Cave Trail.................................

Lesson Plan #2 - Cave Formations............................

Lesson Plan #3 - Bats.......................................

Appendix A - Cave Formations................................

Appendix B - Bat Biographies................................

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #1 - Cave Trail

Introduction: The National Park Service is directed by the United States Congress to provide for recreational uses of the lands it administers and at the same time to leave those lands "unimpaired." The Federal Caves Resource Protection Act directs the United States Forest Service and the Bureau of Land Mangement to protect caves as well. The amount of money that all these federal agencies have to carry out these directions is limited and must be carefully handled to maximize and balance the goals of recreation and protection. Privately-run caves also must protect cave resource as damage could reduce the number of people willing to pay to see a cave. Consequently, this game is applicable, with some modifications, most commercialized caves.

The following game attempts both to build a new trail in a cave and to protect its rare species. The goal of the game is to allow access to the cave to the public for as long as possible without causing the extinction of an insect species or the extirpation of a bat species in the cave. Extinction occurs when the insect is no longer found anywhere. Extirpation occurs when a certain bat or other species is no longer found in the cave. The game is over when either extinction or extirpation is inevitable or when conditions close the trail. The game is similar to a real life situation in caves, especially those managed by federal agencies. Giving certain points to some of the factors involved in deciding how to build and maintain a trail often is based on educated guesses, as is often the case in real life. Unforeseen situations occur and can be only partly prepared for.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #1 - Cave Trail

<u>Participants</u>: Pre- and post-site: 25-30 students from seventh graders up to seniors in high school. Field Trip: 50-60 students from seventh graders up to seniors in high school.

<u>Objectives</u>: Students will be able to list five ways that impacts from development of a tour route can be lessened.

<u>Time</u>: three hours for field trip, and twenty minutes for post-site classroom activities. Time to other sites or from other schools vary.

<u>Materials</u>: Maps of the cave tour route.

<u>Major Points</u>: Total Length of trail is 3,000 feet.

Cost of cement trail is $100 per foot.

Cost of fiberglass grate trail is $200 per foot.

Cost of cave gate that allows bat access is $10,000.

Total number of light bulbs in the cave is 500.

Cost of incandescent light bulbs is $1 per bulb.

Cost of compact fluorescents is $10 per bulb.

Cost of electricity using incandescents (the current system) is $10,000/year

Cost of electricity using compact fluorescents or "E bulbs" (radio-powered) is $5,000/year

Cost of removing organics is $5,000 per pound per year

Cost of fire truck is $20,000

Annual Park Budget: $40,000

Humans deposit one pound of lint, hair and skin flakes per year. The present temporary trail deposits two pounds of sap, fungi, and bacteria per year. All of these things are organics that affect a rare millipede that is known only from Oregon Caves.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #1 - Cave Trail

Every time a Park Service worker goes off the trail to change a light bulb, he or she deposits 1/10 of an ounce of organic material in the cave. If all incandescent light bulbs are used, a hundred incandescent light bulbs have to be replaced every year. If all compact fluorescents or E bulbs are used, ten light bulbs have to be replaced every year. At least five lights have to be replaced each year or the cave must be closed.

The present bat population is 800. The main cave gate does not allow bats to easily enter the cave. It reduces the bat population by 100 per year. When there are only 100 bats, extinction is inevitable. This could occur for several reasons. For example, with such a low population, bats have trouble finding each other and mating. Also, the body heat of a small group of bats cannot raise the temperature of their nurseries high enough to raise young. Inbreeding at low populations can cause an increase in genetic defects and some of the bats born at this time can become sterile.

When the human-caused material reaches ten pounds, extinction of the millipede is inevitable, assuming this insect is not found elsewhere. The added organic material attract non-cave insects that outcompete and drive out the native millipede.

Each roll of two dice constitutes a year. Before each dice roll, the team decides how the money will be spent that year. The possible rolls are:

2 - Visitor gets sick by seeing through a grated trail. She vomits two pounds of organics onto the trail. This action occurs only if more than 50% of the trail is grated.

3 - Flood washes out all organics and destroys 1,000 feet of trail. The trail must be repaired before the next dice roll or the cave is closed.

4 - The Federal Government, in order to reduce the federal deficit, eliminates the park budget for the next dice roll.

5 - A dying millionaire patriot wills $80,000 to management at the Caves. The money can be spent before the next roll.

6 - A visitor falls on the cement trail and sues the park, claiming that a grated trail would have been safer. With the help of a good lawyer, she wins her case and $80,000 is taken out of the park budget. For the next two dice rolls (2 years) the resources management budget is zero. This action occurs only if more than 50% of the trail is cement.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #1 - Cave Trail

7 - A visitor falls on the dirt trail and sues the park, claiming that a grated or cement trail would have been safer. With the help of a smart lawyer, she wins her case and $80,000 is taken out of the park resources management budget. For the next two dice rolls (2 years) the resources management budget is zero. This action occurs only if more than 50% of the trail is dirt, the original condition of the trail at the time the game begins.

8 - A clumsy maintenance worker breaks all compact fluorescents in the cave. They have to be replaced before the next roll.

9 - A new park manager insists that all the compact fluorescents be replaced with incandescent bulbs. This occurs for three years until the manager leaves. A new cave is discovered in the Monument with the millipede in abundance.

10 - A man slips where there is a bulb that was not replaced. He sues the Park Service, and the Monument's budget for the next year goes to paying off the claim.

11 - Poor trail conditions (more than 50% dirt) reduces visitation to the park. The park budget is reduced to $20,000 per year until a trail of cement and/or grate is in place.

12 - Unless a fire truck is present, a fire burns above the cave. It takes $40,000 to clean up the mess.

Pre-site Activities: A series of games is played until the length of the game no longer increases. Two groups of students can compete against each other, with one or two members from each group makings sure that each change after and before each roll of the dice is noted on the blackboard where bar graphs can be filled in or deleted until a limit is reached.

Discuss safety and logistics of field trip.

Post-site Activities: After a visit to a cave, students will discuss some of the mistakes in allocating resources.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #2 - Cave Formations

Introduction: Cave formations known as **speleothems** form from various mineral salts deposited by dripping or flowing water or water films. **Speleogens** are features carved or dissolved on speleothems or the wallrock of a cave. They are spaces in which something has been removed as well as what is remaining. The cave itself is one large speleogen. Most of the speleothems and speleogens mentioned in Appendix C are found in many caves in the U.S. and Canada. Except for the **clay worms** and **conulites**, the speleothems are **limestone**, a sedimentary rock. Most of the speleogens are either formed on limestone or **marble**, a metamorphic rock. Rocks are divided into three main groups.

Sedimentary rocks form at temperatures normally found at the surface of the earth. If they precipitate out of water, they are known as **chemical sedimentary** rock. Most of the limestone cave formations are examples. If sedimentary rock is composed of pre-existing rock fragments, they can be called **fragmental rock**.

Igneous rocks form from molten rock. If this material cools, hardens, and crystallizes beneath the ground, it is called **plutonic** rock. Granite is an example. If the molten mass reaches the surface it often becomes lava that cools into a **volcanic** rock. Basalt is an example of a volcanic rock.

Metamorphic rock forms under conditions between that of sedimentary and igneous rocks. Heat and pressure alter the rocks without melting them. If molten material is nearby it can "fry" the surrounding rock and create **contact metamorphic** rock. If there is a large region of rock under heat and pressure, **regional metamorphic** rock results.

Participants: Pre- and post-site: 25-30 students from seventh graders up to seniors in high school. Field Trip: 50-60 students from seventh graders up to seniors in high school (two classes).

Objectives: Students will become familiar with the world's three major rock type and the six subdivisions of these types. Students will explore the processes through which cave formations are deposited (speleothems) or dissolved out (speleogens) in caves.

Time: One hour tour to talk about the various ways water precipitates cave formations. Half an hour to return to school.

Materials: Two one-quart glass jars; soft yarn, 24" long; hot plate; 8 oz. powdered alum; water; 2 small rocks

<u>Major Points</u>: The salt-icicle forming on the loop is called a "stalactite." The salt-icicle forming on the surface and rising is called a "stalagmite." If they come together they are called a column. Think of a stalactite holding "tight" to the ceiling to remember the difference in terms.

Soda straws are "baby" stalactites found in caves. Inventories of broken formations near the tour route in many caves show that the average regrowth of actively growing soda straws is about one inch per 1,000 years. Most formations do not seem to have grown since they were broken about a hundred years ago. The longest regrowths are about half an inch, suggesting that the fastest rate is about one inch every two hundred years. Most soda straws grow far slower than this.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #2 - Cave Formations

<u>Pre-site Activities</u>: Heat water and fill the two glass jars. Stir the powdered alum into both jars. At each end of the yarn tie one rock. Place one rock in each of the jars. Form a loose yarn loop between the jars so that the middle of the yarn hangs slightly lower than the rims of the jars. Then place the apparatus in a corner, on a washable surface, where it can be watched. After several days, a small salt-icicle will begin to form on the bottom of the loop of yarn. As the salt water drops on the surface from the loop, a small stalagmite will begin to rise from the surface.

Students will come up with different shapes caused by the various ways water deposits or dissolves out spaces in a cave.

Discuss safety and logistics of field trip.

Use the drawings and text in **Appendix C** (Cave Formations) to become familiar with the shapes and origins of the various speleothems and speleogens.

<u>Field-Trip Activities</u>: The following checklists will use the letters a, r and c to record whether a type of cave formation or speleogen is (a)bsent, (r)are, or (c)ommon in a particular room. Students in groups of three will record this information on one of the checklists. Assignments will help make sure that both the speleogen and speleothem checklists have equal coverage.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #2 - Cave Formations

The cold draft at the entranceof many caves in summer shows that they act as a giant chimney. During summer, cool, dense cave air sinks and flows out the entrance. But during winter, the cave is warmer than outside air. Then, warm air rises out of the exits and draws freezing air into the entrance.

PETRIFIED GARDENS: Cave decoration forms more rapidly when there is a large entrance. Then, carbon dioxide in cave water can seep out into the cave air. This reduces the **carbonic acid** and so forms calcite crystals, as in **dripstone**, a **chemical sedimentary rock**. Dripping water can form a **stalactite** ("c" for ceiling) and a stalagmite ("g" for ground). Flowing water forms **draperies** and smooth **flowstone**. All these formations are easily damaged by touching.

Bevels (Imagination Room)**, pendants, potholes, rills, and scallops** mostly occur in the lower sections of the cave near the main entrance because this is where stream action and flooding has dissolved or eroded out these features. The rills are parallel groves while pendants are sharp pointed rocks hanging down from the ceiling or walls. Both are on the right side of the trail from the bridge. Both formed by rapid stream erosion.

PASSAGEWAY OF THE WHALE: The odd shape of this passage may result from gravels over the floor that preventing the floor from being dissolved. So the passage dissolved upward instead of downward. Flowstone has cemented some of the gravel, resulting in a conglomerate, a **fragmental rock** similar to concrete.

CONNECTING TUNNEL: Once clays, this black rock has been metamorphosed into **argillite**, a dark brown **regional metamorphic rock.** Like toothpaste, it flowed along tilted rock layers.

IMAGINATION ROOM: **Cave ghosts** are white, rounded masses on the ceiling. They are the remains of formations, mostly stalactites, that have been partly dissolved away by acidic dew. **Cave ghosts** and the **boxwork** found in the Wedding Cake Room occur in the upper parts of the cave because warm air rises and condenses on the cold ceilings. It is two degrees Fahrenheit warmer at the bottom of Oregon Caves than it is at the top of the cave. The warm air brings up from the bottom of the cave so much carbon dioxide that dew dissolves enough of this gas to form carbonic acid to eat away calcite.

DRY ROOM: **Scallops** are cusp-shaped depressions on the ceiling that formed when acidic water flowed down between the rock layers and dissolved out this room.

BEEHIVE ROOM: Fungi in the soft, white Mondmilch may help form microscopic crystals of calcite and prevent it from crystallizing into rock. The name Mondmilch once meant "little earth man," because farmers cured livestock wounds with it, believing it came from magical gnomes. Indeed, some Mondmilch contains the same antibiotics used to cure people.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #2 - Cave Formations

---

110 EXIT: **Moonmilk**, and **cave popcorn**, a type of **coralloid,** tend to form near entrances as evaporation is greatest in such areas. Based on this information, the gate has been modified to restore the natural airflow in the cave.

NIAGARA FALLS: An 1884 geology class signed their names here. Within the last hundred years, a very thin, translucent layer of flowstone has formed over the signatures.

Bumpy cave popcorn occurs only on the right side of the stalagmite above Niagara Falls. Winter airflow evaporates water from the right side and leaves behind calcite. The reverse also occurs. Heat from friction and radioactive decay deep inside the earth warms up the bottom part of the cave. Warm air flows up from the cave's bottom, condenses water on the higher, colder formations and thus dissolves the calcite, leaving various layers exposed like the layers of an onion.

NEPTUNE'S GROTTO: **Stalactites**, **shelfstone**, and **flowstone** are more common in the upper part of the cave because that part of the cave is older and therefore has had more time for formations to grow in it. **Stalactites** may be more common than **stalagmites** because of pools, trail construction, or washed-out clays and gravels may have prevented or destroyed **stalagmites**. Slow drips also would favor **stalactites** over **stalagmites**. The one major **shelfstone** area (Neptune's grotto) along the tour route occurs near a **dome-pit**, a source of abundant water for creating cave pools. **Dome-Pit**s, also found in Paradise Lost, may occur where the non-marble, "baked" mudstones on the surface of the ground meets the marble.

MILLER'S CHAPEL: A water droplet adds a ring of calcite to a soda straw. If the central hole is plugged up, water oozes to the outside and the soda straw grows into a wide stalactite.
On the way to the Ghost Room, parallel ridges of **rimstone** can be seen down to the left. **Rimstone** forms where there is or was slow water flow.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #2 - Cave Formations

GHOST ROOM: The vertical ledge across the room is a quartz diorite dike, a **plutonic rock**. When molten, it cracked surrounding rocks as it rose up and squeezed into the cracks. Fragments of **volcanic rock** were carried into the cracks like raisins in a pudding. The molten rock recrystallized the surrounding marble to form **contact metamorphic rock.**

The brown squiggles on the ceiling of the Ghost Room platform are called clay worms. Films of water once kept the clay particles apart but, upon drying, particles were attracted to each other by electric charges. **Clay worms**, also found in the Ghost Room, tend to occur under the baked mudstones (argillites), the source of the clay.

PARADISE LOST: Volcanic ash has been found in water-deposited clays above the stairs. Wind blows ash from Cascade volcanoes mostly to the east during the present time but, during the last Ice Age, winds blew off Canadian glaciers in a southwest direction and so may have carried volcanic ash from the Cascades to southwestern Oregon.

The dome pit probably formed when a waterfall cascaded down and ate away the surrounding rock.

The stalagmites here are flat topped because the water droplets fall a long way and splatter calcite all around.

WEDDING CAKE ROOM: The side passages apparently have been offset from each other by a fault that cuts the room in two. The fault probably formed as the molten rock continued to push its way up, pushing the overlying rock aside. The movement of the fault shattered the surrounding rock. Large crystals of calcite filled in the cracks. Since they dissolved more slowly than the smaller crystals of the surrounding marble, they now stick out as small ridges.

EXIT TUNNEL: Construction rubble piled into side passages made much of the cave look like this tunnel. To restore the cave to a more natural state, the Park Service has removed over 1,000 tons of rubble in the last few years. This was the last area near the trail that was restored by park staff. Now volunteers do most of the restoration in areas not visible from the trail.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #2 - Cave Formations

The breakdown of "fool's gold" (pyrite) forms rust stains and a small amount of sulfuric acid that dissolves marble. The effect is minor here but caves like Carlsbad Cavern may largely result from sulfuric acid.

Movement along a fault has fractured rock, leaving a **fragmental rock** called a fault breccia on the ceiling.

DEVELOPED AREAS: In the main parking lot, the contact between white marble and the surrounding metamorphosed shales, mostly brownish argillites, can be seen. Some greenish serpentine rock occurs as thin sheets intruded into the argillite layers.

Marble layers with thin chert lenses are exposed on the walk along the road towards the cave. Some of the chert layers have been deformed so much that the tops of the folds have been torn off and tilted in a second period of folding.

SURFACE TRAILS: The winding Cliff Nature Trail is mostly underlain by marble. Trees are fewer and smaller here compared to wetter areas underlain by argillites. Little soil forms when marble dissolves. Soil as well as water move down into the caves, so that even less soil is left to hold moisture at the surface.

Most of the rock types in the Monument occur along the 3 1/2 mile Big Tree Trail. The northern end extends through marble which is intruded by sheets of volcanic rock and bordered by argillites with erosion-resistant chert lenses that stand in bold relief. The highest part of the trail is underlain by dark, altered basaltic volcanic rock called **greenstone**. A connection to the Boundary Trail leads south to fairly barren, open areas underlain by serpentine rock and quartz diorite. Tiny garnets occur in a contact metamorphic rock in the first large meadow on the way back to the cave.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #2 - Cave Formations

<u>Post-site Activities</u>: The entire class will combine results and discuss reasons for the differences in abundance of various cave formations. Factors to be considered include depth of the cave room from the surface, nearness to entrances, the age of cave passages, and the overlying rock layers. The second half of the cave (Niagara Falls to Exit) is older, formed largely underwater, and has **argillite** (non-marble, "baked" mudstones) between it and the ground's surface. The first half of the cave (Entrance to 110 Exit) is younger, formed in part by cave streams, and has marble between it and the surface.

<u>SPELEOTHEMS</u>: **Coralloids** and **moonmilk** tend to form near entrances as evaporation is greatest there. **Stalactites**, **shelfstone**, and **flowstone** are more common in the upper part of the cave because that part of the cave is older and therefore has had more time for formations to grow in it. **Stalactites** may be more common than **stalagmites** because of pools, trail construction, or washed-out clays and gravels may have prevented the growth of **stalagmites** or destroyed them once they had grown. Slow drips also would favor **stalactites** over **stalagmites**. The one major **shelfstone** area (Neptune's grotto) along the tour route occurs near a **dome-pit**, a source of abundant water for creating cave pools. **Clay worms** (Ghost Room, Miller's Chapel) tend to occur under the baked mudstones, the source of the clay. **Rimstone** (Rimstone Room) forms where there is or was slow water flow.

<u>SPELEOGENS</u>: **Bevels, pendants, potholes, rills, and scallops** mostly occur in the lower sections of the cave near the main entrance because this is where stream action and flooding has dissolved or eroded out these features. **Dome-Pit**s may occur where the non-marble, "baked" mudstones on the surface of the ground meets the marble. **Boxwork** and **cave ghosts** occur in the upper parts of the cave (Beehive Room, Wedding Cake Room) because warm air rises and condenses dew on the cold ceilings. It is two degrees Fahrenheit warmer at the bottom of Oregon Caves than it is at the top of the cave. The warm air brings up from the bottom of the cave so much carbon dioxide that the dew dissolves enough of this gas to form carbonic acid to eat away calcite.

Have students list ways that the formations in Oregon Caves could be affected by human activities. These changes include vandalism, changes in airflow from tunnels, changes in carbon dioxide in the outside air from the burning of fossil fuels and trees, sulfuric acid caused by the rusting of pyrite from tunnels, and solution of formations from algae and lint.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #3 - Bats

Introduction: Bats are useful to humans and care should be taken to protect and preserve natural populations of bats.

Participants: Pre- and post-site: 25-30 students from seventh graders up to seniors in high school. Field Trip: 50-60 students from seventh graders up to seniors in high school (two classes).

Objectives: 75% of all students will present a bat gate design that takes into account at least two characteristics of bats. Based on information supplied in this teacher's guide and on the guided tour of the cave, 75% of all students will list at least three actual or potential uses of bats by people.

Time: Two 50 minute classroom sessions. The material is read in the first session and a bat gate designed. The second session deals with determining possible uses of bats. Time to other sites or from other schools vary.

Materials: No materials needed

Major Points:**Bats:** In order of abundance in Oregon Caves are **Long-eared Myotis (**Myotis evotis), Yuma Myotis (M. yumanensis), Long-legged Myotis (M. volans), Fringed Myotis (M.

TEACHER'S GUIDE FOR CAVES

LESSON PLAN #3 - Bats

thysanodes), Townsend's Big-eared Bat (Plecotus townsendii), California Myotis (M. californicus), Little Brown Myotis (M. lucifugus), and Big Brown Bat Eptesicus fuscus, the latter not usually known as a cave dweller. Five of eight population size estimates in 1988 range from 785 to 873 (Cross, 1989). Townsend's Big-Eared Bat is the bat most commonly seen in the Cave.

About 80% of the Oregon Caves population are males who may be "waiting" for females who arrive during fall.

The bats are quite loyal to the cave, with many of the bats marked in 1976 being recaptured in 1977. Further, nine bats banded in 1958 were recaptured between 1976 and 1980 establishing longevity records for three species as follows:

Myotis thysanodes ......18 years

Myotis evotis...........21 years

Myotis volans...........22 years

Maximum bat use of Oregon Caves usually sharply peaks in late summer and/or early fall, usually during the first part of September. This period of concentrated cave usage, known as "autumn swarming," is associated with breeding activities. The period of maximum use of the cave may depend primarily on changes in local abundance and the breeding condition of the bats, but it may also be greatly influenced by local and cave conditions such as temperature, humidity, barometric pressure and air flow. As the summer progresses, the peak of bat activity shifts to earlier in the night. (Cross, 1989).

Age: For their size, bats are very long lived. This may be due to a slowing of cell aging during hibernation. The hearts of most mammals beat about 100 million times during their lifetimes; bats and humans are exceptions. In people, this may be the result of delayed maturity compared to other primates. For example, the face of an adult person looks much more similar to the face of a baby chimpanzee than to an adult chimpanzee. In bats, their longevity may be due to hibernation. By studying how bats retard the aging process, human may be able to apply what they learn to increasing human longevity.

Birth: Breech births are common, perhaps to minimize the chances of the young becoming tangled in the birth canal. The thumbs and hind feet of baby bats are almost adult in size, permitting the young to cling to their mothers (Fenton, 1985). Unlike most mammalian births, a bat starts to grope with its feet and hind legs as soon as they are freed from the birth canal, thus allowing quick attachment to the mother. If the baby does fall, the birth cords acts as a safety line in some species.

Blood: Bats can control the amount of blood in the wings. Some bats have 50% more red blood cells in their blood compared to non-flying mammals or birds. This helps supply more oxygen, especially during flight when so much oxygen is needed by the bat's muscles. By studying how bat produce so many red blood cells, anemic humans may be helped. People with low numbers of red blood cell often fell tired and worn out.

Bones: The scapula (shoulder blade) is roughly rectangular and ribs are broad for attachment of large flight muscles. Vertebrae (backbones) have been fused together to keep the body rigid and facilitate flight. Unlike birds, which have hollow bones, bats light in weight because they have very thin bones. The skull of many bats appears to be almost paper thin.

Echolocation: A means of orientation in which animals utter high-pitched pulses of sound, and detect the presence of objects by the echoes produced. Bat echolocation is, ounce per ounce, watt per watt, a billion times more sensitive than radar. It may have evolved out of communication between mothers and their infants.

During an initial food search, many bats use a single frequency signal spaced at fairly wide intervals, similar to an AM radio. Certain bones called stapes in the inner ear pull away from the eardrum at the instant the bat emits its signal, thus preventing damage to the ear from such a loud signal. Although this signal saves on energy, it gives the bat very little information. Such a signal may simply tell the bat if an insect is somewhere ahead of it. If an insect is detected, the bat sounds off with a broad range of frequencies, similar to an FM radio. This takes more energy than the single frequencies but it gives better information as to where the insect is. Changes in frequency of this signal allows better reflection of the sound signal off the insect when the wavelength of the sound wave approaches the size of the insect. This echo helps the bat locate the insect more accurately. The bat now increases the rate of signals in order to get more information and, based on the doppler effect, may find out in what direction and how fast the insect is flying. Actual capture is based on where the bat thinks the insect will be at the precise moment of attempted capture. The Doppler shift is the change in sound waves when reflected from a moving object. Bats can sometimes figure out how fast an insect is moving from the Doppler shift data it gets through echolocation. For example, a train whistle sounds like it is at a higher frequency as the train comes towards a person compared to when the train is leaving in the opposite direction.

An even more complicated signaling system occurs when certain bats leave a cave. Then they employ multiple harmonics, frequencies that are even fractions of the original frequency, vibrating their vocal chords in much the same way that a rope can be vibrated at different whole number intervals of the initial wavelength.

The discovery that bats used echolocation, much the same as sonar used in submarines, was quite a shock to many scientists. One scientist in 1940 shook a bat researcher, saying, that he could not possibly mean such an outrageous suggestion. As part of the war effort, sonar at that time was still classified research.

Evolution: About one out of every four or five mammal species is a bat. Most insect-eating bats are thought to have arisen from small arboreal **insectivores** that may have possessed gliding membranes. Insectivores are a group of primitive insect eating mammals that include shrews.

The most primitive bat is Icaronycterus. It lived 50 million years ago. This bat shows many primitive characteristics. It has no elbow lock; the radius/ulna is not fused; there is a second digit claw; there is less fusion of bones to the hip bone compared to modern bats. The fusion of bones was apparently necessary to withstand the stresses of flying.

Feeding: Several species of tiger moths and lacewing insects can hear bat echolocation and thus take actions to avoid being eaten. Some moths even have the ability to confuse the bat by making its own high frequency sounds. Some moths may have evolved "hairs" that dampen the return echo, thus making it harder for the bat to find the moth. Insects in tropical countries tend to be more sensitive to high frequencies than those living in temperate areas. This may be because there has been more pressure on insects in the tropics to evade bats trying to eat them. Because mites on moths can destroy hearing, the mites often live only on one side so as not to "kill the goose that lays the golden egg."

Flight: The wings of a bat are spread between outstretched, elongated fingers. The ability of bats to move these fingers gives them a great degree of maneuverability in low-speed flight than most types of birds. But the innermost panel of the wing still has to be supported by the hind leg which has, as result, been rotated at the thigh so that the knees point backwards. This makes it almost impossible for bats to walk on a flat surface, and forces them to take off by dropping from a height. Compared to birds, bats generally have narrower and thinner wings. This reduces air friction. But the bats must fly faster to avoid stalling as the potential for turbulence is increased. Bat wings are so thin that one can read a newspaper through them. Because of the thinness of the wings, bats have been used in the microscopic study of the process of cell movement in live capillaries.

Hibernation: Red blood cells are stored in the enlarged spleen. Cold temperatures appear to start hibernation. Generally warm areas are needed or preferred for the summertime activities of bearing and rearing young and breeding, whereas a stable, cool, and humid environment is needed for efficient hibernation. Understanding hibernation may one day help people undergoing surgery, as lowering the metabolic rate during surgery would result in fewer fatalities and speed healing after surgery.

Muscles: Hearts are very large relative to body size. If humans had the same size heart relative to body size, our hearts would be the size of large grapefruits. Large size organs are useful in medical research. By hanging upside down, the bat's weight is transferred from the thin leg bone to body muscles and tendons. Each toe has a sharp, backward and curved claw which allows bats to cling to a ceiling.

Pollination: One type of bat (Musonycterus) has a tongue almost as long as its body. Bat pollinated flowers tend to be large, sturdy, bell-shaped, wide-mouthed, drab, white, and easy to reach. Bats pollinate agaves in the Southwest. Tequila is an alcoholic drink made from a species of agave pollinated by a bat.

Population: The bat population in Oregon Caves appears healthy. Bat populations in 1977 and 1983 at the park were as high or higher than those of 1976 and 1958. Further studies in the last few years (1986-88) indicate populations are comparable to levels measured during the past 30 years. However, clear cutting, herbicide use, and disturbance of roosting sites has reduced bat populations in most of the country. In 1990, a bat accessible gate was installed on the 110 Exit and a airlock with a bat louver was installed in the Exit Tunnel that was constructed in the 1930s. The louver is left open during bat swarming but closed during the winter when impacts from man-altered airflows is the greatest. This maintenance of an artificial bat habitat helps compensate for loss of habitat outside the monument and helps comply with the Endangered Species Act.

TEACHER'S GUIDE FOR CAVES & SERPENTINE PLANTS

LESSON PLAN #3 - Bats

Sex: Studying sperm storage in bats has contributed much valuable medical information to fertility and birth control studies as well as to those concerning organ transplant rejection and suppression thereof. Under normal circumstances, white blood cells (leucocytes) attack and destroy foreign cells; this is the body's first line of defence against various germs and diseases. In most mammals, including bats, there is a massive buildup of leucocytes in the uterus shortly after insemination occurs. The body apparently regards the sperm as foreign cells and reacts by concentrating leucocytes to kill those cells. In some human females, the white blood cell concentration in the uterus is so great that conception is difficult or impossible. In those bat species that store sperm in the female tract, this leucocyte onslaught does not occur. Apparently the wall cells in the body enclose dead sperm cells and thereby prevent the white blood cells from finding the live sperm cells. Understanding how the bats do this eventually may enable scientists to get around body defenses in humans and allow certain women to bear children.

Size: Most bats in Oregon Cave are only slightly larger than a person's thumb. The largest bat in the world weighs just over two
pounds and has a wingspan of five to six feet. The smallest bat
weighs less than a penny and has a wingspan of four to six inches. Most of the bats in Oregon Caves are smaller than a mouse.

Urine - A high amount of urea is concentrated in the kidneys and urine to cope with the high protein diet of insect-eating bats.
Understanding how bats hand such large amounts of protein may help doctors develop ways of treating the diseases of human patients who eat large amounts of meat.

Pre-site Activities: Using information supplied by the teacher on the biology of the bats of Oregon Cave, students design a bat gate. Discuss safety and logistics of field trip.

Field-Trip Activities: Accompanied by a Park Ranger, students tour Oregon Caves from the main entrance to the 110 Exit, a forty minute trip. The bat gates are discussed.

Post-site Activities: Based on information on the biology of bats supplied by the written material and the field trip, students list possible uses for bats.

TEACHER'S GUIDE FOR CAVES & SERPENTINE PLANTS

Appendix C - Cave Formations

SPELEOGENS

Speleogens are cave features shaped by dissolving rock. Any negative space or object carved or "eaten" by erosion in a cave is a speleogen. The entire cave is one huge speleogen. The following speleogens are found in Oregon Caves.

Bevels, Corrosion are level notches in the walls of caves. Floodwaters are usually rich in carbonic acid formed by carbon dioxide dissolved in water, the fizz in soda. This is because the fizz has not been neutralized by contact with calcite-rich rocks. When the Caves was close to its present size, floodwaters filled the Caves with dirt and stream gravels. In the highest levels, the top of the floodwaters stagnated for months or years and etched water lines on the walls, as in the Imagination Room.

In the picture on the right, the rounded upper part of the passage formed underwater, a **phreatic** passage. The slot in which the lower part of the ranger stands was cut down by a stream with air above it, a **vadose** passage.

Boxwork is a network of cracks filled with a material that dissolves more slowly than the surrounding wallrock. It often resembles post office boxes, hence the name. Boxwork in Oregon Caves is most common near faults. Faults cracked the surrounding rock and the cracks then filled with calcite. Crystals grew large because there was little competition from other crystals during their growth. Large crystals don't dissolve as easily as small crystals and so are exposed as boxwork by **atmospheric corrosion** on the ceiling.

Cave Breakdown**:** When rock falls in a cave it is called cave breakdown. Since the fall often results from water solution, it can be called a speleogen. In the picture to the right, rocks fell along lines of weakness called **bedding planes**, the surface between two rock layers. The bedding planes are at first fairly flat but the rise of mountains at Oregon Caves tilted them.

Cave Growth: Marble caves form along ground-water paths of greatest water flow and acid. In Oregon Caves water flowed, in order of importance, along **joints**, **faults**, and between rock layers. Joint are a parallel group of cracks in rocks while faults are cracks in which both sides moved relative to each other.

Steep streams increase water flow. The greatest acidity and steepest streams occurred where water moved from non-marble rock to the marble. This helped produce the South Room and Ghost Room, the largest rooms in the Cave. The overall size of Oregon Caves was largely controlled by the total amount of water in the Caves, in turn determined by precipitation (165 cm/yr, 69 inches per year) and the size of the surface basin that collects all the rainfall.

Most caves take from 1,000 to 10,000 years to reach a size people can crawl into. Most caves begin as hairline cracks between about one fiftieth to 1 millimeter wide. A single letter in this teacher's guide is about 2 millimeters. Most of the cracks in the Caves lie in the same direction as the major **faults**. Pull-apart cracks during the cooling and shrinking of a large mass of molten rock and, to a lesser extent, cracking when the mountains were twisted around, may have widened cracks enough to start and speed up cave development once erosion removed argillite overlying the Caves. Argillite are mudstones baked by heat and pressure. Water doesn't pass through it very easily and it doesn't dissolve very fast in acidic water. Therefore, it acted like a waterproof seal over the marble until erosion removed it and started to dissolve out a cave. This can be seen in the Dry Room, where a layer of argillite in the Connecting Tunnel extends over the Dry Room and keeps water from seeping in.

A great increase in solution begins when a crack reaches about 5 millimeters in diameter. Experiments suggests that without mechanical widening from faults, etc., this may take about 4,000 years. The first passages exhibiting turbulent flow conditions will enlarge about ten times faster than the others. The wider fractures capture more water which widens the joints even further, process known as stream piracy. This is a "snowball effect," as when a snowball rolling downhill get bigger and bigger. Piracy results in one or a few large passages. It may take a thousand more years for the cracks to reach a diameter of one centimeter (1/2 inch) and another 4,000 years to reach two meter (six foot) high passages.

Cave Levels: Underground water tables are the surfaces between air-filled holes in rock above and water-filled holes in rock below. In calcite layers with only a small number of cracks or interconnected holes, horizontal **water table** caves don't usually form. Instead, the water moves downward due to blockage at higher levels. The steep angle of the marble rock layers at Oregon Caves slowed water so that up-and-down loops were created, as in the Grand Column area. As Oregon Cave grew older, it developed larger cracks, increased water flow, and partly drained. More horizontal water surfaces and cave passages then developed, as in the first few rooms on the tour route. Rotting of organic matter by bacteria near the top of the water saturated zone probably released carbon dioxide that acidified water at that level, especially during back flooding. Cracks tend to decrease in width with depth and so there is more and faster flowing water at the top of the **phreatic** zone. But when many of the upper passages with their associated vertical pits were forming above water saturated rock, lower passages from the Connecting Tunnel and Imagination Room to the main entrance probably were forming underwater.

Cave Passages: Where the floor and lower walls of a passage are protected by sediment, solution moves upward. This may be the case for the upward part of the passage in the Passageway of the Whale, the "key" of the keyhole in the first picture. The lower part of the "key" was carved/dissolved out by the present stream. Cave breakdown in the picture to the right of this page often occurs as surface erosion nears the cave. These blocks of rock reduce the amount of cave.

Cave Rooms Enlarged: The relatively small pod of marble on the Monument is surrounded by baked mudstones that in some places are pyrite-rich (fool's gold), as near the Clay Pockets. Such contacts may have released sulfuric acid (car battery acid), changed flow rates, or caused solution from the mixing of waters with different amounts of carbonic acid, all of which increase solution and cave development. But the most important effect is acidity. When water flows on or in non-carbonate rocks, it rarely becomes saturated with respect to calcite. So when it contacts calcite-rich rock, solution occurs at the boundary.

Dome Pits: As the Caves drained, vertical shafts formed in Paradise Lost, the Bone Dome, and Neptune's Grotto below the surface contact between marble and the baked mudstones. As acidic water drained, rocks no longer partly supported by water fell into the River Styx stream as **cave breakdown** and diverted water flow and erosion to the south side of the Ghost Room.

Ghosts, Cave: Cave ghosts are the remains of **cave formations** that have dissolved away. **Atmospheric corrosion** occurs when warm, moist air rising in a cave condenses on colder surfaces and, by absorbing carbon dioxide, dissolves ceilings, walls, and cave formations. The rising air is driven by a two degree F. temperature difference between the top and bottom of the Caves. Heat released by radioactive minerals and by tidal friction make the interior the earth hotter than its surface. **Atmospheric corrosion** in Oregon Caves is minor. The picture to the right of this page shows solution of about four inches (10 cm.) of calcite on the left side of this flowstone ridge sticking out from the wall.

Pendants: Sharp projections sticking out of the ceiling or walls often result from turbulent stream flow.
In Oregon Caves they are found in the lower sections of the cave where stream action is most noticeable.

Pitting: Most **flowstone** near the shafts shows small solution pits that may result from **atmospheric corrosion**, as in the picture to the upper right. Acidic flowing water makes braided cuts, much like those seen in tiny rivulets in mud and in the picture to the lower right. Further solution may have occurred in flowstone after construction of the Exit Tunnel allowed air to reach the pyrite. The air changed the pyrite into rust and released **sulfuric acid**. Increased solution in and near vertical shafts may have occurred as acidic forest soils came nearer to the cave and there has been less buffering of **carbonic** and organic acids reaching the cave.

Potholes: Rocks twirled by water flow create circular depressions called potholes, as in the picture to the right. Often they form along parallel cracks called **joints**.

Rills in the picture to the right are evenly spaced parallel grooves often formed by stream action. Small, closely packed rills can result from **atmospheric corrosion** or from acidic water coming down a **dome pit** or **fault**. Condensation water on ceilings forms thick and thin layers due to surface tension, the attraction between water molecules. Thicker ribbons develop turbulent flow and dissolve out parallel rills. Increased flow and slope angles widen the rills. Condensation water still occurs in the highest parts of the cave in summer but large cave entrances now flush out enough carbon dioxide to prevent most or all atmospheric corrosion.

Scallops: Scallops are small, shallow, intersecting hollows dissolved on the surface of rock by swirling water. Their steeper sides point upstream and their size decreases with speedier water flow. The smallest scallops in Oregon Caves indicate a flow of about 30 centimeters (one foot) per second. Water flow initially may have been slow enough to dump gravels and silts in the Caves. With a widening of the cave passages and the enlargement of the spring outlet, the speed of the stream increased and removed most of the sediment from the Caves. Thus, the smallest scallops are in the lowest parts of the Caves.

Spitzkarren: If rills intersect, sharp peaks form called spitzkarren. These can be found in Miller's Chapel in Oregon Caves. The picture to the right shows the bottom of a spitzkarren in Miller's Chapel. The triangle shape on the left side of the picture ends in a sharp point. Notice the vertical rills on most of the rock.

SPELEOTHEMS

Speleothems are secondary deposits in a cave that are formed by the action of water. Except for **clay worms** and **conulites**, only calcite speleothems are known in the Caves. Rapid water flow deposits flowstone and dripstone. Slower flows deposit cave popcorn. Slow seepage favors **Mondmilch** growth. Flowing water forms flowstone. **Shelfstone** grows by pools. **Dripstone**, (**stalactites** and **stalagmites**) form from drips.

Cave crusts form from seeping water and in this picture look worm-like.

Cave Formation Colors, such as browns, reds, oranges and yellows, often come from organic material, such as rotting wood, and less often from rust. Acids from the soil dissolve and bring in iron and organics into the cave. Although pure calcite can be clear, trapped bubbles and crystal surfaces reflect light and make formations white.

Clay worms, also called vermiculations, probably form from clumping of clays in drying, liquid films. Each plate of mud has tiny electrical charges that attract each other. Clay worms in the Caves range from small clumps and thin, parallel lines to hieroglyphics and dendrites. The type depends on the ratio of fine-grained material to water. A high proportion of water results in more complex forms. Increased water flow can form vertical clay lines. Most of the horizontal lines may form in the bottom of small water waves. Some of the spot clay worms result from a mix of algal growth and lint from visitors' clothing. Some clay worms are covered with calcite. Clay worms form where there is much clay from **dome pits** and where there are smooth walls or **breakdown**. Rough surfaces break up the worms before they form.

Conulites are hollow, cone-like speleothems. They form by erosion of mud by dripping water and then cementation of the surrounding walls by calcite. The mud surrounding the pit is then eroded away leaving the calcite shells standing in the remaining sediment. Conulites are rare in Oregon Caves. The picture to the right is of a gypsum conulite which forms in a way similar to that of a calcite one.

Coralloids are globular, rounded cave popcorn or angular cave coral. Cave popcorn can form underwater, by slow seepage of water, by the action of algae, by splashing water, or by evaporation. Cave popcorn in Oregon Caves formed mostly by loss of carbon dioxide and water during slow seepage of water on cave walls. **Flowstone** more likely occurs where water flow is greater and loss of carbon dioxide overpowers evaporation. Cave coral usually forms underwater where slower fizzing and subsequent calcite deposition results in larger and more angular crystals. Evaporation forms crustier popcorn made up of tiny crystals. If temperature is fairly constant and humidity is high, large crystals can form, as in cave areas far from surface entrances. Much of the cave popcorn in Oregon Caves points towards cave entrances. As cold outside air enters in winter, relative humidity drops as the air warms. As this dry and carbon dioxide-poor air hits entrance-facing sides of formations, evaporation and fizzing of cave water deposits cave popcorn.

Crystal Size: Where films of water are exposed to the air, conditions are variable and water can quickly become overfilled with dissolved calcite. Then calcite rapidly crystallizes on whatever points (nuclei) are available. This results in many tiny, microscopic crystals typical of newly formed **flowstone** or **Mondmilch**. In contrast, conditions are more constant in standing water. There is often just a little more dissolved calcite than the water can hold. The dissolved material moves to areas where calcite can most easily precipitate, as onto already existing crystals. Therefore, only a few large calcite crystals form, as in **shelfstone** or **cave coral**.

As in the formation of the original **limestone** and **marble**, the "rich" (larger) crystals get "richer" and the "poor" (smaller) crystals get smaller. Therefore, even small crystals in **flowstone** and **Mondmilch** eventually will enlarge if enough water is present. Broken **stalactites** sometimes show complete recrystallization and destruction of the original calcite crystal rings. The picture to the right show large crystals that grew in an open space.

Draperies are a composite **flowstone**-dripstone speleothem. At first, drapery growth is nearly in a straight line, with water flowing along an tilted bedrock surface. Small bumps in the bedrock cause the drapery to become slightly curved, and there is more deposition of calcite on the outside edge of each curved segment because there is more surface area for deposition and often a greater exposure to evaporation. Consequently, the curves eventually grow wider. The picture on the right shows some very wavy draperies in which once curve has been pinched off and has stopped growing, much like an ox-bow lake.

Flowstone: Sheet-like deposits are called flowstone. Where evaporation is more important than loss of carbon dioxide, as at the edges of flowstone, **coralloids** may develop.
Microscopic calcite crystals cause
velvet flowstone.

Helictites are contorted speleothems which may twist in any direction. The name comes from the Greek root "helick," meaning "to spiral". Each helictite has a central canal and an outside surface through which water moves under capillary pressure. Growth is by calcite precipitation due to evaporation and degassing of capillary water at the tip. Crystal shapes, evaporation, or impurities may alter the direction of helictite growth. Capillary water seeping out of cracks form welts. The few welts and helictites in the Caves suggests that high water pressure and evaporation that favor their growth is lacking because the cave is close to a relatively humid surface. The picture on the right shows an helictite growing from a baby stalactite.

Microgours are tiny **rimstone** dams. A picture of these interconnecting ridges are seen on the right.

Mondmilch is a cave mud of more than 90% calcite when dry. With half its weight in water, it looks and feels like cottage cheese. Mondmilch in Oregon Caves probably formed by rapid crystal growth. The origin for the name Mondmilch is from the German Mannlimilch, meaning "little earth-man." Peasants in Europe used its mysterious properties for centuries to heal infected cuts in livestock. Some believed that magical gnomes put Mondmilch in caves for people to use. Mondmilch often contains bacteria that are the main producers of antibiotics that humans use. Mondmilch often contains algae and the fungus threads seen in Oregon Caves Mondmilch. They may assist in breaking down the minerals in the wall rock and adding them to the Mondmilch. Eating of organic acids by certain organisms could cause calcite to form. Evaporation and moderate rates of seepage probably aid its formation. The absence of any

Mondmilch under **flowstone**, etc. suggest most of the Cave's Mondmilch formed due to higher evaporation rates as a result of entrance enlargement in the last few thousand years. Evaporation causes rapid crystallization, resulting in very small crystals. Organic coatings may then prevent the smaller crystals from dissolving and larger crystals from growing larger, a process that happens in wet dripstone and flowstone. Some of the drier Mondmilch apparently has recrystallized into a hard rock but the crystals are still microscopic.

<u>Pearls, Cave</u>: Cave pearls are rare in Oregon Caves. Loss of carbon dioxide by splashing water or evaporation forms layers of calcite around an initial nucleus. The crystals grow perpendicular to the sphere, like the layers of an onion skin. The pearls at Oregon Caves are of calcite. The splashing keeps rolling the smaller pearls around and prevents them from being cemented to the floor of the depression. Crystal growth on the lower sides of the larger pearls may elevate the pearl before crystal growth cements it to the pool bottom at the point of contact. Clay films or differences between floor and pearl crystals may also prevent the pearls being cemented to the depression. When the pool becomes crowded, competition from crystal growth may cause the pearls to become oblong or indented.

Rafts, Cave: Cave rafts are thin plates that form on cave pools. Calcite cave rafts average a thickness of about .07 inches and are rare in Oregon Caves. The upper sides of the calcite rafts are smooth and glossy, whereas the lower, water side is rugged with tiny crystals, a reflection of a more stable environment resulting in slower growing and larger crystals. Growth of rafts is rapid; they can appear in weeks or months. Rafts are supported by surface tension until sunk by water droplets.

Rimstone dams are straight barriers of **flowstone** that at least at one time lay across a cave stream or shallow pool. Fizzing of carbon dioxide and subsequent calcite precipitation is caused by turbulence, evaporation, and lowered pressure as water upwells over the top of the dam. This is much like shaking a bottle of pop, opening the lid, or leaving it out in the hot sun. In all cases, the carbon dioxide in solution fizzes off and the soda goes flat. Rapidly flowing water has added quartz grains in the rimstone dams of Caves. The edges of the rimstone dams point upstream, as is usually the case with slopes of more than a few degrees. Tall, upright dams result on nearly horizontal slopes with low evaporation, as is the case with the straight layers of brown rimstone pictured in the Rimstone Room. Very small rimstone dams like the white one in the picture are called microgours. They usually are more wavy than the larger rimstone dams

Shelfstone is a flat, carbonate deposit attached as a ledge or eave-like projection to the edge of a cave pool. The curved water line at the edge of the water, as is the case with **soda straws**, allows greater evaporation and fizzing off of carbon dioxide because of the greater surface area. Small waves from dripping water colliding with the edge of the pool may cause enough turbulence to precipitate the calcite by fizzing off carbon dioxide, much like shaking a can of soda pop. Much like water moving up a piece of blotter paper, water may move to the top of the shelfstone by surface tension and thus drop its load of calcite. The thickness of each shelfstone layer may be due to seasonal changes in water level. The great thickness of the different layers in Oregon Caves suggest a high rate of seasonal change when the shelfstone was forming.

Stalactites usually have a central, drip-hole canal that can become plugged, a thin, tubular layer of crystal around the drip canal which is a relict soda straw ("baby stalactite"), and subsequent layers. The initial soda straw is as wide as a water droplet. Because of surface tension, a curved line forms at the edge of the water droplet. As more water is added to the droplet, the droplet moves down and springs back up a little, creating turbulence at drop's edges. From the turbulence and, more importantly, the greater amount of surface area at the meniscus, carbon dioxide fizzes off and is lost to the cave atmosphere. This lowers the amount of carbonic acid in the water and consequently there is not enough acid to keep all the calcite dissolved in the water. Calcite crystals then form at the edges of the water droplet. Some calcite deposited further down migrates to the sides of the water droplet due to the water drop bouncing up and down. Since precipitation is fastest at the edge of the droplet, the crystals grow along their c-axis (faster direction of growth) into the center of the droplet, resulting in a ring of crystals. As the soda straws ages, blockage of the central canal may force water and calcite to the outside of the straw and cause the soda straw to widen. Fast-growing stalactites tend to be long and thin, while a slow-growing one becomes fat and stubby. If water stays on a stalactite a few hours, most of the calcite will come out of the water. But if the water stays only a few seconds, most of the water containing dissolved calcium will continue to fall to the floor of the cave. As it hits the floor, splashing fizzes off carbon dioxide and calcite is deposited. The picture on the right shows stalactites with added **draperies**.

Stalagmites**:** A stalagmite is any conical deposit formed by dripping water. With frequent drips, water can flow fast enough to deposit calcite far from the drip impacts. Therefore, wide stalagmites, common in Oregon Caves, indicate fast flow rates. Stalagmites with their tops flattened have droplets falling from a great height. This causes solution splatters, as in Paradise Lost. Anemolites, also called curved stalactites, are rare in the Caves. Airflow and subsequent evaporation on one side of the stalactite may cause calcite growth in cracks, causing one side to lengthen and bend. The picture shows bumpy cave popcorn on one side where air form the cave entrance evaporates water.

Velvet Flowstone**:** Humid air allows crystals to grow large enough to give the flowstone the appearance of soft velvet.

TEACHER'S GUIDE FOR
CAVES & SERPENTINE PLANTS

Appendix D - Bat Biographies

Eptesicus fuscus - The Big Brown Bat is also called Big Brown Myotis, Barn or House Bat. Except for the Silver-haired Bat, it's the least common bat in Oregon Cave. It can hibernate a maximum of 300-340 days, slowing its heart to 42 to 62 beats per minute.

Flight: The heart rate before flight is 420 to 490 beats per minute and increases to about 1000 beats per minute in flight after two to four seconds. Thin wings allow this bat to "exhale" over 10% of its carbon dioxide through its wings during active flight. About 80% of the total surface area of this and most other Western bats is in the wings. With a doubling of carbon dioxide (CO_2) in the atmosphere, bats may not be able to get rid of all their CO_2 during flight. This bat should see stars: it uses post-sunset glow to orient during flight.

Food: Some Big Brown Bats have an average diet consisting of beetles (36%), moths (26%) and flies (13%). This bat may establish a repetitive circuit going from one street lamp to another and back again to catch moths. It will chase away members of its own species but will tolerate other species. It can catch insects in the tail scoop and then bring them to its mouth. The scoop is also used in giving birth. Echolocation can detect two identical objects placed less 12 millimeters (1/2 inch) apart. Echolocation involves the emitting and receiving of ultrasonic sound by an animal. The closest human equivalent is sonar.

Habitat: The Big Brown Bat ranges from Alaska to northern South America. This bat isn't as tolerant of temperature ranges as the Little Brown Bat. During freezing weather it may wake from hibernation and remain active. It often stays away from other bat species in a cave. This bat is susceptible to DDT. They use Oregon Caves during warm clear fall days, up to 200 in a single night. They prefer dry, warm areas.

Sex - Females emerge from hibernation before males and cluster at traditional nursery colonies. Small sexually mixed groups form in late summer and mating continues through hibernation and even into early spring. Infant mortality between birth and weaning is about 7%. Mortality after 7 years is about 80%; females die somewhat sooner than males. Bats less than two weeks old who fall on the floor squeak continuously and are sometimes rescued by their mothers. Young bats grow rapidly, adding as much as a gram per day. They can fly when they are three weeks old.

Myotis species had activity levels 2.5 to ten times higher in old growth forests than in younger stands (Thomas, 1989). Myotis means "mouse ear."

Myotis californicus is the California Bat. This is the smallest of all the myotis. The wingspan is only 230 millimeters (6 inches). The bats quite often stay near vegetation in their search for food. Food includes midges, flies, craneflies, and moths. Females appear to be more active than males in winter months. This bat ranges from Alaska to northern Mexico. It uses man-made structures as roosts more than any other bat. The bats emerge from dormancy in late February or early March along the Oregon coast. Babies are normally born in mid-June.

Myotis evotis - Long-eared Myotis constitute over half of bats caught at the cave in 1988. This bat is often found at fairly high elevations in western conifers. It is most often found in August. The term evotis means "large ears."
A bat banded in Oregon Cave holds the record for the species life-span, 24 years.

Myotis lucifugus is called the Little Brown Bat. Lucifugus means "light to flee." It may have the finest hair of any mammal and the greatest number of hairs per unit area of skin surface.

Hibernation: The Little Brown Bat (also called Little Brown Myotis) can hibernate a maximum of 163 days, at which time its use of oxygen may decrease to one percent what it consumes at 40 degrees C. Only .015 grams of fat per month are required in hibernation. Females accumulate more fat before hibernation than males, probably because of the demands of pregnancy. Where they hibernate in Oregon is unknown but is likely to be away from raccoons or snakes who eat them.

Sex - Females emerge from hibernation before males and congregate at traditional nursery colonies. Gestation is from 50 to 60 days. The baby is wrapped in the mother's wing soon after birth. When about half grown (2 weeks), they begin to hang beside their mothers. Eastern females sometimes have twins; western ones do not. Two to ten adult females remain with the baby bats while the other females are away foraging for food. These "baby-sitting" females guard the young and retrieve those that accidentally fall out of the roost. Babies fly about three weeks after birth.

Echolocation intensity is comparable, in terms of energy, to those produced by jet engines. It uses more frequencies when it has found an insect. This makes it more likely that a sound pulse will bounce off the insect and be heard by the bat. As the bat approaches its target, it shortens the pulse by about 1 millisecond per 2.6 meters of approach. The shorter pulses allows the echoes to come back sooner, thus allowing the bat to pinpoint the insect's location with greater accuracy. The bat emits 200 pulses per second when close to an insect, each pulse emitted at 110 decibels (db) (equivalent in loudness to a jack hammer).

Food - The Little Brown Myotis can specialize on mosquitoes in certain areas and can detect minute fruit flies several feet away. In western Oregon, its three main food items are midges, internal organs of large insects, and flies. It also eats gnats, caddis flies, small wasps, beetles, ants, crickets, leafhoppers, crane flies, and noctuid moths. Insects are often captured on the wing and then transferred to mouth by way of the flap of skin on the sides of the tail. When bat babies are born, they also are deposited into this skin pouch. Insects may be gathered at a rate of one gram per hour (.04 ounces), about one insect every seven seconds. Attempts at capturing an insects is successful about 50% of the time. Average food size is about 2 milligrams. Food passes through the bat in less than an hour. This bat frequently roosts in the attics of houses or barns.

One bat from Ontario lived 30 years, the longest known for any bat. This species may have the highest temperature tolerance of any vertebrate, from 20 to 129 degrees F. The Little Brown Bat often resides in buildings during the summer and males sometimes are seen in caves in winter.

Myotis thysanodes - The Fringed Bat's specific name, thysanodes, means "fringe," refers to the fringe of short, stiff hairs along the margin of the tail membrane. A typical diet is about 46% moths, 26% harvestmen, 16% crickets, 6% craneflies, and 5% spiders. Wing membranes are thicker and less elastic than those of most other bats and thus allows it to forage on or near the ground with less likelihood of puncturing its wings. The Fringed Myotis can store as much as .17 grams of fat per day. So much fat storage allows it to spend a up to 163 days hibernation. Two to ten adult females remain with the baby bats while the other females are away foraging for food. These "baby-sitting" females guard the young and retrieve those that accidentally fall out of the roost.

Myotis volans - Also called the Hairy-winged Myotis and the Long-legged Myotis. Volans means "flight," referring to its excellent flight capabilities. Long-legged bats are the only brown bats with belly hair extending onto the undersides of the wings, covering the membranes as far as the knees and elbows and forming a line that parallels the body. It hunts over open fields and in clearings. This is the most common bat in the west. It occurs from sea level up to about the elevation of the Cave. A bat banded in Oregon Cave holds the record for the species longevity. Parasites found on this bat include crab lice, bat bugs, mites, fleas, chiggers, and bat (wingless) flies. Babies usually are born in July. The Little Brown Bat and the Long-legged Myotis prefer drier habitats than most of western Oregon.

Myotis yumanensis - Also called the Fringed Bat, because of the tiny hairs on its rear end skin flap. Yuma Myotis expands its wing capillary blood vessels to lose heat in hot weather. It is usually found near water. While capturing insects, it can fill its stomach in fifteen minutes. They normally feed just a few centimeters (one inch) over the surface of the water. They often feed within regular routes that they fly again and again.

Maternity colonies do not tolerate human disturbances and will abandon their nurseries. Tar-paper and wooden siding of buildings appear to be the main roosting sites used by Yuma bats along the Oregon coast. Where the bats hibernate in Oregon is unknown. Yuma Myotis can hibernate a maximum of 192 days. A bat banded in Oregon Cave has lived
19 years, a world record.

Plecotus townsendii - Also called Lump Nosed or (Western) Long-eared Bat. John Kirk Townsend first recorded the species while at old Fort Vancouver, Washington, in 1835. A now famous naturalist, he was in charge of the hospital at Fort Vancouver the winter of 1835-36. The men at the fort protected the bats because they ate the dermestid beetles whose larvae so often ruined furs and hides. Most Oregon bats eat almost nothing but moths.

Rarity: Two subspecies are already on the federal endangered species list. The species is protected in California and Washington and is being considered for special protection status in Oregon. About 2,500 may survive in Oregon and about 1,500 in Washington (Perkins, 1988). This bat represented a higher proportion of captured bats in Oregon Cave in 1988 than in any previous year (Cross, 1989).

Hibernation: California bats do not usually hibernate if the temperature in their roost is warmer than 17 degrees C. The tendency to hibernate is stronger in females than in males, and in midwinter females were usually dormant both day and night.

Townsend's Big-eared Bats are the main hibernators in the Dry Room. Unlike the other species at Oregon Caves they hibernate here and use the cave as a day roost site. All hibernating P. townsendii in Oregon and Washington have been found in caves or mines (Perkins, 1988). Summer searches revealed 18 nursing colonies with only one of these in a building, the rest of the colonies being found in mines and caves.
Hibernating Townsend's Big-Eared Bats in Oregon Caves typically stay within 20 meters of cave entrances. Selected areas have an average temperatures of 5.1 C (41.2 degrees F). The bats showed no definite preference for a given temperature, but did stay in the cooler and better ventilated portion of the Cave. Bat populations tended to fluctuate more in warm periods than in cold periods.

Townsend's Big-eared Bats are intolerant of disturbance and rouse frequently from hibernation, thus loosing fat reserves. They may move deeper into a cave if the near-entrance temperature become too extreme. Because of human disturbance, all nurseries have all been abandoned in California. The bats often follow a sequence of moving into the more inaccessible part of a cave before abandoning it altogether. Although they easily move from one roost to another, they probably don't migrate a long ways.

Townsend's Big-eared Bats deflate their ears by closing special valves in blood vessels that enter the ear conch, thereby allowing the ears to collapse and curl inward. This curling probably reduces heat and perhaps water loss when the bat is at rest or in hibernation. Population densities in some places in California average one bat per 100 hectares (247 acres).

Reproduction: Females breed when they are four months old. The young fly when they are about three weeks old and are almost full grown at one month. Sperm is stored in the female during hibernation. When the eggs descend the duct to the waiting sperm, females become pregnant in mid-March and give birth in mid-June. The females abandon their young at the time of weaning and rejoin the males or live in solitude until the next breeding season. Both sexes mate from mid-August to mid-October although males sometimes mate with completely torpid females during winter.