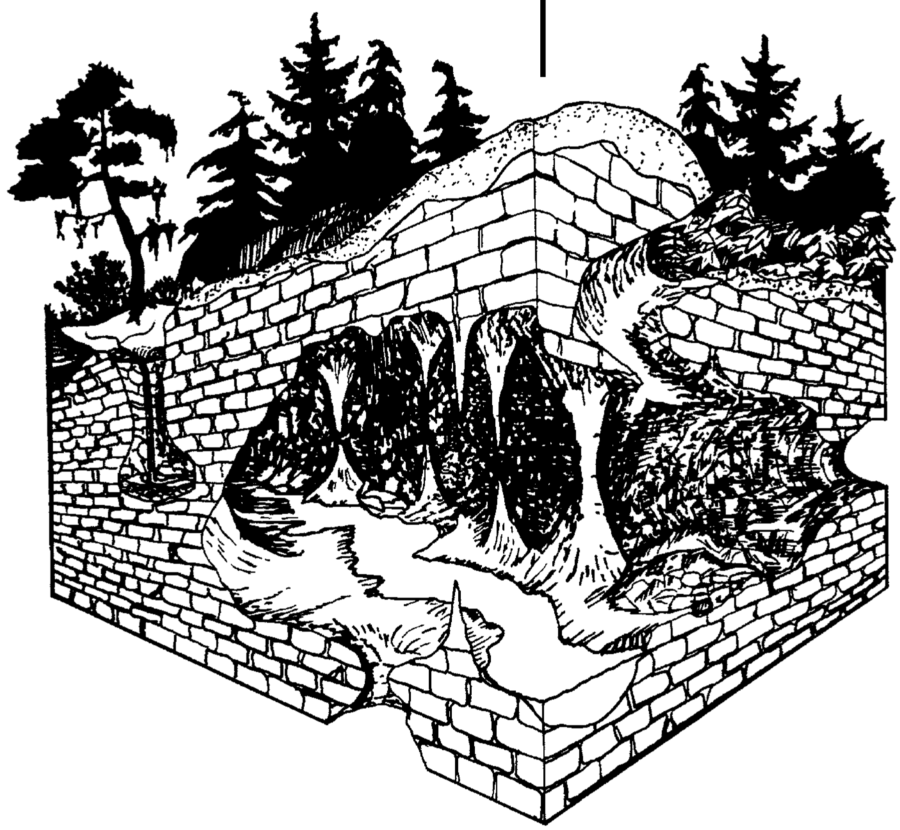
Karst Landscapes and Caves of Southeast Alaska

A RESOURCE FOR TEACHERS



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A cave in Southeast Alaska meets tide water. The widespread karst landscapes of the region tell stories millions of years old—for those who learn how to read them.

Acknowledgments

for the First Edition

Many people made indispensable contributions to this guide.

Scientists Jim Baichtal, John Autrey and Terry Fifield of U.S.D.A. Forest Service contributed text and reviewed material.

Robert Wangerin and Risa Carlson wrote significant portions of the text, as did Marcel LaPerriere and Connie LaPerriere.

Ward Serrill provided photographs of scenes inside and outside the caves.

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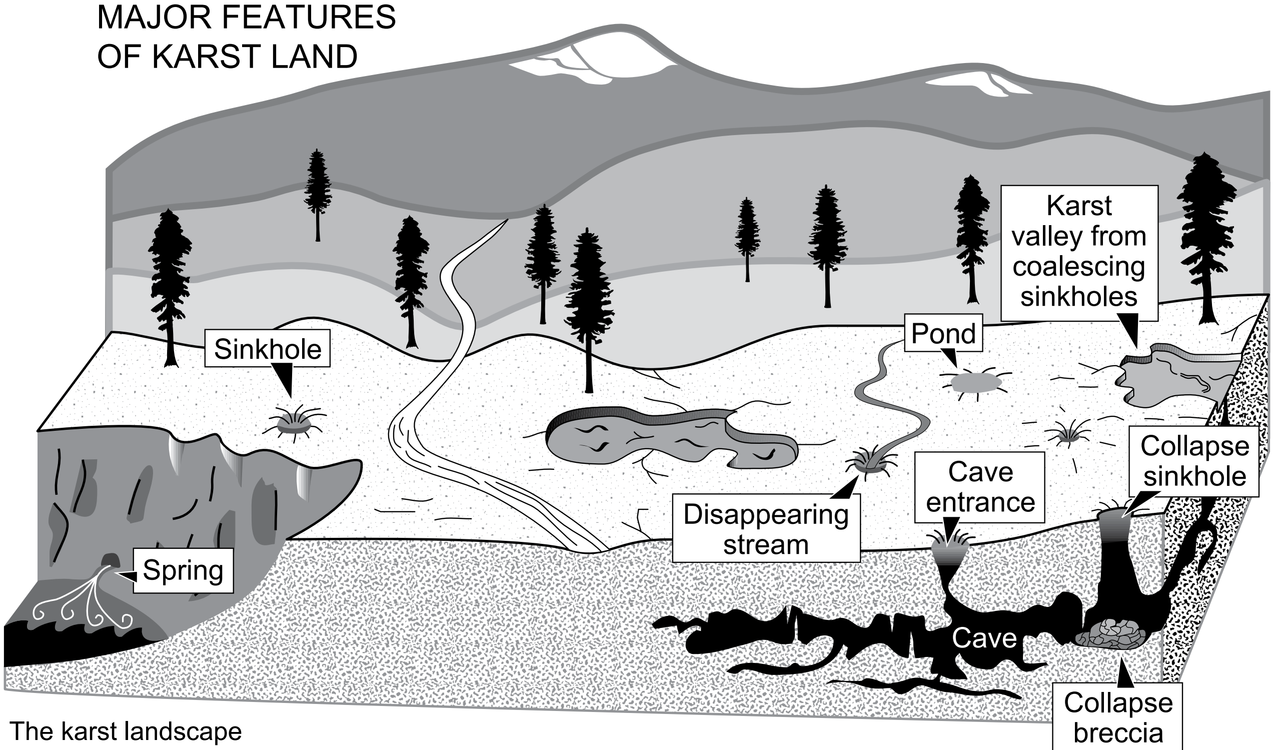
Valerie Steward and Jan Bush contributed to the text and Stephen Roguski to the glossary.

The Klawock Parent-Teacher-Student Association aided the original educational project.

Anatomy of a landscape

MAJOR FEATURES
OF KARST LAND



The karst landscape is a dynamic and changeable place. Its features are rarely as obvious as our diagram suggests, and you don't find all of them together this neatly. However, the diagram offers a guide to the most typical physical traits of the landscape we'll discover in this book on the karst lands and caves of Southeast Alaska.

INTRODUCTION

This resource guide was prepared for middle-school and secondary-school teachers as a source of information and ideas about the caves and karst lands of Southeast Alaska. We include in the binder a map depicting the karst lands and geology of Southeast Alaska; a descriptive guide with glossary and student activities; goals and objectives for activities; and useful appendices.

Another good overview of caves and karst lands was produced by the American Cave Conservation Association. *Learning to Live With Caves and Karst* includes excellent teaching activities and resources. Send your request to:

American Cave Conservation Association
P.O. Box 409
Horse Cave, KY 42749

Project Underground is also a good source of information on caves and karst landscapes. Their contacts:

Project Underground
8 Radford St.
Christiansburg, VA 24073
540-394-2553
www.projectunderground.org

This guide together with the publications from American Cave Conservation Association and Project Underground provide a comprehensive discussion of the topic as well as information specific to our own Alaskan caves.

GLOSSARY ITEMS

When you come across words and terms printed in italicized small capital letters (e.g., *SINKHOLES*), refer to the glossary starting at page 37 to learn more.

THE KARST LANDSCAPE AND CAVES OF SOUTHEAST ALASKA

Some of Alaska's most impressive natural and scientific wonders are out of sight.

The fascinating underground world of Southeast Alaskan caves has remained out of sight for thousands of years — known only to uniquely adapted cave creatures and visiting bears, otters and humans.

Only in recent years have scientists and other explorers pushed into the region's intricate systems of subterranean karst features, mapping the geological and biological resources of the caves.

An overview of the underground

This resource guide provides you with a broad perspective on karst landscapes and caves. We look at the origins of Southeast Alaska's karst features. We see the geological and chemical processes that sculpt them. These pages survey the process of limestone dissolution and review the creatures that inhabit and visit the caves, and how their remains tell scientists more about the ancient past in this area. This book also offers a guide to conserving this precious natural world while safely visiting it.

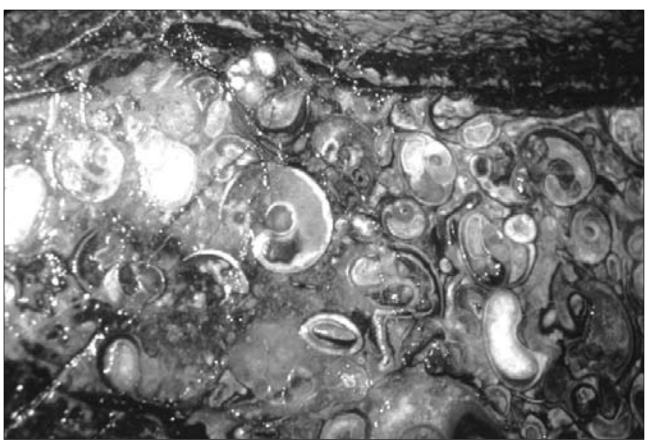
First, fundamentals: What is karst?

Karst landscape **is** composed of bedrock that can be dissolved by water. This geological feature is more common in the continental United States than in Alaska. In fact, temperate rain forest karst landforms are unique to Southeast Alaska.

About 20 percent of the earth's surface is karst geology. It's common in the southern continental United States, in California and in British Columbia: for example, 40 percent of the lands east of Tulsa, Okla., are karst landscapes. Karst geology is also found in southern Asia, in Indonesia, in Tasmania, in New Zealand and, in Europe, in the Balkans—the region that gives this landform its name (see sidebar).

Why we have karst land features in Southeast Alaska: it's a combination ...

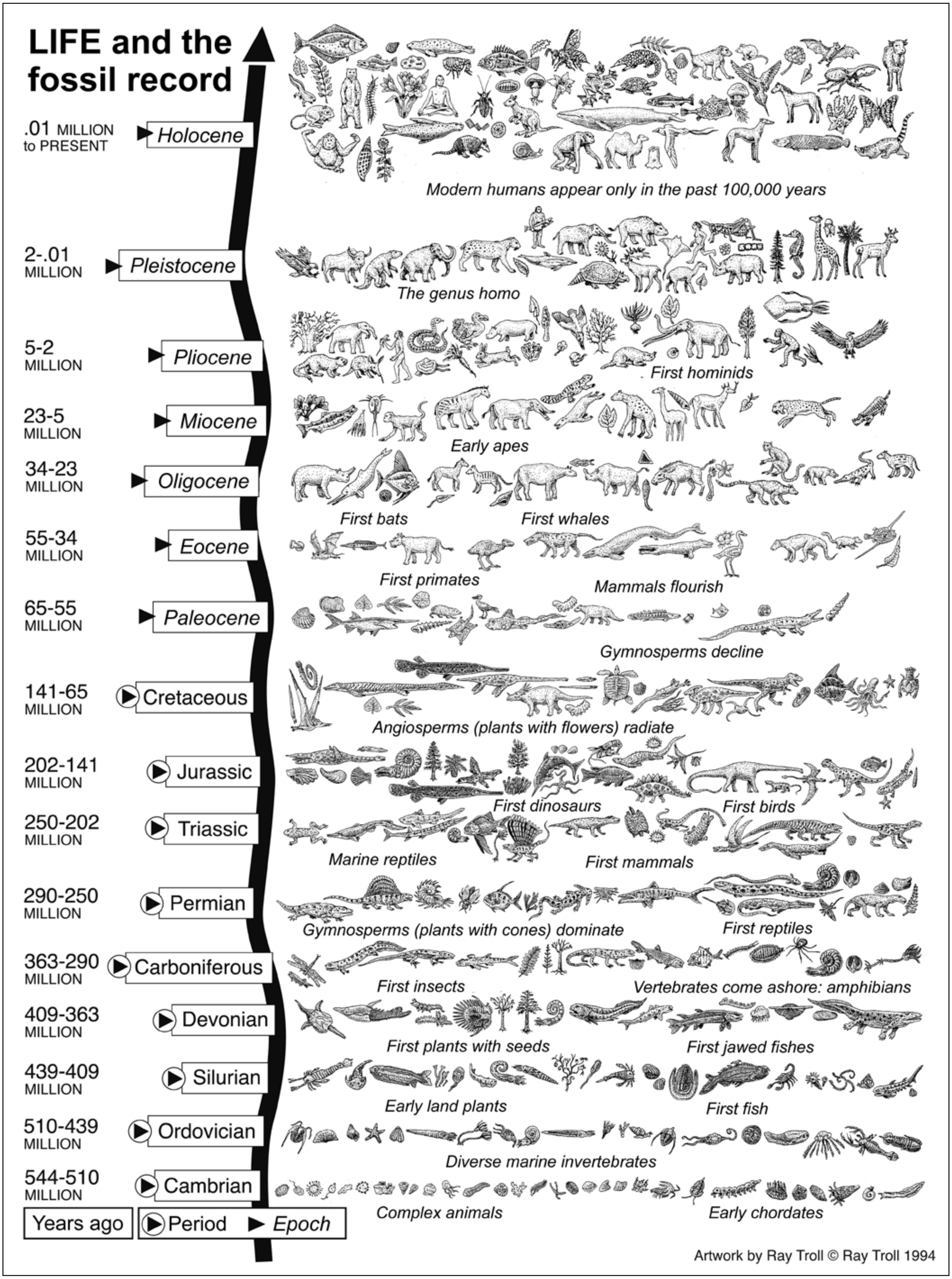
■ Pure carbonate bedrock
■ Bedrock contortions: faulting , fracturing, folding
■ Intrusions of igneous rock
■ Local tectonic events
■ Glacial history
■ Proximity of carbonates to peatlands and forest vegetation
■ Abundant precipitation
■ Moderate temperatures



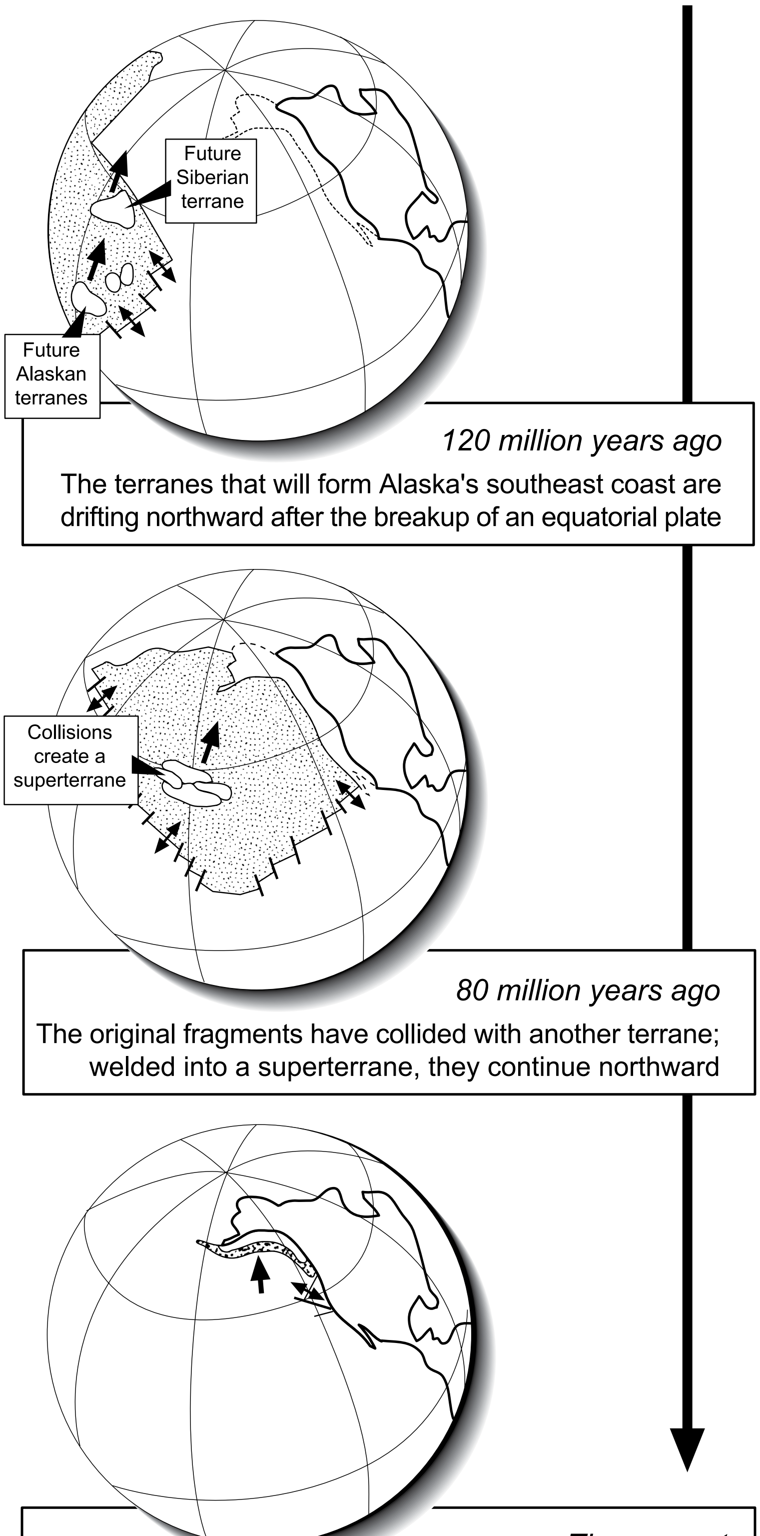
Well-traveled fossils—*Marine invertebrates that died near the equator in the Silurian period 400 million years ago are now embedded in limestone on Heceta Island along northwest of Prince of Wales Island.*

"Karst" — a name that came from the Balkans

The adjective used for this geological feature derives from *Kras*, an area of Croatia near the coast of the Adriatic Sea. Some of the earliest research on karst landscapes was conducted in that Balkan region.


LIFE and the fossil record
.01 MILLION to PRESENT
Holocene
Modern humans appear only in the past 100,000 years
2-.01 MILLION
Pleistocene
The genus homo
5-2 MILLION
Pliocene
First hominids
23-5 MILLION
Miocene
Early apes
34-23 MILLION
Oligocene
First bats
First whales
55-34 MILLION
Eocene
First primates
Mammals flourish
65-55 MILLION
Paleocene
Gymnosperms decline
141-65 MILLION
Cretaceous
Angiosperms (plants with flowers) radiate
202-141 MILLION
Jurassic
First dinosaurs
First birds
250-202 MILLION
Triassic
Marine reptiles
First mammals
290-250 MILLION
Permian
Gymnosperms (plants with cones) dominate
First reptiles
363-290 MILLION
Carboniferous
First insects
Vertebrates come ashore: amphibians
409-363 MILLION
Devonian
First plants with seeds
First jawed fishes
439-409 MILLION
Silurian
Early land plants
First fish
510-439 MILLION
Ordovician
Diverse marine invertebrates
544-510 MILLION
Cambrian
Complex animals
Early chordates
Years ago
Period
Epoch
Artwork by Ray Troll © Ray Troll 1994

Alaska's coast: how it got here



120 million years ago

The terranes that will form Alaska's southeast coast are drifting northward after the breakup of an equatorial plate

80 million years ago

The original fragments have collided with another terrane; welded into a superterrane, they continue northward

The present

The Alaska terranes are in place – but not entirely at rest: active volcanoes punctuate the southwest rim of Alaska

Adapted from Stone, Panuska and Packer (1982)

GEOLOGY

Karst landscapes in Southeast Alaska, like other karst areas around the world, are characterized by surface features we can easily see, such as ***SINKHOLES*** and disappearing streams. They are also places of subsurface wonders, such as underground streams and cave systems. Interaction of soluble bedrock — usually ***LIMESTONE*** — and acidic surface water produces these unusual features.

Alaskan landscape made in the South Pacific

The story of the karst landscapes of Southeast Alaska begins with the formation of its carbonates in the South Pacific during the Silurian Period, 438 million to 408 million years ago. Warm, shallow equatorial waters teemed with ***CYANOBACTERIA***, plankton, algae and numerous kinds of invertebrates. Many of these organisms took dissolved ***CALCITE*** from the water to build shells, external skeletons and other hard body parts. When they died, soft body parts deteriorated and hard parts drifted to the ocean floor. Mats of photosynthetic bacteria and sediments trapped in them accumulated as ***STROMATOLITES***. These reef formations also shed fragments. Over time, huge calcite deposits were transformed into limestone by compaction and cementation.

North to Alaska: migration of South Pacific land

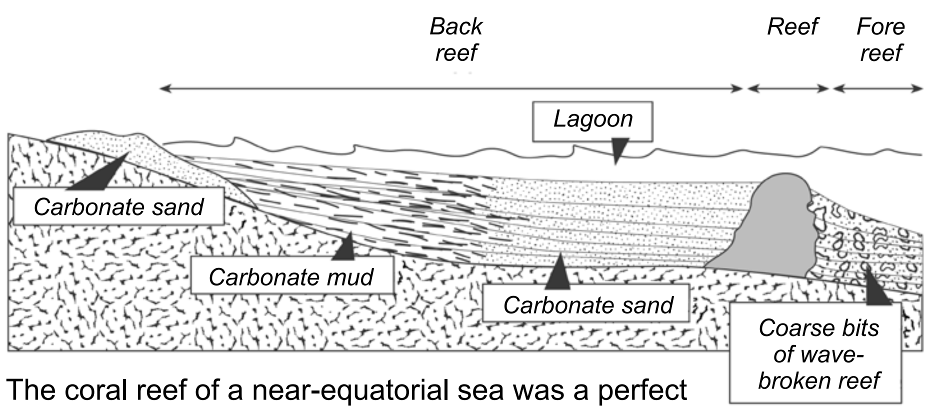
About 400 million years ago, our continental fragment and others began riding northeast on the slow-moving Pacific ***TECTONIC PLATE***. Some fragments collided with other continental pieces and joined in a large microplate as they drifted thousands of miles northward. This microplate and other fragments "docked" with the northern coast of North America between 150 million and 100 million years ago. The oblique collisions smeared the fragments along the coast, like multiple icings applied haphazardly to the side of a cake. After the collision with the North American continental mass, the fragments continued their northern migration, leaving bits and pieces behind. The forces that keep these fragments in motion have folded, fractured, and sheared the bedrock. Because these fragments traveled great distances to their new geologic home, they are called *EXOTIC TERRANES*. Southeast Alaska is a mosaic of at least 11 different terranes. Each has a distinct geologic character, range of ages, sites and characteristics of origin.

The karst landscapes of Southeast Alaska *tell stories tens of millions of years old — tales of plate tectonics and chemical processes.*

The wandering Alexander terrane comes to rest as Southeast Alaska

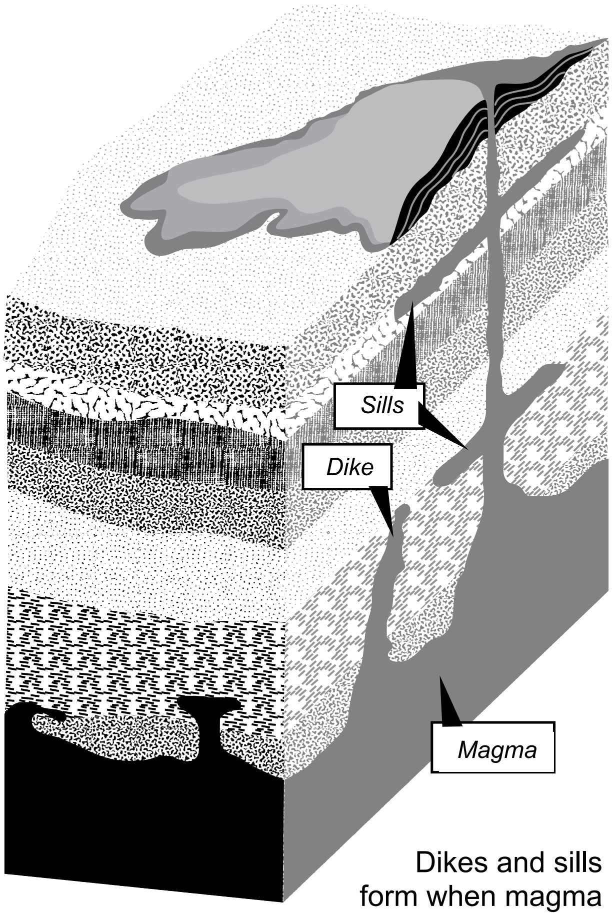
The Alexander terrane is the principal terrane of Southeast Alaska. Carbonates record the terrane's wandering from its origins during the Silurian Period. These carbonates contain massive limestones of three distinct types: fore reef deposits; reef deposits; and back reef deposits of thin, wavy-bedded, fossil-rich limestone. The heat and pressure of extreme collisions and forces of plate tectonics caused a metamorphosis of some of the limestone into marble during certain *DOCKING* events. When the Alexander terrane collided with the ancient shore of southeast Alaska, it was spectacularly fractured and then fragmented. The force of the collision made large strike-slip faults, oriented northwest-southeast. Smaller strike-slip faults oriented north-south intersected

Ancient seas: limestone factories



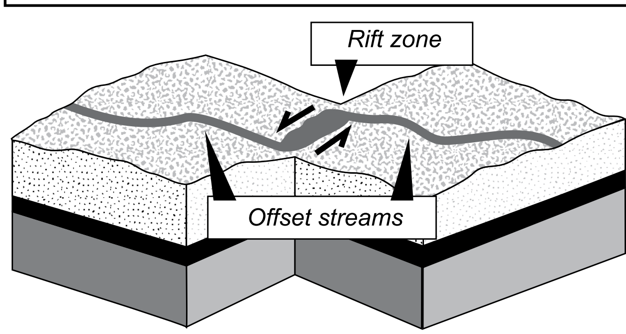
The coral reef of a near-equatorial sea was a perfect calcium carbonate production area in the Silurian Period. Such sites and the sea bottom in deeper areas gathered the organically produced minerals that moved thousands of miles to Alaska and became part of our karst landscape.

Formations from fiery rock



Dikes and sills form when magma invades subsurface rock. Vertical igneous intrusions are dikes; horizontal igneous intrusions are sills.

Faults with shear power



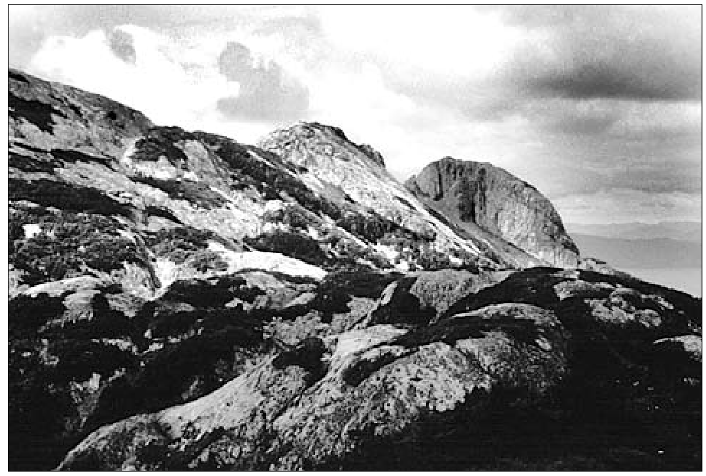
Strike-slip faults occur with horizontal movement of blocks on opposite sides of a fault plane. These shearing forces were commonplace as the Alexander terrane took its present place along the coast.

these and broke the terrane into huge blocks. Thus, terrane blocks bounded by the large faults are in turn broken into smaller blocks by small faults; these small faults mimic the pattern of their larger counterparts. The same fault pattern can be seen at all scales of magnitude, from terrane boundaries to outcrops and specimens you can hold in your hand. The large-scale faults — as big as islands or mountains — help to define karst system boundaries in Southeast Alaska.

About 632,000 acres (988 square miles) of carbonate rock have been mapped throughout Southeast Alaska. Southern Southeast Alaskan carbonates are especially pure, averaging more than 96 percent calcite. These carbonate formations provide soluble bedrock that is fundamental in the karst landscape. Limestone and marble in karst areas are dissolved or chemically weathered by abundant acidic surface waters.

Surface waters follow fractures, faults and folds in the carbonates, sculpting both the surface of the karst and dissolving cave systems below. Igneous intrusions such as dikes and sills also provide sites of structural weakness in the bedrock where solution features can develop. Surface waters in Southeast Alaska are acidic due to carbonic acid in rainwater and organic acids in runoff through forest soils and peatlands. Recharge areas, which supply water to karst systems, may lie on carbonate rock or on non-carbonate ***substrates***, such as conglomerates, sandstones, or volcanic rocks.

Karst landscapes have existed in Southeast Alaska for a long geologic time and have been impacted by ***glaciers***. For example, passages in two different caves on Prince of Wales Island are found through what may be Tertiary (65 million to 2.5 million years ago) ***paleokarst breccias***. These findings suggest that caves have been forming in the carbonate for a long period. Most caves predate the latest glacial advance, which reached its maximum extent between 22,000 and 17,000 years ago. At that time the vast Cordilleran ice sheet covered most of the landscape, although it is likely that some ice-free *REFUGIA* remained at high elevations and along the coast. The inferred ages of the caves are based on the presence of glacial clays, glacial sediments, wood, *VERTEBRATE* remains from the late Pleistocene (2.5 million to 10,000 years ago) and possibly even ancient ice. One small cave has yielded a *MARMOT* tooth which has been dated to more than 44,500 years ago. The remains of a black bear more than 41,000 years old and a brown bear 35,300 years old have been found in another cave. Similar features have been found in field reconnaissance on Kuiu and Chichagof islands and on islands seaward of Prince of Wales Island. Such evidence clearly suggests that glaciation modified a pre-existing karst landscape. Glacial activity collapsed certain cave passages and systems, gouged into others, and filled some with sediments. Features of the *EPIKARST* were also influenced by glaciers.



Typical epikarst *is impressively on display on an alpine mountaintop in Southeast Alaska.*

Thin soil *lies atop low-lying epikarst.*

Epikarst is the highly dissolved karst connection zone that links the surface to the subsurface. Vertical fractures in the epikarst are conduits between upper areas and cave systems below. The extent of epikarst development in Southeast Alaska is linked to the glacial history of the land, the elevation, and other factors. Epikarst is well-developed throughout the karst areas of Southeast Alaska, but is exceptionally pronounced at higher elevations (above 1,800 feet), where the most recent glaciation has not removed deep and elaborate epikarst features. Epikarst in alpine areas is less vegetated and is characterized by deep shafts, crevasse-like fissures, eroded rills of all sizes and spires and spikes of carbonate rock. Below treeline, epikarst is more vegetated and shallower. Epikarst in the alpine zone may be more than 100 feet deep, compared to less than 5 feet along the coast and at lower elevations. Epikarst at all elevations is very important in moving water, inorganic nutrients, organic matter and soil from the

Explorations continue

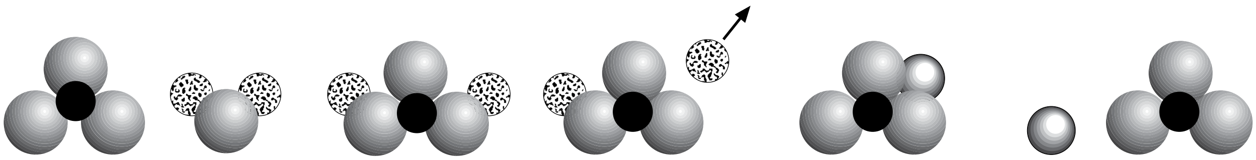
Hundreds or even thousands of yet-unexplored caves exist in Southeast karst areas. El Capitan Cave is the longest cave discovered so far, with 12,000 feet of surveyed passages and a depth of 256 feet.

Caves can keep secrets of glacial times

Most caves predate the latest glacial advance, which reached its maximum extent between 22,000 and 17,000 years ago. Because of this, we can use the caves to look at ancient life.

KARST CHEMISTRY
The calcite equation

Oxygen, Carbon, Hydrogen, Calcium



$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows HCO_3^- + H^+ \rightarrow CaCO_3 \rightarrow Ca_2^+ + CO_3^{2-}$$

$CO_2 + H_2O$	H_2CO_3	$HCO_3^- + H^+$	$CaCO_3$	$Ca_2^+ + CO_3^{2-}$
Carbon dioxide and water in the air combine to form carbonic acid that falls to earth and flows into the ground	Carbonic acid molecules—before the breakup	Bicarbonate ions and hydrogen ions part; the more hydrogen ions present, the stronger the acid	The acidic groundwater attacks the calcite of limestone or marble ($CaCO_3$)	Caves form as calcite rock rapidly dissolves into ions of calcium and carbonate and is carried away in solution

The 96 percent solution

Southern Southeast Alaskan carbonates are especially pure and provide soluble bedrock for the karst landscape. Acidic surface waters focus on fractures, folds, or other weaknesses in the carbonates, sculpting both the surface of the karst and dissolving out cave systems below.

land surface and rooting zone into subsurface regions. From subsurface areas, these materials move laterally to seeps and springs, or to vertical collecting structures which channel materials down to caves.

Hundreds or even thousands of caves in Southeast karst landscapes are still unexplored. They typically have vertical entrances and shafts that open to networks of cave passages. Huge volumes of groundwater surge periodically or continually through the passages. Scalloped walls and ceilings, spiral passages, deep plunge pools, flooded passages and sumps are common features. Boulders more than 2 feet in diameter seasonally batter the walls of some cave passages.

HYDROLOGY

Hydrology is the study of the properties and effects of water on the earth's surface, in the soil, in underlying rocks and in the atmosphere. Karst caves are dramatic examples of the action of acidic groundwater on soluble bedrock. Karst is formed primarily by chemical weathering of rock, rather than by mechanical weathering.

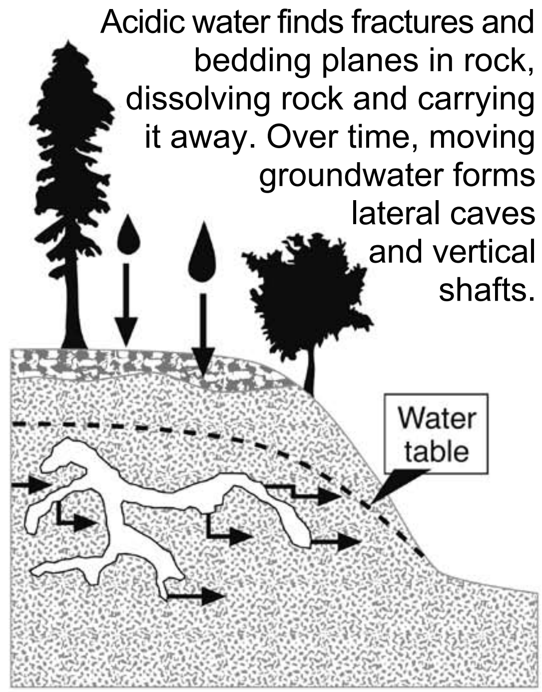
Carbonic acid occurs naturally in the ample rainfall of southeast Alaska due to the combination of atmospheric carbon dioxide and water. Organic matter in the soil also produces carbon dioxide, which reacts with water percolating through the soil to form more carbonic acid. Another source of acidity in the ***groundwater*** is organic acids, common components in the soils of coniferous forests and peatlands. The resulting acidic groundwater dissolves calcite in limestone and marble into its constituent ions, such as calcium and carbonate ions. The dissolved ions remain in solution and are then carried away in surface water and groundwater. A complex network of vertical shafts and lateral cave systems develops over time as the carbonate rock dissolves along joints and bedding planes.

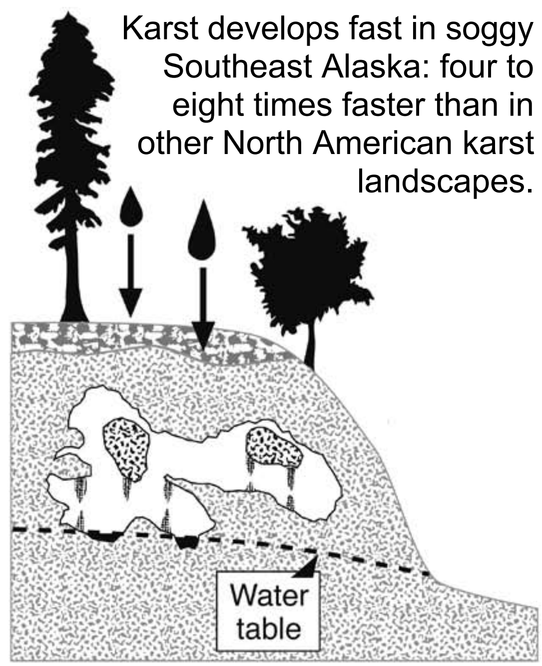
Speleothems: unique, natural works of art

Deposits of calcite form in caves when the mineral precipitates from the groundwater onto the cave's ceiling, walls or floor. Because hydrologic activity is intense in the caves of Southeast Alaska, dripstone deposits, or ***speleothems***, are not as plentiful as in other areas. But some striking formations of flowstone and delicate structures of ***helictites*** and ***soda straws*** can be observed. Another speleothem, called ***moon milk***, forms in deposits several feet thick — unusual for this type of formation.

Waters in surface peat are particularly important contributors to karst topography and caves in Southeast Alaska. Peatlands occur around the world and have a variety of common names, such as fens or bogs. Here in Southeast Alaska they are called muskegs. They are always characterized by

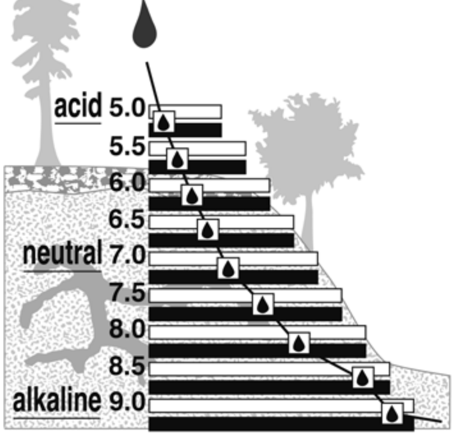
SPELEOGENESIS Creation of caves in karst landscapes





pH

Karst landscape chemistry



The flow from muskegs is acidic—in some areas, with a pH value as low as 2.4. Rainwater is also acidic. But the karst process chemically changes the water as it flows through calcite rock. Outflows from karst landscapes commonly have pH values of 7.5 to 8.0.

pH

A solution's pH number is its measure of acidity or alkalinity. A neutral solution has a pH of 7. Greater numbers indicate relative alkalinity; lesser numbers indicate relative acidity. The chemical shorthand comes from "p(otential) of H(ydrogen)."

waterlogged, acidic soils. In this region, peatlands develop on two types of sites: atop poorly drained, non-carbonate rocks, or on top of impermeable, compact glacial tills and marine silts that lie above non-carbonate or carbonate rocks. Plants characteristic of the peatlands, such as sphagnum moss and sedge species, tolerate acidic water. The decay of dead plant material further increases the acidity of the water. Water flowing from these peatlands is quite acidic, with pH values as low as 2.4. Water movement is slow in these poorly drained areas, but when the water reaches true carbonate substrate, it seldom flows more than a few yards before diving below ground, down vertical shafts, or into cave entrances. Here, the highly acidic water from the peatlands accelerates development of karst and caves. The buffering capacity of the pure carbonates is evident, for water flowing from cave systems charged by acidic water commonly shows a pH of 7.5-8.0.

Ample precipitation drives the karst process faster

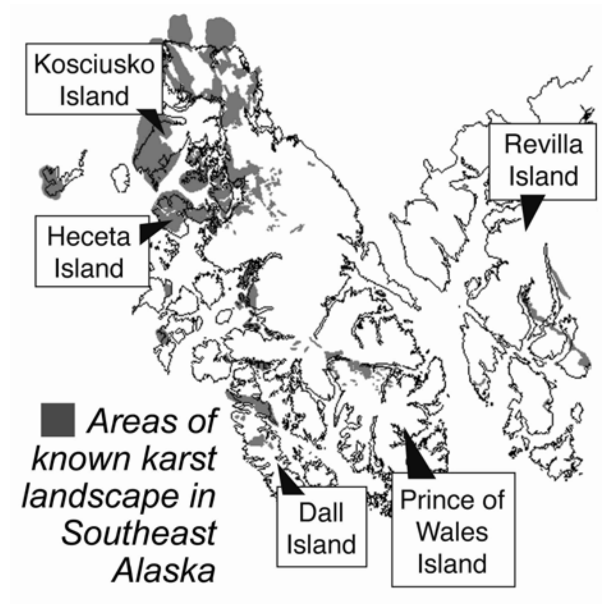
Rainfall is heavy in areas dominated by karst terrain; average annual precipitation ranges from 80 to 250 inches. Flooding occurs as well, particularly when rainstorms fall on wet snowpack. Most of the caves studied in Southeast Alaska are hydrologically active and very dynamic. Limited dye tracing work on Prince of Wales Island demonstrated that karst groundwater systems routinely transport water thousands of feet to springs and surface streams.

It is important to understand the differences in material transport mechanisms between karst and non-karst landforms. A particle of soil in a deposit atop non-carbonate substrate must be transported by gravity, landslides and/or surface water flows, sometimes over great distances, into a surface watercourse to become sediment. Atop a karst landform, depending on the openness of the karst system, a soil particle is transported laterally a few inches or feet before it washes vertically through a solution-widened fissure of the epikarst into the deep conduits of the system. Fissures in the epikarst become injection points for water and sediments to move rapidly downward into the complex subsurface drainage system. Even the presence of a single sinkhole, which intermittently retains water, indicates the a direct surface/subsurface connection. Sediment transported from roads and disturbed lands may emerge unexpectedly at distant springs, or even across the boundaries of surface watersheds or topographies.

PHYSICAL GEOGRAPHY

Southeast Alaska is a narrow strip of mainland coast and hundreds of islands in the Alexander Archipelago. The islands of the archipelago vary greatly in size, from small, unnamed islands to Prince of Wales Island, the third-largest island in America. The mainland strip averages only 25 miles wide from the tidewater to the mountain crests which mark the United States-Canada border. Large peaks dominate this boundary. For example, Mt. St. Elias, in northern southeast Alaska, is more than 18,000 feet tall. The peaks on the islands are less formidable, but still range in height from 2,000 to 4,000 feet. Only small areas of karst lands have been identified on the mainland portion of the region.The majority of the karst landscapes is in the archipelago, primarily on Prince of Wales Island and on nearby Dall and Heceta islands.

Areas of karst development in Southeast Alaska



Southeast Alaska consists of temperate rain forest ecosystems—a rich biological setting. As the name implies, this rain forest is the product of mild temperatures and abundant rain. The warm Alaska current, an offshoot of the northern Pacific Ocean's Kuroshio Drift, moderates temperatures: freezing winter weather and hot summer weather are infrequent and brief. Average Fahrenheit temperatures range from the high teens to the low 40s in the winter, and from the 40s to the mid-60s in the summer. The moderating influence of the ocean is even more pronounced along the outer coasts than farther inland. The maritime air masses carry great amounts of precipitation. As incoming clouds from the Pacific Ocean are intercepted by mountains of the islands and the mainland, the terrain is bathed with frequent showers and storms. Average rainfall ranges from 80 to 160 inches, although local topography and climatic conditions cause much variation. One area may receive only 27 inches a year, while another area is drenched with 400 inches.

This magnitude of moisture is pivotal in the biotic environment, just as it shapes the physical features of the karst areas. The landscape of Southeast Alaska forms an intricate

The watery web

Southeast Alaska is an intricate network of water, terrain and life. Alpine, forest and wetland areas are interconnected by a web of streams, ponds and lakes, all of them influenced by the rainforest's moisture.

pattern of mountain, alpine, forest, and wetland terrain, all interconnected by a network of streams, ponds, and lakes. The variability of bedrock, soil and microclimatic conditions provides the foundation for a rich mosaic of ecosystems across the landscape of Southeast Alaska. The ecosystems of most relevance to the karst landscapes are those of the alpine, forest and peatland.

Alpine areas do not support tree growth above about 2,500 feet, due to their elevation, cooler temperatures and greater snow accumulation. At these higher elevations, alpine meadows and alpine tundras persist.

At lower elevations, where sites are not too wet, coniferous forests become established; they are dominated by western hemlock and Sitka spruce. Where windthrow topples small areas of trees, sunlight reaches the forest floor and fosters growth of shrubs and herbs. Because of the great amount of precipitation, disturbance by fire is not an ecological factor.

The landscape of lower-elevation karst areas in Southeast Alaska contains nutrient-rich, well-drained soils that promote vigorous plant growth. Although the soil is shallow, well-developed subsurface drainage encourages growth of large trees because the numerous bedrock fractures provide root-holds. The trees are anchored to better withstand strong winds. In turn, the mature hemlock and spruce forest of the karst landscape supports highly productive terrestrial and aquatic animal communities.

In areas with poor drainage, wetlands or peatlands occur. Peatlands are in fact ancient wetlands. They are dominated by mosses in the genus *Sphagnum* and various sedge species, which thrive in the acidic waters.

CAVE BIOLOGY

The terrestrial and aquatic environments of Southeast Alaska provide a variety of habitats, and the array of organisms living here is just as diverse. Caves of the region provide unique habitats and niches for many life forms. These animals, plants, and other organisms range from opportunistic users of caves to species which are totally dependent on the caves' specialized environment. ***Disjunct*** and ***relictual*** populations of cave organisms also can provide valuable clues about ecosystems in the geologic past. Relictual cave populations can no longer live in the surface world due to long-term climatic changes, but can persist in the more stable conditions of caves. These populations are often found as isolated groups, living in caves separated by hundreds or thousands of miles.

Portal to a unique *environment and community of creatures — where the forest gives way to the darkness of the cave, scientists and cavers find fascinating adaptations.*

Go into a cave and you progress through a series of environments, from a realm of light at the entrance, to the twilight zone of more limited light, and then to the region of complete darkness in the interior spaces of the cave. These environmental gradations are home for different communities of organisms. Because many of the life forms that inhabit caves are small or microscopic, we can also visualize the cave community as an interconnected assemblage of ***habitats*** and organisms, varying in size from the ***microscopic*** to the ***macroscopic***. All the habitats of Southeast caves also contain some degree of moisture, from slick rock to pools of water and rushing streams.

Biologists who study cave life — their work is called ***biospeleology*** — classify cave-associated organisms according to their degree of dependence on and adaptation to cave conditions. Three categories are used: ***trogloxenes***, ***troglophiles***, and ***troglobites***.

Each of the five kingdoms of life has many representatives in Southeast Alaska caves, including some rare and unusual creatures.

Creatures of the caves fit into three main categories

Trogloxenes — cave visitors: they use cave habitat for specific purposes, on a sporadic basis, and cannot complete their entire life cycles in caves.

Troglophiles — cave lovers: they have a strong affinity for the dark, moist and cool conditions of cave interiors, and sometimes show changes in their anatomy, physiology or behavior.

Troglobites — Cave dwellers: they spend their entire life cycles in the dark zones of caves and exhibit a variety of adaptations to interior cave conditions.

Bacteria, members of the kingdom *Monera*, are common inhabitants in a range of cave environments and play an important role as decomposers of organic matter. These organisms are ***prokaryotic*** (without a nucleus in the cell). ***Cyanobacteria***, the photosynthetic ***monerans***, live in moist or watered sites exposed to light.

Phytoplankton, the unicellular algae of the kingdom Protista, are also found in the waters at or near cave entrances. Protozoans, the animal-like ***protists***, inhabit the aquatic communities of all the cave zones. The bacteria and plankton are microscopic, but their sheer numbers have ramifications on the life cycles of larger organisms and on the cave environment.

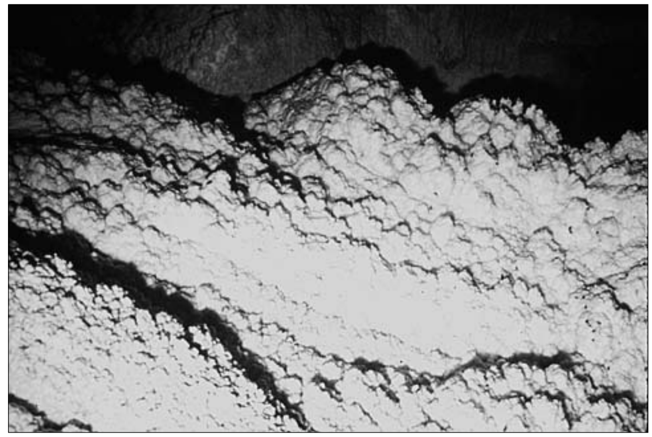
Members of the kingdom ***Fungi***, which are eukaryotic and multicellular, exist in both the light and dark regions of caves. Because fungi usually obtain nutrients through extracellular digestion of dead organic matter, they act as decomposers in the food webs, like the bacteria.

Plants, of the kingdom ***Plantae***, are photosynthetic, multicellular eukaryotes. They, of course, need light to carry out their autotrophic processes. Thus, they are restricted to cave entrances and to the twilight zone. However, the dead plant material that washes into caves is an important nutrient source for cave species.

Members of the kingdom ***Animalia***, multicellular eukaryotes which ingest their nutrients, belong to either of two broad categories: invertebrates or vertebrates. Most cave invertebrates are ***arthropods***, with jointed legs and exoskeletons — external coverings composed of hard ***chitin***. The other invertebrates are species of ***gastropods*** (snails and slugs) and various kinds of worms (flat, round, or segmented). Cave-associated vertebrates (animals with internal skeletons of bone) include most of the living classes of vertebrates — bony fish, amphibians, birds, and mammals. Southeast Alaskan karstlands lie too far north to support warmth-loving reptiles.

Into the cave: a spectrum of critters

Now let's explore the organisms of southeast Alaskan caves as one moves from the cave entrance to the interior. The environment at the entrance to a cave and in the twilight zone is exposed to sunlight and is readily accessible to cave visitors — the trogloxenes. Plants, especially those adapted to low levels of light intensity such as bryophytes (mosses, liverworts, and hornworts) and ferns, thrive at these sites. Various fungi also prosper here. Little is known about the ***BOTANY*** and ***MYCOLOGY*** of cave entrance flora, but it is probable that ***RELICTUAL POPULATIONS*** persist here. They have been found in other areas, such as California ferns and Illinois limestone glades.

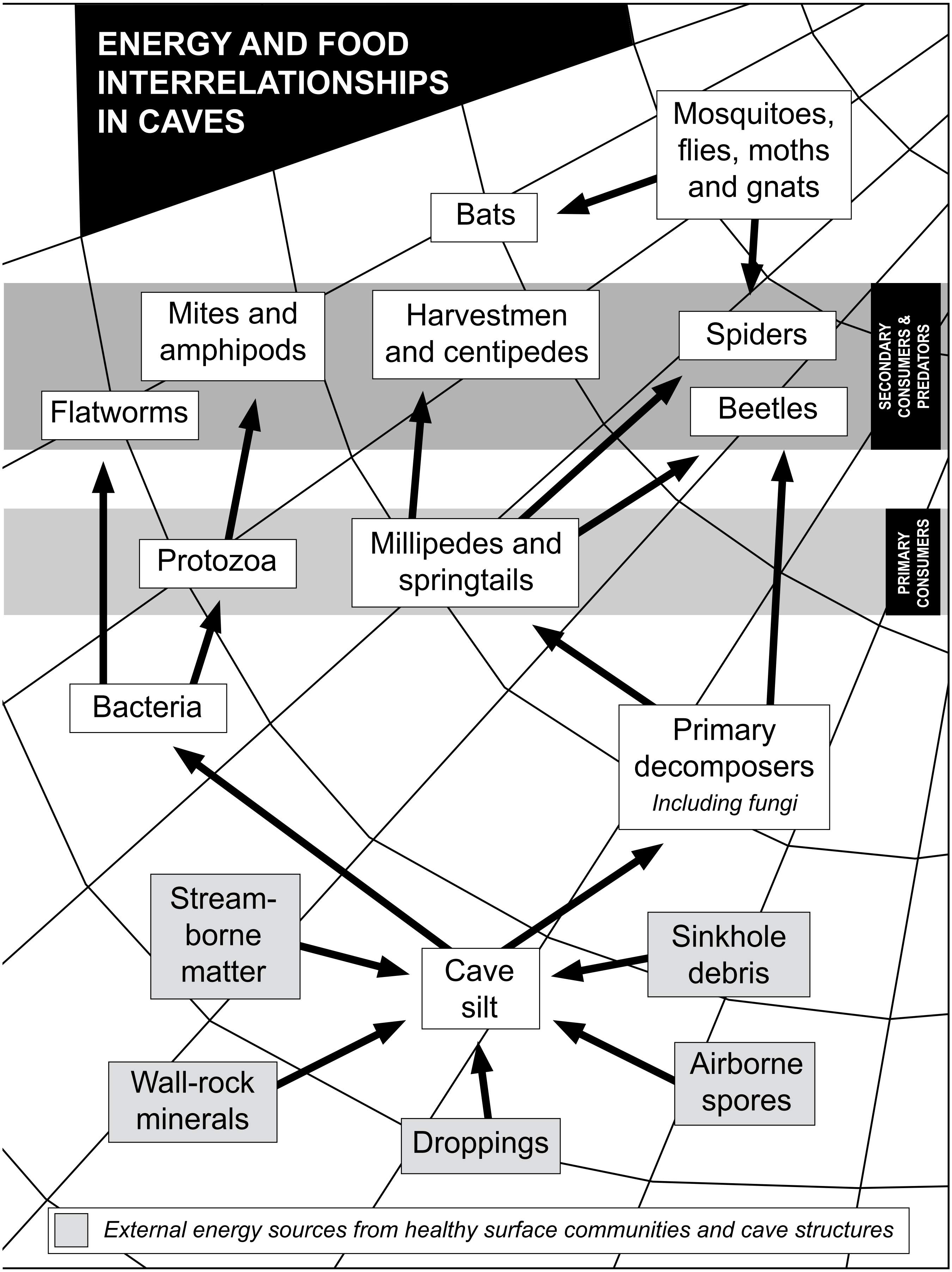


Moon milk *in a Southeast Alaskan cave — a peculiar deposit of calcite that looks a little like cottage cheese. Scientists have discovered that bacteria are involved in the unusually thick growth of this cave feature. Southeast Alaska caves contain unique microbial organisms that form these rare structures.*

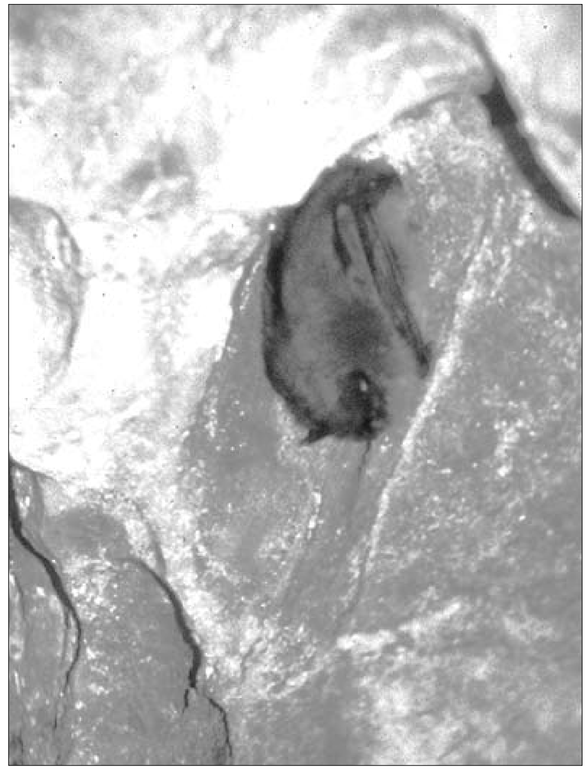
Sitka black-tailed deer are known to rest around cave entrances both in summer, when the air coming from the caves is cooler, and in winter, when the cave entrance environment is warmer than elsewhere. Certain passerine birds — such as the dipper, at least two swallow species and three species of thrush — use entrances for nesting and foraging. Some ***LITTORAL*** cave entrances support rookeries of cormorants, pigeon guillemots, murres, and puffins. Streams associated with cave systems support vigorous and plentiful species of fish because of their diverse and abundant aquatic invertebrate populations. For example, measurements indicate that fish from these streams grow six to eight times faster than fish from other streams. Although not yet observed, it is likely that other vertebrates such as rodent species and the region's two amphibian species, the rough-skinned newt and the western toad, utilize the resources of the entry areas. In temperate areas, amphibians are commonly found in caves, where they can shelter from dessication and the temperature extremes of the surface.

In addition to the aquatic invertebrates found in cave water, ***TERRESTRIAL*** invertebrate populations are present on the ground and in the soil. The moist litter of decaying organic matter and shelters such the undersides of rocks provide habitats for a diverse microcommunity of worms, snails, slugs, spiders, harvestmen ("daddy longlegs"), milllipedes, centipedes, mites and beetles. Like their aquatic relatives, these trogloxenic invertebrate populations of the terrestrial world are important components of the food webs of the cave entrance area.

Bats are probably the best-known of the trogloxenes. Preliminary surveys in Southeast Alaska show that bats are using some of the inventoried caves. Bats pick caves that fulfill some very particular requirements: the right cave


ENERGY AND FOOD INTERRELATIONSHIPS IN CAVES
Mosquitoes, flies, moths and gnats
Bats
Mites and amphipods
Harvestmen and centipedes
Spiders
Beetles
Flatworms
SECONDARY CONSUMERS & PREDATORS
Protozoa
Millipedes and springtails
PRIMARY CONSUMERS
Bacteria
Primary decomposers
Including fungi
Stream-borne matter
Cave silt
Sinkhole debris
Wall-rock minerals
Droppings
Airborne spores
External energy sources from healthy surface communities and cave structures

structure, appropriate temperatures and humidity, and proximity to feeding areas. Bats in Southeast Alaska eat a variety of insects and arachnids. The interaction of bats and their prey species is a vital part of the forest ecosystem. Two species of bats have been observed in Southeast Alaskan caves: the little brown bat (*Myotis lucifugus*) and the California bat (*Myotis californicus*). Another member of the genus *Myotis* has been collected in karst areas: the Keen's long-eared bat (*Myotis keenii*). The silver-haired bat (*Lasionycteris noctivagans*) may also use karst regions in Southeast.



A trogloxene sleeps: *this creature represents one of four species of bats found in Southeast.*

Bats take shelter in the zone of darkness

As the twilight zone merges into the zone of darkness, some trogloxenic species also use these dark regions for more extended periods of time. Southeast Alaska caves are especially important hibernacula for bats because freezing temperatures sometimes occur outside the caves during the winter. Colonies of hibernating bats are found in the protected interior areas, where temperatures remain above freezing. It's likely that female bats also aggregate in Southeast caves to rear their young during summer months. Such maternity colonies are common in caves of locales farther south. It has been noted that other mammals, such as bears, wolves, and river otters, use interior areas for hibernating and for giving birth to their young.

The zone of darkness in Southeast caves is home to both troglophilic and troglobitic species. One study at two karst areas found more than 17 troglophilic species of terrestrial and aquatic invertebrates. On the floors of the caves, springtails — wingless insects with specialized springing organs — hop about while spiders, harvestmen and stoneflies cling to the walls. The calm surface of streams and pools provides habitat for white mites that skim the surface, searching for prey. Beneath the surface, flatworms, segmented worms and insect larvae move slowly on the bottom and amphipods swim through the water, filtering it for minute particles of food.

Amphipods are the best invertebrate representatives for troglophilic and troglobitic types in Southeast caves. These

Troglobites: they caved in to their new environment

Troglobites are totally dependent on the cave environment. Their adaptations are well-developed: small bodies and long limbs; receptors that are highly sensitive to chemical and tactile stimulation; reduced or lost vision; lowered metabolic rate; and greater efficiency in movement and feeding behaviors.

This spider *tracing its way across moon milk is a troglophile: it often visits the cave for shelter or food, but it's just as much at home in moist, dark places outside the cave.*

FOR BEST ADAPTATION BY A SPECIES FROM ANOTHER ENVIRONMENT, THE NOMINEES ARE … This amphipod *typifies the cave-adapted features of the troglobite: a small body, long appendages and sightlessness. This* Stygobromus *was discovered on Heceta Island. It's virtually identical to its counterparts in caves on Vancouver Island. Our area of Southeast Alaska is the farthest-north extent of* Stygobromus*.*

animals are members of the crustacean subphylum, which also includes shrimp, lobsters and crabs. Their laterally compressed bodies give amphipods a shrimplike appearance. The occurrence of the troglophilic amphipod *Cratigonyx olliquus richmondensis* is the first observation of this species in any cave in northwestern North America. Troglobitic species of amphipods, such as the blind *Stygobromus quatsinensis*, have been collected from cave groundwater on Dall and Heceta islands of outer Southeast, but not from cave systems on Prince of Wales Island. This may indicate that glaciation caused the extinction of cave-adapted species on Prince of Wales Island, but that the outer islands were ice-free and thus retained the troglobites.

Troglobites are distinguished from troglophiles by their total dependence on the cave environment, and by a range of adaptations to this environment. These adaptations include small bodies and long limbs, highly sensitive receptors to chemical and tactile stimulation, reduced or lost vision, lowered metabolic rate, and greater efficiency in movement and feeding behaviors. The last two types of adaptations especially reflect the limited amount of nutrients available in the dark cave interiors. Without the rich source of food from photosynthetic organisms, food chains and webs in the dark zone involve more limited nutrient sources, with bacteria, fungi, and invertebrates playing the important roles. All these organisms are ultimately dependent on the flow of water from the surface world, which carries inorganic and organic nutrients to the obligate cave dwellers.

An intriguing potential bacterial association may occur in moonmilk, a deposit of calcium carbonate which reaches a thickness of several feet in some southeast Alaska caves. Bacterial species may be involved in the unusually thick growth of these formations. Clearly, caves of Southeast Alaska hold mysteries of life yet to be discovered.

PALEONTOLOGY AND ARCHAEOLOGY

Over the last decade, a small group of people has emerged with a determination to bring light to the mysteries of the limestone caves of the Alexander Archipelago. They come from diverse ethnic and professional backgrounds and include archaeologists, paleontologists, biologists, geologists, hydrologists, divers, pilots, fishermen and loggers. By pooling their information, they are piecing together the cultural and ecological past of Tongass National Forest.

The caves are on beautiful rain-drenched islands separated from the mainland of Alaska and British Columbia by wide straits. Strong currents, extreme tides and unpredictable weather dominate. The islands' rugged mountains rise sharply from the shore. The land is densely covered with trees, shrubs, bushes, ferns and mosses. The caves on these islands have preserved animal bones, tools, wood, and artwork. Cool air, constant temperature and high pH levels protect artifacts from decay. These keys to the past are sheltered from weather, wind and animals that might move them.

Illuminating the darkness—diverse explorers go into the Southeast Alaskan caves

A member of a scientific *exploration team drops carefully into a Southeast Alaskan cave. Sophisticated equipment, good preparation and teamwork are prerequisites for this work. The results are significant for biologists, paleontologists, archaeologists, geologists and others with an interest in the region's underground world.*

Archaeology is a wet business

Outside the caves, the weather and the rainforest environment of Southeast Alaska make it difficult to find archaeological sites. Plants, bushes and huge trees grow quickly, covering sites and artifacts. The Sitka spruce, red cedar and hemlock trees of southern Southeast Alaska grow into giants and when they fall they bury sites under massive amounts of organic material. The most detrimental factor for the preservation of archaeology though, is the destructive ability of the highly acidic water flowing out of the muskegs or wetlands, over organic artifacts. The extremely low pH of the water quickly breaks down and destroys organic artifacts. This means wooden spears, bone points, carved wooden implements, woven mats and baskets, sinew threads, and many,

This fossil bear skull and the remains of other animals taken from the caves tell scientists a lot about ancient climates and seacoasts. They can also provide clues to the human history of this region.

many other aspects of domestic life are all quickly lost to the elements. Only the inorganic materials survive, usually in the form of stone tools, commonly referred to as lithics. However, the limestone in the caves has a very high pH which neutralizes the naturally acid waters of Southeast Alaska and allows for excellent preservation of these and other organic artifacts.

Discoveries of many caves accompanied the intensification of logging and other development on the Tongass National Forest. Scientists working for the USDA Forest Service studied the caves and found entire karst systems.Their job was to inventory resources to determine whether proposed uses were appropriate. The Forest Service was concerned about preserving water systems, animal habitat, and archaeological sites while permitting responsible development and timber harvest. As scientists and loggers found more and more caves, they recognized that important new information was being discovered.

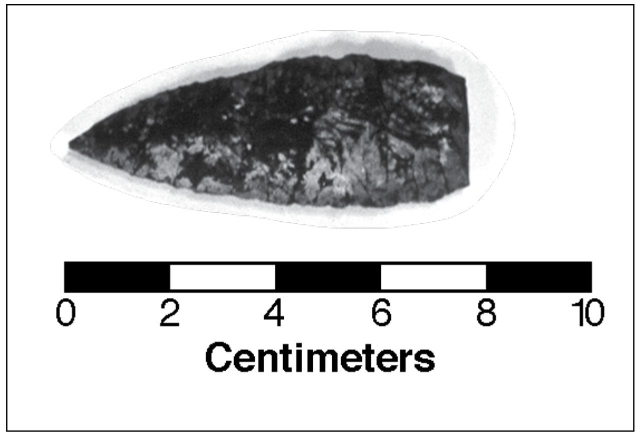
Forest Service scientists shared their discoveries with other scientists around the world. Now, many cave experts travel to the islands of Southeast Alaska each summer to search for evidence about how the island environment has changed since the last ice age. They also look for clues about how ancient peoples traveled throughout the islands and how the caves served for shelter and ceremonies.

Although the Pleistocene and Holocene vertebrate record has captured the attention of researchers studying the evolution of the modern environment, a far older history is captured in the caves. The Devonian and Silurian limestones that form the medium for cave formation contain a fascinating invertebrate fossil record of a period 450-350 million years ago. Nautilus Cave on Heceta Island was carved from Silurian gray and black marbilized limestone. Spaces between the stromatolites hold gastropod and brachiopod fossils that are replaced by white calcite or stained red by iron oxides.

The caves of Southeast Alaska are a paleontologist’s dream. Bones of animals trapped over thousands of years rest in countless sinkholes across the landscape. There is an undisturbed record of the animals that inhabited the area. Scientists are doing paleontological work where the caves' stable environment has preserved shells, bone, teeth, feathers, fibers, wood and charcoal. A single marmot tooth dated to more than 44,500 years ago was found in a cave on the west coast of Prince of Wales Island.

Bones from black bears (*Ursus americanus*) in an important cave on northern Prince of Wales Island have been dated to 41,600 years ago. Bones of brown or grizzly bears (*Ursus arctos*) from this cave have been dated to 35,363 years ago. To date, the remains of 16 brown bears have been recovered from caves in the southern Alexander Archipelago; they range in age from 35,363 to 7,205 years ago.

The blackened humerus of a deer or caribou was radiocarbon dated to 8,300 years ago. Other remains in the caves include a ringed seal dated to 17,600 years ago and a caribou dated to about 10,600 years ago. These mammal finds, combined with the presence of tundra voles and red foxes found in deposits, suggest that a landscape similar to that near present-day Kotzebue, Alaska, might have existed long ago in Southeast.

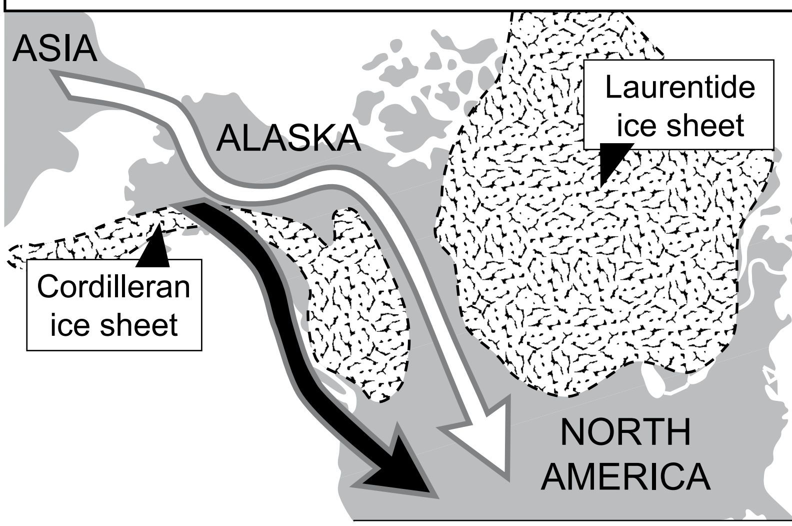


Cultural artifacts *such as this projectile point fashioned from dark grey chert, dated about 9,800 years ago, may be clues to human migration and habitation along this part of the coast. Scientists are watchful for circumstantial evidence for a theory that people with boats and navigation skills migrated southeastward along the Gulf of Alaska coast tens of thousands of years ago.*

A hibernaculum was discovered in El Capitan Cave on the west coast of Prince of Wales Island, in a glacial valley some 400 feet above present sea level. It contained the remains of at least four black bears and three grizzly bears, ranging in age from 12,300 years ago to 6,400 years ago. The bones of these bears were stained a dark, mahogany red and some were extremely well-preserved. Also recovered were the bones of bats, river otters and a red fox; the skull and jaw of an ermine; and many small fractured fish. Fish bones dated to 5,770 years were discovered. They had passed through the digestive tracts of river otters. Under two large rocks in the alcove, test digging revealed the skull and bones of a juvenile river otter sandwiched between fragmented cedar bark or matting. The otter was dated to 3,290 years ago. The cave may have been used as a natal den 6,000 years ago and perhaps visited by humans using cedar bark mats about 3,300 years ago. Grizzlies and marmots are extinct now on Prince of Wales Island.

Grizzly bears and black bears do not coexist on many of the islands of Southeast Alaska, but they do share the ground on the coastal mainland. It's possible that, before the end of the ice age and the rise in sea level, the outer coast of Southeast Alaskan islands was physically similar to present coastal mainland. As the sea rose, the two species were isolated together on islands. Black and grizzly bears did overlap at El Capitan Cave from 11,565 to approximately 7,000 years ago. The hibernaculum was open between 12,300 to 6,400 years ago. Grizzly bear fossils were also found in Blowing In the Wind Cave. These were dated to 9,995 years ago and provide more evidence of an early grizzly bear population on Prince of Wales Island. Scientists previously believed that ice covered Southeast Alaska until 10,000 years ago. These bears could not live in a glaciated environment because of inadequate food and shelter. Therefore, the presence of a 12,300-year-old grizzly bear in El Capitan Cave pushes the ice-free date back about 2,300 years. Significantly, both bears and humans are omnivores. It is very likely that where bears could live, humans could also live.

PLEISTOCENE PATHS: theorized routes of ice-age migration from Asia to North America



Conventional theory: hunters of large mammals followed herds from Asia via an ice-free corridor east of the Rockies.

Fladmark theory: humans with boats migrated south along the coast 40,000-11,000 years ago, avoiding ice obstacles.

For many years, most archaeologists believed that human migration to North America from Asia was blocked by massive glaciers in Alaska and Canada during the Pleistocene ice age. But recent evidence from karst regions in Southeast Alaska indicates that the southwesternmost islands of the Alexander Archipelago may not have been glaciated in the late Pleistocene. This region may have been a corridor for human populations much earlier than scientists thought possible. We see two indicators of an early coastal refugium: remnants of Pleistocene plant communities in alpine areas and greater genetic variation in chum salmon populations. Surveys by the Tongass Cave Project reveal caves and passages that predate the end of the Pleistocene. They would have been crushed by the ice had they been glaciated at the end of the

Pleistocene. Not only do the caves exist, but paleontological and archaeological components in them indicate they were ice-free.

Who was here first, and how?

Speculations about the first inhabitants of the Northwest Coast and the first human entry into North America are among the most intriguing topics of current archaeological research. In the "traditional view" popular for most of the 20th century, early Asian migrants traversed the Bering Land Bridge and followed herds of megafauna, or large prey animals, such as caribou and bison south through an ice-free corridor between the Cordilleran and Laurentide Ice Sheets, eventually entering into the northern plains and dispersing across North and South America. Another theory, introduced by Knut Fladmark in 1975, is gaining acceptance among archaeologists studying the Northwest Coast. According to this theory, as recently as 11,000 years ago or as early as 40,000 years ago, people with boats and ocean-going navigation skills migrated south along the coast. These people followed the exposed southern shore of the Bering Land Bridge, along the Alaska Peninsula and Gulf of Alaska, eventually traversing the exposed continental shelf of the Alexander Archipelago on their way south.

A link to the past: *this drawing reminds us that caves have provided shelter and a cultural canvas for Native inhabitants for millennia.*

Evidence for this theory is sparse and circumstantial at present. Study of the glacial history and paleontology of the coastal route suggests that no insurmountable obstacles to the journey existed and that ice-free refugia existed between 10,000 and 12,000 years ago and possibly even as much as 38,000 years ago on Prince of Wales Island. An obsidian source on Suemez Island was utilized for tool manufacture as early as 9,500 years ago. This distinctive volcanic glass has been found at archaeological sites in northern southeast Alaska and in British Columbia. This provides evidence that a boating people with an intimate knowledge of the resources was present in southeast Alaska at that time. Such familiarity suggests some length of occupation.

In 1996 a remarkable find was made by Dr. Timothy Heaton, a paleontologist working in a cave on north Prince of

Some caves *in Southeast Alaska result from physical weathering. Littoral or sea caves found along the coast demonstrate this process, as at this Baker Island site.*

Wales Island. Portions of a human skeleton and three tools were recovered from the same cave that had previously yielded bear bones dating to 41,600 and 35,363 years ago. The human bones proved to be about 9,800 years old, the oldest from Alaska and the Northwest coast, and offered a tremendous opportunity to learn about the early peoples in this area.

Human presence in Southeast Alaska

All of this supports the theory that there was a human presence in Southeast Alaska significantly earlier than 10,000 years ago. We still have not found that elusive site of 15,000 or more years ago where the first migrating groups of humans sat out bad weather and wondered what was ahead to the south. The search for such sites intrigues archaeologists and geologists of the Outer Island Cave Inventory Project, as well as many of the speleo-specialists of the Prince of Wales Island Expedition. The search brings together diverse scientific disciplines to answer questions such as: Where was the shoreline 15,000, 13,000 or 11,000 years ago? What species of marine and terrestrial animals were present? When were anadromous fish runs established and where? What plant resources were available and how were they distributed? In short, what ***PALEOECOLOGICAL*** clues are present to help us narrow down the search for the first human inhabitants of Southeast Alaska?

Understanding the changes in sea level with the melting of the Pleistocene glaciers is a major factor in finding the older sites. The sea level 17,000 years ago was 120 meters lower than it is today. The ice melted and by 10,000 years ago sea level was a few meters to as much as 100 meters higher than today—depending on the local magnitude of isostatic rebound, in which the earth rises as its burden of glacial ice is removed. For most of the time prior to 10,000 years ago, the shoreline was much lower than it is today. The archaeological remains of coastal camps from those times are now under water and difficult to find. Therefore, the search has focused on inland or elevated locales, where hunters and foragers would have sought temporary refuge. Caves offer the best opportunity for finding such sites.

Cave archaeology also sheds light on the more recent past

The bulk of archaeological evidence from caves in southern southeast Alaska is less than 4,000 years old. Most significant deposits are from rock shelters and shoreside caves rather than from deep solution passages. Only at El Capitan Cave do we find artifacts 600 feet back in a solution cave. Researchers are trying to determine the role of caves in the settlement pattern and seasonal round of inhabitants of Prince of Wales over the past several thousand years. Shells, animal bones, charcoal and a few broken tools provide the best evidence of what people were doing in caves. There are also a few caves with beautiful rock art panels. Archaeologists made exciting discoveries in one cave: two decorated wooden planks and an L-shaped wooden club. The planks have unique carved and painted designs and seem to have been made for connecting with lashing: in fact, cedar cordage was found in holes in the planks. Broken fish spines are embedded in the club and archaeologists think it may have been used as a fishing tool.

This wooden artifact *is believed to be a fish club — used and left behind 4,500 years ago by people who took shelter in a cave.*

Memories and oral histories of the Tlingit, Haida, and Tsimshian peoples are important sources of information on these caves and their uses. Alaska Native peoples of Southeast Alaska have a rich heritage and deep knowledge and understanding of the area and its resources. Their histories recount the spiritual as well as the everyday significance of localities in Southeast Alaska.

SAFETY IN THE CAVES

Caves throughout the world are fragile places of mystery, wonder and beauty. But they are also places of danger. Caves in Southeast Alaska can pose greater danger than others when cavers enter them without proper preparation. The National Speleological Society's observation is especially valid for Southeast Alaskan caves: "Reasonable safety in caving can be achieved only through a combination of a proper attitude, good equipment and training from those already well-versed in the specialized techniques of cave exploration."

A caver prepares *his equipment. Most Southeast caves are at least partly vertical; proper gear is essential for safe exploration. Technical training is also a good bet for safety.*

Caves are dark, so take several sources of light. The type and quantity of lights used in Southeast Alaskan caves are important considerations. These caves typically are wet and cold and contain rugged passages; they are in remote areas. Although a flashlight provides bright light, it is difficult to maneuver in the passages while positioning the flashlight. Climbing through windy passages while carrying a flashlight is a challenge best avoided. The best solution is to use headlamps. It is also important to carry at least three reliable sources of light per person. Extra lights are vital if first sources fail, if a partner's source goes out, or if lights are lost or broken — all common occurrences. Be sure to start with new batteries and test every light before entering the cave.

A hard hat is the second most important item of equipment. No matter what care the caver takes when negotiating difficult moves, encounters with the hard rock interior can happen. It is especially important to protect the head. Limestone can also be very sharp and the hard hat protects the head from cuts as well as impact injuries. It's useful for the hard hat to be secured by a quick-release device; even if the hard hat is jammed in a crevice, the caver's head can be freed. A light mounted to the hard hat frees the hands for maneuvering, but it adds weight.

To explore Southeast Alaskan caves, dress as if preparing to hike in the forest during the winter. Caves drip water throughout the year, so it is a good idea to wear some kind of tough, water-resistant cloth as outer protection. Underneath exterior clothing, wear several layers of warm clothes so that some can be removed during strenuous activity, or replaced during less-active periods. Wear or bring plenty of clothes. Caves are about 40 degrees Fahrenheit year-round, so hypothermia is a threat. Sturdy boots with slip-resistant soles are important. A small pack is useful for carrying extra clothing and equipment.

File a trip plan before going into the caves

Before departing for a cave, be sure to arrange for a "surface watch": a person who knows exactly where you are going, and when you plan to be out of the cave, and who has contact information that can aid cave rescue personnel in an emergency. When you leave the cave and return home, immediately get in touch with your surface watch to let them know you are safe. Even cavers on professional expeditions file daily trip plans. In the harsh underworld environment, little incidents can lead to major difficulties. Someone will be alerted to take action if accidents or complications knock you off schedule. It's also a good practice to notify friends or family about your itinerary: destination, expected time of return, etc.

Before deciding which caves to explore, find out which caves are subject to flooding. Some caves in Southeast Alaska can flood two days after rain stops. Consider the length of time to be spent in the cave and recent and current weather conditions outside the cave. If there is any concern about flooding, do not enter that cave. You can wait for a future trip.

While hiking to the cave, remember that although more than 500 caves have been identified, hundreds more wait to be discovered. Watch for cave entrances that might be covered with vegetation. Since many cave entries in Southeast Alaska are vertical shafts and pits, careful observation of the terrain is also a safety precaution.

After entering the cave, move slowly and take note of all the surroundings. Careful exploration prevents the accidental breaking of delicate formations. Watch for side passages and have some way of marking the main passage. Use some method that will not disturb the cave. If survey tape is used, be sure to pick it up on the way out. Know your limits and never exceed them. Unlike a mountain hike, the trip out of the cave can be just as strenuous as the trip in, so save

Good gear makes for safer cave exploration

- Use headlamps
- Carry at least three reliable sources of light per person
- It is especially important to protect the head: wear a hard hat
- Wear some kind of tough, water-resistant cloth as outer protection

enough energy for the return trip. Remember that it can be easy to climb up something that is very difficult to climb down. Turn around often and look back. Many people get lost on the way out because the cave looks very different from that perspective. Look up at the ceiling for rocks that might fall.

Careful observation increases the safety and enjoyment of the trip. Cave decorations can be quite dainty but very beautiful. Bats can be small enough to fit into a 35mm film canister. Other organisms are even smaller. Fossils and bones can blend into surrounding rocks. It takes a keen eye to see these things.

Consult an expert for information on caves

Information and training for exploration of Southeast Alaskan caves is available through the Glacier Grotto in Ketchikan. For information on caves and caving nationwide, get in touch with the National Speleological Society at Cave Avenue, Huntsville, AL 35810; telephone 205-852-1300.

The Rule of Three makes for smart caving

It's always a good idea to team up in a cave and experts recommend at least three people in the party. If one member of the team is injured, another person stays to care for the injured person while the third goes for help. One member of the party should bring first aid supplies and a small quantity of survival gear; a space blanket is a good item to have. If the trip is to be very long, carry food and water. Caving requires much energy simply to stay warm and it is important to maintain a high energy level. Water in the cave is subject to the same problems as on the surface, so don't drink the water in the cave without first purifying it. Partners can also watch for signs of stress in each other. Stress can include chills, discomfort in small areas, fatigue, hunger and fear of the unknown. A team that enters a cave should depart as a team, with one exception: when there is an adequate number of team members to leave some individuals behind, at least one of whom has experience in that cave, or is an experienced caver. A person who wishes to leave should not be made to feel badly. It's not a good trip unless everyone is having a good time.

Sometimes, despite all precautions, cavers get disoriented and lost. What to do? The worst thing is to rush up and down passages. That will probably lead to more disorientation. Don't panic. Stop, think, and assess the situation. Remember that it's impossible to panic if your breathing is normal. If there is immediate danger, move to a safe area and stay there. Move in place to stay warm. This common emergency emphasizes the importance of leaving a trip plan with your surface watch, along with family or friends. A detailed itinerary facilitates an informed rescue effort

Technical gear may be needed

It is important to remember that most of the caves in Southeast Alaska are vertical. Technical training and proper gear are essential if rope is needed for exploration. Mud, unstable rock, humidity and total darkness underground can't be surmounted with the usual aboveground climbing techniques.

USDA Forest Service has information on the caves of Tongass National Forest. Two cave sites have been developed by the agency for easier public access. Cavern Lake Cave has a trail and viewpoints at the entry area. Swimming through the cave should not be attempted due to the dangers of hypothermia and drowning. An excellent trail leads to El Capitan Cave and guided tours of the front passages are available during the summer. This cave is subject to rapid flooding and a gate was installed at the entrance to eliminate entrapment. El Capitan also has other hazards, such as deep vertical pits. Exploration of even developed caves in Southeast Alaska requires care and caution.

Cave explorers *find a raw beauty in formations such as this stalactite and stalagmite. And though such features develop over decades or centuries, they can be ruined in a moment. (See El Capitan Management plan in the appendices for more information.)*

CONSERVATION IN THE CAVES

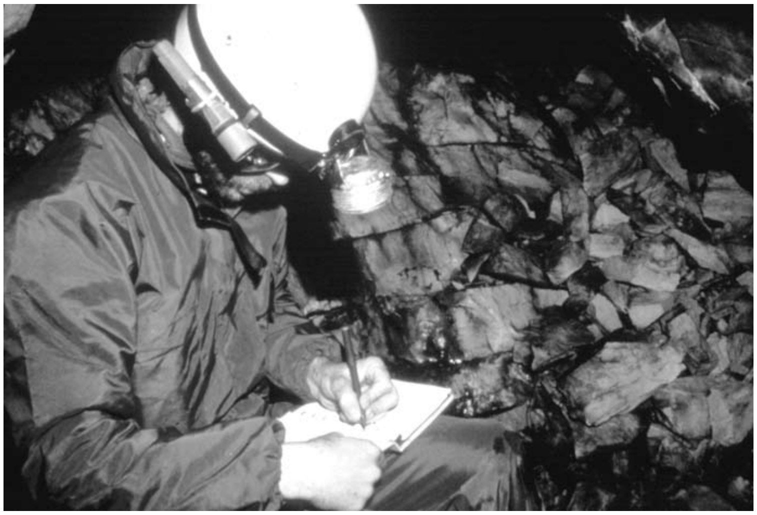
Every time people enter a cave, some kind of impact results. For example, in Carlsbad Caverns, New Mexico, species of microscopic organisms now line the visitor paths, waiting for hair, dead skin and other particles people shed as they pass through. These species were not there before humans entered. In another instance, ancient paintings in the caves of southern France are decomposing due to changes in the caves' climatic conditions caused by visitors. Visitors to developed caves and cavers in "wild" caves should minimize their impacts on cave environments.

Responsible cavers leave no signs of their presence and pack out any signs other parties may have left behind. They move slowly through caves and carefully consider their next sequence of movements. They watch the placement of muddy hands. Conservation-minded cavegoers try not to

Get info on Alaska's karst landscapes

For more information on Tongass National Forest caves, contact USDA Forest Service staff …

- Forest Supervisor in Ketchikan at 907-225-3101
- Craig Ranger District Office at 907-826-3271
- Thorne Bay Ranger District Office at 907-828-3304.



Help science, but don't hinder nature. *If you find an apparently valuable object in a cave, don't take it out or get a sample. Just note its position. Sketch it. And then report it to cave experts.*

lose their balance and accidentally grab some decoration; contact with even skin oil can stop formation of stalactites or stalagmites. These formations grow continually, over hundreds of years, and should not be disturbed. A removed formation may be decorative in a home, but it is even more beautiful in its natural setting, where many more visitors can enjoy it. Careful cavers leave alone any broken formations they find: removing broken formations simply encourages further collection. Visitors should bear in mind that many cave passages remain unsurveyed, because entry into the passages would have damaged the formations. No-impact cavers know to avoid handling or moving something of scientific interest, because its scientific value can be diminished. They note its position in the cave and notify a professional later.

Although it is a thrill to see a large wall of flow stone, moon milk, or a stalactite, cavers should take time to watch for cave popcorn and small fossils. Cave popcorn, a formation of delicate crystals, is very common in Southeast Alaska caves. Fossils embedded in cave walls have drawn micropaleontologists to Southeast Alaska from other areas of the country for several years. Sometimes bats may be seen in the caves. It's important not to disturb them. A hibernating bat can use up most of its stored energy if it is disturbed and will be unable to live through the winter.

The Tongass Cave Project in the late 1970s led the initial effort to increase awareness of cave resources. The value and the vulnerability of Southeast Alaska caves were recognized in the 1980s, with El Capitan (or El Cap) Cave first in focus. In 1984, USDA Forest Service staff saw the recreational potential at El Cap about the same time as they noted vandalism to formations inside. By 1992, they were developing a management plan and solutions to vandalism. Forest Service staff decided that a gate would most effectively prevent vandalism to fragile speleothems and disturbances to little brown bats — *Myotis lucifugus*. The management plan further identified the need to control access beyond a gate and looked at protecting recreational cavers from several deep pits along the main passage at El Cap Cave.

The Forest Service installed a so-called air flow bat gate about 150 feet inside El Cap Cave during the summer of 1993. A lot of research and experience went into the gate. Roy Powers of the American Cave Conservation Association and Robert Currie of the U.S. Fish and Wildlife Service were consultants on the design. Jim Nieland of the Forest Service contributed on-site design and construction. The gate was welded and installed by Robert Wetherell of Thorne Bay Ranger District. Air flow, temperature, humidity and deterring human intrusion are essential factors in a successful design. A heavy steel gate with few opening will keep people out, but won't allow proper air exchange and regulation of temperature and humidity — requirements to maintain an undisturbed population of bats and to preserve growth of cave formations. A properly used gate is one of the most powerful tools for implementing and enforcing a cave closure. Gates are, on the other hand, expensive to install and to maintain. They can also be ineffective if they're designed poorly or installed incorrectly — or if they're not part of a comprehensive management plan.

Tongass Cave Project *volunteers were pioneers in discovering, mapping and protecting Southeast Alaska's caves, starting in the 1980s.*

El Cap Cave gate: a ton of prevention

Weight of steel 2,100 pounds
Cost of steel $2,000
Labor cost $9,000
Logistical support cost $4,000
Configuration horizontal steel members 5.75 inches apart keep out people, let in air, allow bats to pass in and out

Not much is known about the effects of gates on caves. Some caves have flora and fauna that are susceptible to the minutest of changes. At a minimum, efforts should be made to study a cave before and after installation of a gate in order to record these effects. Future designs should take such effects into consideration and should be modified to accommodate them.

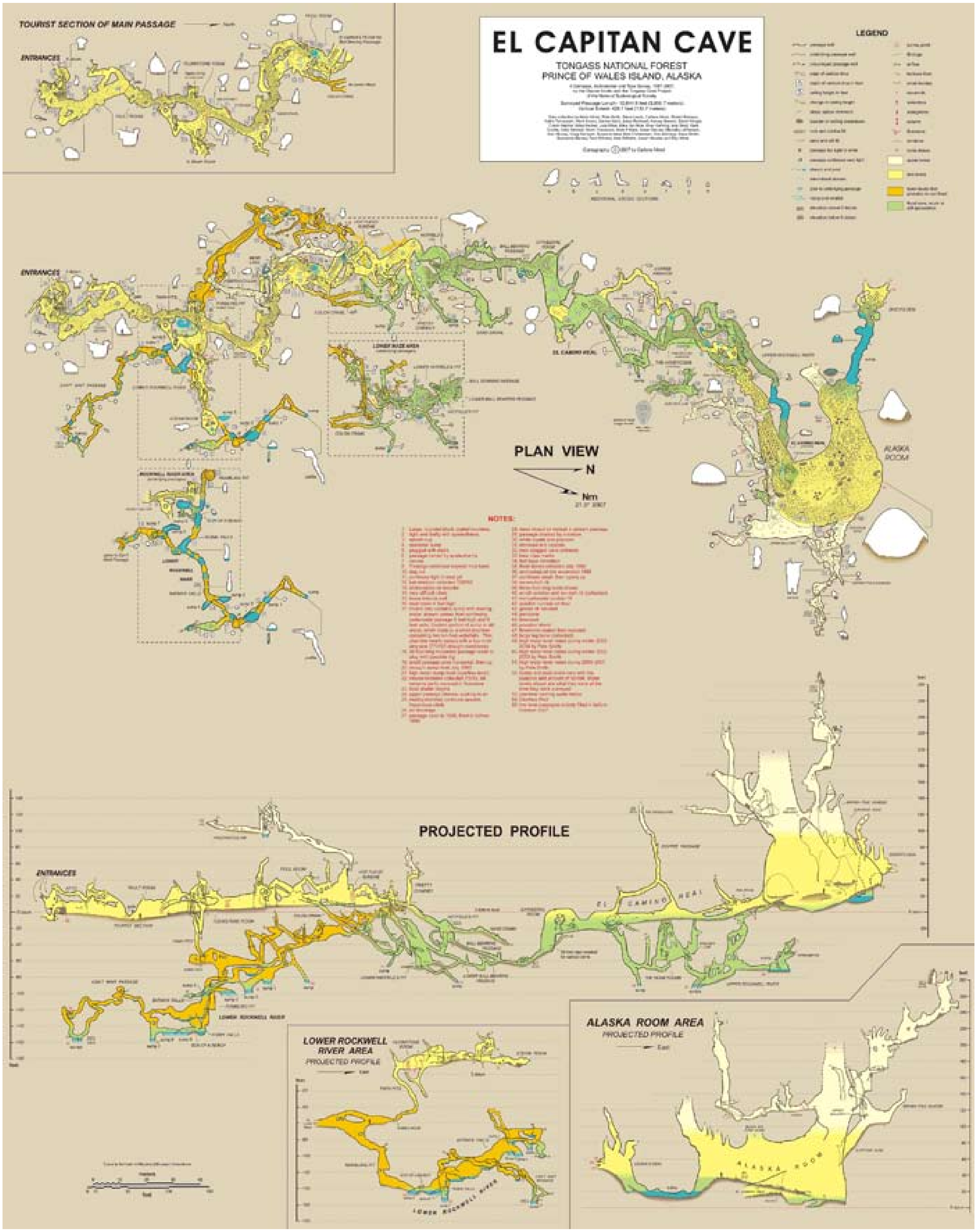
The bats *Myotis lucifugus* and *Myotis californicus* have been seen behind the gate at El Cap and don't seem to mind flying past the gate.The eastern species *Myotis grisecens*, or gray bat, isn't so easygoing: the bats will not tolerate any kind of full gate on their maternity caves, but will tolerate some gating on hibernation caves. This goes to prove that cave gating is an inexact science.

Forest Service *scientists and technicians such as this group pictured in the 1990s have been instrumental in both exploring and managing these unique karst areas.*

The best way to protect the cave is for cavers to be on the alert for all the wonders of the cave, large and small. They can then avoid moves or actions that could damage the caves. By following these guidelines, cave visitors can ensure that the caves are protected and we can continue to enjoy the mystery and beauty that lie underground.

The karst landscapes and caves of Southeast Alaska offer a precious legacy to scientists and everyday people—including students and teachers.The fascinating geological stories they tell and their unique influences on the rain forest ecosystem are nature's textbooks for studies ranging from tectonic drift to human migration.

APPENDICES


EL CAPITAN CAVE
TONGASS NATIONAL FOREST
PRINCE OF WALES ISLAND, ALASKA
TOURIST SECTION OF MAIN PASSAGE
ENTRANCES
LEGEND
ENTRANCES
PLAN VIEW
N
Nm
NOTES:
ALASKA ROOM
PROJECTED PROFILE
ENTRANCES
EL CAMINO REAL
LOWER ROCKWELL RIVER
LOWER ROCKWELL RIVER AREA
PROJECTED PROFILE
ALASKA ROOM AREA
PROJECTED PROFILE
ALASKA ROOM
LOWER ROCKWELL RIVER

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GLOSSARY

ALKALINE Water or another substance with a pH (percentage of hydrogen) greater than 7. Acidic water (pH less than 7) from muskegs can be neutralized and become alkaline by reacting with the calcite of karst formations.

ALPINE Higher-elevation terrestrial region, above treeline, and often the associated vegetation community. Alpine epikarst typically lacks vegetation.

AMPHIPOD Small crustaceans of the group *Amphipoda*, including beach fleas and sand hoppers.

ANADROMOUS Migrating from the sea up a river to spawn, as in salmon species.

AQUATIC Of, in, or pertaining to water; living or growing in water.

AQUIFER A permeable subsurface stratum, or zone, through which groundwater moves in sufficient quantities to supply water for wells and springs.

ARCHAEOLOGY Scientific study of historic or prehistoric peoples and their cultures by analysis of their artifacts, inscriptions, monuments and other such remains, especially those that have been excavated.

ARCHAEOLOGICAL SITE A scientifically administered location that yields evidence relating to historic or prehistoric peoples and their cultures; may be above ground, in a cave, buried below ground level, or even under water.

ARACHNID An arthropod of the class *Arachnida*, comprising 57,000 species of spiders, scorpions, mites and ticks. Most are terrestrial, breath air and have four pairs of walking legs.

ARTIFACT A human-made object, such as a prehistoric tool, weapon, or pottery shard.

ARTHROPOD Any segmented invertebrate of the phylum *Arthropoda* having jointed legs and exoskeletons composed of hard chitin; includes insects, arachnids, and crustaceans. This largest phylum in the animal kingdom, with more than 1 million species classified to date.

AUTOTROPHIC Capable of utilizing only inorganic materials as a source of food, as most plants and certain bacteria and protozoans.

BEDROCK Solid rock that lies beneath the soil. In karst landscapes the bedrock, often limestone, is soluble (can be dissolved) by the chemical action of carbonic acid and is referred to as soluble bedrock.

BERING LAND BRIDGE The connecting land mass which existed between Siberia and Alaska during the last glacial advance, which lowered sea levels. People and animals may have migrated along this continental connection 15,000 to 11,000 years ago.

BERINGIA Referring to the Bering Land Bridge region of the last ice age.

BIOSPELEOLOGY Exploration and study of the flora and fauna (plants and animals) of caves.

BIOTIC Of or pertaining to life; typically, plants and animals in a natural environment or ecosystem.

BOTANY Scientific study of plants, plant life and plant communities of a region.

BRACHIOPOD A mollusk-like marine animal, phylum *Brachiopoda*. These animals have hard dorsal and ventral shells, resemble clams and feed by means of a lophophore. They are represented by 30,000 extinct species and 250 living species.

BRECCIA Rock composed of angular fragments of older rocks cemented together.

CATCHMENT Something that catches water.

CAVERN/CAVE Any naturally occurring void, cavity, recess, or system of interconnected passages which occurs beneath the surface of the earth or within a cliff or ledge and which is large enough to permit an individual to enter, whether or not the entrance is naturally formed or human-made. This includes any natural pit, sinkhole, or other feature which is an extension of the surface. (From the Federal Cave Resource Protection Act, 1988.)

CALCAREOUS Containing calcium carbonate.

CALCITE A common mineral, also known as calcium carbonate, that occurs in a great variety of crystalline forms. It is a major constituent of limestone, marble, chalk and the exoskeletons of many marine organisms.

CAVE POPCORN A formation of delicate crystals.

CEMENTATION Binding and cohesion of sediments to form a solid mass.

CHIROPTERA The order of animals comprising the bats.

COMPACTION Consolidation of sediments resulting from the weight of overlying deposits.

CONGLOMERATE Rock containing worn and rounded stones embedded within a finer cementation.

CRUSTACEAN An arthropod of the class *Crustacea.* An aquatic creature with compound eyes, two pairs of antennae and one pair of mandibles. It is represented by lobsters, crayfish, crabs, shrimp, and the shrimp-like, but much smaller, amphipoda.

CYANOBACTERIA Photosynthetic moneran autotrophs (bacteria), known as blue-green algae, but including species of many different colors, living in moist or watered sites exposed to sunlight.

DECAY Entire or partial dissolution, deterioration, or decomposition by progressive natural processes.

DIKE A long, narrow and more or less vertical mass of igneous or eruptive rock intruded into a fissure of surrounding older rock.

DISJUNCT Disjoined or separated; as in organisms living in caves hundreds or thousands of miles from like organisms.

DISORIENTATION Confusion concerning relative location and position; loss of sense of direction.

ECOLOGY The branch of biology that studies the interactions of organisms with their physical environment and with each other, and the results of such interactions.

ECOSYSTEM A system formed by the interaction of a community of organisms with their biotic and abiotic environment.

EPIKARST A highly dissolved land surface consisting of an intricate network of intersecting roofless dissolution-widened fissures, cavities, and tubes dissolved into the carbonate bedrock. Other features include vertical fractures, shafts, spikes, spires and eroded rills of carbonate rock.

EUKARYOTIC Cells with a membrane-bound nucleus and membrane-bound organelles.

EXOSKELETON The outer supporting covering of an invertebrate body; common in arthropods.

EXTINCT No longer existing; died out.

FAULT A break in the continuity of a body of rock, attended by movement along the break.

FLORALTURBATION A disturbance process involving plants that changes the context of the archaeological record and affects interpretations of the locations and conditions of artifacts.

FLOW STONE Smooth sheets of calcite deposited by water flowing down the walls of a cave. Crystals in the deposits grow perpendicular to the flow.

FORMATIONS Either a body of rocks, or stratum, classed as a unit for geologic mapping; or a deposit of calcium carbonate material of various types, shapes and sizes, such as stalactites, or stalagmites.

FUNGI Plants without leaves, flowers, or chlorophyll which usually obtain nutrients through extracellular digestion of dead organic matter. Eukaryotic and multicellular, they act as decomposers in food webs, like bacteria. Examples are mushrooms and molds.

GASTROPOD Asymmetrical mollusks of the class *Gastropoda*. These invertebrates with spiral shells and heads with one or two pairs of tentacles, include snails, whelks and slugs.

GEOLOGY The science that deals with the physical history of the earth, the rocks of which it is composed and the physical changes which the earth has undergone or is undergoing. Also refers to the geologic features and processes occuring in a given region of the earth.

GLACIER An extended mass of ice originating from a region of perpetual snow, either moving slowly downward from high elevations as mountain-valley glaciers or moving outward from centers of accumulation, as in continental glaciers. Glaciers are immense agents of erosion and landscape modification.

GROUNDWATER Water beneath the surface of the land, consisting largely of surface water that has seeped or permeated downward. May become part of an aquifer, or the source of a spring. Acidic groundwater dissolves calcite in limestone, creating karst.

HABITAT The native environment, or home, of a plant or animal; the kind of place that is natural for the life and growth of an animal or plant.

HETEROTROPHIC Relating to an organism that must feed on organic materials formed by other organisms in order to obtain energy; contrast with autotroph. Includes animals, fungi, and many unicellular organisms.

HIBERNACULA A protective, secure residence, such as a cave or burrow, of an animal that spends time in a dormant condition.

HIBERNATION A period of dormancy or inactivity, varying in length depending on the species, and occurring in dry or cold seasons. Metabolic processes are greatly slowed and body temperatures may drop close to the freezing point.

HOMEOTHERMIC Relating to an organism, such as a bird or mammal, capable of maintaining a stable body temperature independent of the environment.

HUMERUS A bone of the upper arm or limb of an animal.

HYDROLOGY The science dealing with the occurrence, circulation, distribution, properties and effects of the waters of the earth and its atmosphere.

HYPOTHERMIA Life-threatening condition of having a body temperature greatly below normal.

ICE AGE A time of great glacial advance, the last one ending about 10,000 years ago.

IGNEOUS Produced under conditions involving intense heat, as rocks of volcanic origin or rocks crystallized from molten magma.

INTRUSION The forcing of extraneous matter, as molten rock, into some other geologic formation.

INVERTEBRATE An animal lacking a vertebral column, or internal backbone, such as crustaceans, bacteria, plankton, and algae.

ISOSTASY/ISOSTATIC REBOUND Land areas rebounding, or returning to equilibrium, from a period of depression due to an overriding mass of glacial ice, as during the last ice age. Isostatic rebound in southeast Alaska has been found to be anywhere from a few meters to a hundred meters, depending largely on the degree of glaciation at a particular location.

KARST Topography that develops in areas underlain by soluble rocks, primarily limestones. Dissolution of subsurface strata results in areas of well-developed subsurface drainage characterized by sinkholes, collapsed channels, vertical shafts, and caves. The name derived from the Balkan region of Kras, where early karst research was conducted.

LIMESTONE Stone consisting primarily of calcium carbonate. Exoskeletons of many marine organisms contain calcium carbonate. With time, sea floor accumulation, compaction and cementation, these calcite beds become limestone formations.

LITTORAL Pertaining to the shore of a lake, sea, or ocean.

MACROSCOPIC Generally small, but visible and distinct to the unaided eye. Gastropods are macroscopic organisms.

MARITIME Living, situated, or found near the sea or ocean.

MARMOT Bushy-tailed, stocky rodent of the genus *Marmota*, common in northern terrestrial regions.

MEGAFAUNA Referring to large animals, such as caribou, bison, bear, and moose.

MICROCLIMATE The climate of a small or confined area, such as a cave, plant community or wooded area.

MICROSCOPIC Organisms, for example, so small as to be invisible or indistinct without the aid of a microscope. Bacteria are microscopic organisms.

MIDDEN A refuse heap; a pile of discarded waste associated with a human settlement; shell midden. Middens are often rich archaeological sources.

MIGRATION Movement of people or animals from one place or region of habitation to another. Examples are the migration of people from Asia to North America or migration of birds south for the winter. Also refers to plate tectonics and the migration of terranes or microplates.

MONERANS Of the kingdom *Monera.* Prokaryotic bacteria that play an important role as decomposers of organic matter. The most abundant, oldest and smallest organisms in the world; they can survive in many environments that support no other form of life.

MOON MILK A dripstone calcium carbonate deposit or speleothem; accumulates to several feet thick in some southeast Alaska caves, with possible bacterial associations accounting for the depth.

MUSKEG The Alaskan name for a swamp or bog. Characterized by waterlogged soils, impermeable substrate, acidic water and plants such as sphagnum moss and sedges. The acidic water flow from muskegs accelerates development of subsurface karst.

MYCOLOGY The branch of botany dealing with fungi.

NATAL Pertaining to birth. Bears, wolves, and river otters use caves for natal, or birthing, purposes.

OBSIDIAN A volcanic glass similar in composition to granite, usually dark but transparent in thin pieces and having a good conchoidal fracture.

OMNIVORE An animal that consumes both plant and animal foods.

PALEOECOLOGY Study of the ecological relationships prevailing in past geologic ages.

PALEOKARST Karst formations existing for a great period of geologic time. Most caves in southeast Alaska predate the latest glacial advance, with some evidence showing ages of millions of years.

PALEONTOLOGY The science of the forms of life existing in former geologic periods, as represented by fossil animals and plants.

PASSERINE Birds of the order *Passeriformes*, with feet adapted for perching. Includes more than half of all bird species, such as dippers, swallows, and thrush species.

PEATLANDS Otherwise known as muskegs, fens, or bogs. Characterized by waterlogged soils, impermeable substrate, acidic water, and plants such as sphagnum moss and sedges. The acidic water flow from peatlands accelerates development of subsurface karst.

PERMEABILITY Pertaining to a rock or soil and its capacity for transmitting a fluid through its pore spaces.

PHOTOSYNTHESIS Synthesis of complex organic materials, especially carbohydrates, from carbon dioxide, water, and inorganic salts, using sunlight as the source of energy and with the aid of a catalyst such as chlorophyll.

POROSITY The volume of pore space in rock or soil, expressed as a percentage of total volume.

PROKARYOTIC Cells lacking a membrane-bound nucleus and membrane-bound organelles; a bacterium or cyanobacterium.

PROTISTS Of the kingdom *Protista.* Eukaryotic, mostly unicellular organisms, including amoebas, paramecia, and algae.

RADIOCARBON DATING Determination of the age of objects of plant or animal origin by measurement of the radioactivity of their radiocarbon content, which declines at a steady rate over time.

RECHARGE AREA Surface areas that supply water to subsurface karst systems.

REFUGIA/REFUGIUM A place, or places, free or safe from glacial advance, such as a nunatak, or exposed knob of bedrock surrounded by ice.

RELICTUAL Referring to an organism living in an environment different from that which is, or was, typical for it. For example, a population that can no longer live in the surface world due to climatic changes but can persist in more stable cave conditions.

RILL A long, narrow trench; a feature of epikarst terrain.

ROOKERY A colony, or breeding place, most commonly of birds, such as cormorants, pigeon guillemots, murres, and puffins.

SILL An intrusive sheet of igneous rock forced, usually horizontally, between layers of older surrounding rock strata.

SINKHOLE A relatively shallow bowl- or funnel-shaped depressions ranging in diameter from a few feet to more than 3,000 feet. Generally formed by dissolution of and subsequent settlement of bedrock to form a depression, or collapse of shallow cave roofs to form a depression.

SOLUTION The process of chemical weathering by which rock material is dissolved and removed, as in the formation of karst features.

SPELEOGEN Relief features on the walls, ceiling and/or floor of a cave that are part of the surrounding bedroom.

SPELEOLOGY The exploration and study of caves.

SPELEOTHEM Any natural mineral formation or deposit occurring in a cave, including flowstone, helictites, soda straws, and moon milk.

SPRING A surface seepage of groundwater; common in karst landscapes.

SUBSTRATE Underlying stratum or layer, as in bedrock beneath soil.

SUBTERRANEAN Subsurface; below ground level.

STALACTITE Calcium carbonate formation shaped like an icicle, often hanging from the roof of a cave, formed by the dripping of percolating calcareous water.

STALAGMITE Calcium carbonate formation resembling an inverted stalactite, formed on the floor of a cave by the dripping of percolating calcareous water.

STROMATOLITE Reef formation composed of mats of photosynthetic bacteria and sediments.

TECTONIC Relating to forces or conditions within the earth that cause movements of the crust such as earthquakes, folds, or faults. Tectonic forces have caused of the accretion of exotic terranes that comprise Southeast Alaska today.

TECTONIC PLATE Large section of the earth's crust, either oceanic or continental, that is in motion due to forces within the earth. Tectonic activity in Alaska is due to interaction between the Pacific plate, and the North American plate.

TERRANE A rock formation or continental plate fragment of lesser density which rides upon an oceanic plate of greater density. It may either join with other fragments, merge with a microplate, or dock with a major continental plate. The terranes of Southeast Alaska have moved from distant regions and are called exotic terranes.

TERRESTRIAL Pertaining to earth or land, as opposed to water or air; things living or growing on, or in, the ground.

THEORY An hypothesis supported to some extent by evidence but not conclusively proven or accepted as a law.

TOPOGRAPHY Physical features of a region, especially the relief and contours of the land.

TROGLOXENE Cave visitor: uses cave habitat for specific purposes, on a sporadic basis, and exhibits no cave-related adaptations.

TROGLOPHILE Cave lovers: have a strong affinity for the dark, moist, and cool conditions of cave interiors and sometimes show changes in their anatomy, physiology, or behavior.

TROGLOBITE Cave dwellers: spend their entire life cycles in the dark zones of caves and exhibit a variety of adaptations to interior cave conditions.

VERTEBRATE An animal having an internal backbone, or spinal column, such as mammals, birds, reptiles, amphibians, and fishes.

WATERSHED The region drained by a river system; a drainage basin.

WATER TABLE The depth below which the ground is saturated with water; the level of groundwater.

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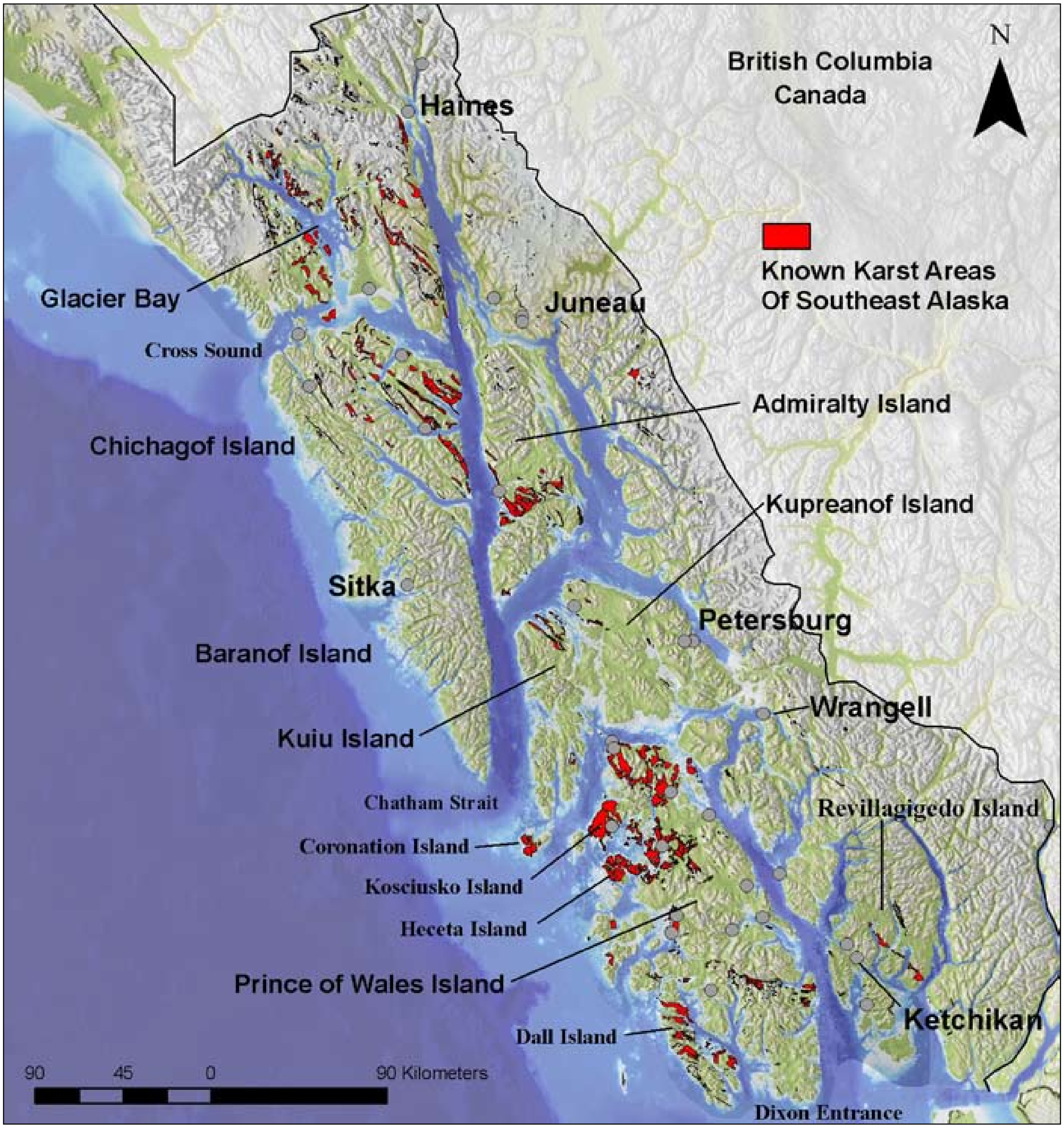
Map of Karst Areas in Southeast Alaska



ACTIVITIES

Acid Rock
Soda Sink
Milk Jug Hydrology
Dew or Rain?
Soil Communities
Archaeological Site Formation Processes
Archaeological Disturbance Formation Processes
Word Find Puzzle
Crossword Puzzle

ACTIVITY

ACID ROCK

GRADE LEVEL: 7-12

Goal

Carbonate rocks and carbonate-dominated landscapes react to and are sculpted by slightly acidic rainwater.

Objectives

At the end of the laboratory activity, the student should be able to observe the effects of an acid on soluble and insoluble rock types and to understand how the interaction of acidic solutions with soluble bedrock contributes to the formation of caves.

Background

When rain mixes with carbon dioxide in the air, it forms a weak acid called carbonic acid. Thus, the rain entering surface and subsurface waters is slightly acidic. As water percolates through the soil and other subsurface materials, it becomes more acidic. This increasing acidity is due to the release of carbon dioxide into the soil from the respiration of microorganisms and plant root systems. Carbon dioxide is also released from the decay of organic matter. Some of the carbon dioxide which dissolves in the subsurface water reacts with the water, and more carbonic acid is formed. Another source of acidity in the soil is organic acids released from the decay of dead organisms.

If an area is underlain with soluble bedrock, such as the carbonates of limestone or marble, it slowly dissolves when exposed to the acidic groundwater. Cracks and fissures in the rock are natural points of water collection and chemical erosion. Over time, these sites enlarge and a cave is formed.

A standard test to distinguish carbonate from non-carbonate rock is exposure to an acid. Carbonate rocks undergo a “bubbling” chemical reaction when exposed to an acid.

Please note: this activity can also be performed as a demonstration, rather than as individual student or group investigations.

ALASKA STUDENT PERFORMANCE STANDARDS

All Alaskan students will understand scientific facts, concepts, principles and theories.

Students who meet this standard will …

(7) Understand how the earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things.

(15) Use science to understand and describe the local environment (Local Knowledge).

All Alaskan students will understand and develop the skills of scientific inquiry.

Students who meet this standard will …

(1) Use the processes of science, including observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting, and experimenting.

(2) Design and carry out scientific investigation using appropriate instruments.

All Alaskan students will understand the nature and history of science.

Students who meet this standard will …
(2) Know that scientific knowledge is validated by repeating specific experiments which may conclude in similar results.

Materials

Small beakers
Watch glasses
Wood splints
Eye droppers
Dilute hydrochloric acid
Safety goggles
Lab aprons
Rock samples (both carbonate and non-carbonate rock)
Universal pH papers

Procedure

1. Place each rock sample into a beaker. Put two or three drops of dilute hydrochloric acid on each sample. Observe and record your observation with each sample. Which samples are carbonates?

2. Extension activities

   a. Place several pieces of limestone in a beaker and add enough dilute hydrochloric acid to cover the rock samples. Cover the beaker with a watch glass. Allow the reaction to take place for at least 30 seconds. Place a burning wooden splint into the beaker. Record your observation. Make a hypothesis based on your observation. For example, what kind of gas is given off in this reaction?

   b. With universal pH papers, test the acidity of water from different sources—peatland (muskeg) water from different areas, streams flowing from peatlands, streams flowing from caves etc.—and record your results. Consider why the acidity varies.

   c. Weigh a clean, dry clam shell or a piece of limestone, and record its weight. Place the sample in a glass container of peatland water. Observe the sample for several days. Does the sample change in appearance? Does any bubbling occur? Record your observations. Take the sample out of the solution and carefully dry it. Weigh the sample and record the results. Compare the before and after weights of the sample. Make a hypothesis concerning the reaction. Speculate about the length of time involved in cave formation.

Assessment

1. Theoretical: Examination of photographs from karst landscapes around the world and determination of the similarities and differences among them.

2. Theoretical: Extension of knowledge about acidic rainwater in other contexts, such as forested muskegs and ages of trees.

3. Practical: Examination of pH of individual home water systems and individual tolerances for drinking water.

ACTIVITY

SODA SINK

GRADE LEVEL: 5-8

Goal

Water that enters the surface of the ground becomes available to act dynamically in a recharge system that is influenced by soluble and insoluble bedrock.

Objectives

At the end of the laboratory activity, students should be able to perform an investigation that will help them to conceptualize the difference between discrete and diffuse recharge and to understand the difference between soluble and insoluble bedrock and how bedrock composition influences subsurface water flow.

Background

The place where rain or surface water enters the ground and becomes part of the groundwater is called a recharge location. In karst areas, where the ground is underlain by soluble bedrock, the soil is thin and groundwater moves quickly through sinkholes, caves and springs. A sinkhole is a rounded depression on the land's surface where water funnels soil and dissolved rock particles into underlying cracks and caverns. Because karst groundwater flows through actual openings in the rock, it is often poorly filtered. This type of groundwater flow is called discrete recharge. Groundwater in discrete recharge systems may move at rates that are measured in feet per minute.

In places where the earth is underlain by thick layers of soil or slowly decaying vegetation (peatlands), groundwater moves very slowly and more filtration occurs. This is called diffuse recharge. Groundwater in diffuse recharge systems may move slowly—at a rate measured in inches per year.

By constructing models of both types of recharge systems, students will investigate rates of water flow and each system's susceptibility to pollution.

Please note: this activity can also be performed as a demonstration, rather than as individual student or group investigations.

ALASKAN STUDENT PERFORMANCE STANDARDS

All Alaskan students will understand scientific facts, concepts, principles, and theories.

Students who meet this standard will …
(7) Understand how the earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things.
(15) Use science to understand and describe the local environment (Local Knowledge).

All Alaskan students will understand and develop the skills of scientific inquiry.

Students who meet this standard will …

(1) Use the processes of science, including observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting, and experimenting.

(2) Design and carry out scientific investigation using appropriate instruments.

All Alaskan students will understand the nature and history of science.

Students who meet this standard will …

(2) Know that scientific knowledge is validated by repeating specific experiments which may conclude in similar results.

Materials (to construct one set of three models)

6 two-liter plastic soda bottles (remove labels)
Gravel rocks (½ inch to 1 inch in diameter)
Soil
Measuring cup
Water
Tomato juice
Scissors
Soda straw
Small buckets

Procedure

1. Assemble models: Cut the bottom off three soda bottles two inches down. Cut the top off the remaining three soda bottles three inches down. Turn the top soda sections upside down and insert them into the bottom sections. These will be the three groundwater models.

2. Label the three models A, B, and C.

3. Pour gravel into the top half of model A until it is half full.

4. Pour gravel into the top half of model B until it measures one inch. Cover the gravel with four inches of soil.

5. Insert a soda straw through the pour spout of the top bottle of model C. Pour gravel into the top half of model C until it measures four inches. Make sure the top of the straw is approximately even with the level of the gravel. The gravel will hold the soda straw in place. Place three inches of soil over the gravel and top of the soda straw.

6. The three groundwater models are now complete.
Model A: discrete recharge system. Water flows through the cracks and fissures between rocks.
Model B: diffuse recharge system. Water filters through soil particles.
Model C: combination of both diffuse and discrete recharge with a cave through the rock units. This gives ideal conditions for a sinkhole to form.

7. Give each student a copy of the results and conclusions sheet for the soda sink activity. Ask students to make predictions about groundwater flow through each model. Remind them to time the flow of water in each model.

8. Measure equal amounts of water and pour the water slowly into the center of each model. (Model C may require more water for the sinkhole to form.) Students should observe and record scientific observations on the results and conclusions sheet.

9. Add "contaminated" water. Measure equal amounts of tomato juice and water, mix and pour slowly into the center of each model. Have students observe and record observations on the activity sheet.

10. As an extension, test the models using other materials such as Kool-Aid mix to simulate contamination.

Results and Conclusions: Soda Sink

1. Record observations from groundwater demonstration. Note the color of the water after it flows through the model and the length of time it took the water to percolate.

	Model A	Model B	Model C
Water	________	________	_______
Tomato Juice	________	________	_______

2. How does diffuse recharge differ from discrete recharge in the models?

____

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3. In which models is water more susceptible to groundwater contamination? Why?

____

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Assessment

1. Theoretical: Using tracer dyes allows a variety of conditions to be simulated. Predict which recharge systems are at work after field visits.

2. Practical: Determine whether point source pollution affects the karst landscape in your community and suggest a solution to the issue.

ALASKA STUDENT PERFORMANCE STANDARDS

All Alaska students will understand scientific facts, concepts, principles, and theories.

Students who meet this standard will …

(7) Understand the earth changes because of plate tectonics, earthquakes, volcanoes, erosion, deposition, and living things (Processes that Shape the Earth).

(15) Use science to understand and describe the local environment (Local Knowledge).

All Alaska students will understand and develop the skills of scientific inquiry.

Students who meet this standard will …

(1) Use the processes of science, including observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting and experimenting.

(2) Design and carry out scientific investigations using appropriate instruments.

(3) Understand that scientific inquiry often involves different ways of thinking, curiosity and exploration of multiply paths.

(4) Understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort and logical reasoning are all aspects of scientific inquiry.

ACTIVITY

MILK JUG HYDROLOGY

GRADE LEVEL: 7-12

Goal

Water that flows beneath the surface plays an active role in cave formation, expansion and the transportation of pollutants.

Objectives

At the end of the laboratory activity, the student should: understand the complexity of subsurface water flow patterns in cave systems; understand how flood waters expand cave systems; and understand how pollutants can migrate through cave systems.

Background

Scientists who study caves believe that limestone caves develop as water slowly flows through the region below the water table. The water table refers to the level below which the substrate is saturated with water. Subsurface water movement is extremely slow, except in a thin zone immediately below the water table. This narrow layer is the area where most limestone caves form. Thus, the level of the water table is important because its horizontal character establishes the depth at which many cave systems develop. Cave passages begin as small fractures in the limestone bedrock below the water table, and gradually enlarge as the acidic water collects in the joints and dissolves the calcite in the limestone. Over thousands of years, the conduits form an interconnecting network of passages and chambers. Throughout this process, cave hydrology is greatly influenced by local and regional precipitation, especially in an area such as southeast Alaska, with its great amount of annual rainfall.

Materials

5 one-gallon plastic milk jugs and 4 gallons of water
1 box of straws with bendable necks
Small electric drill and 3/16-inch bit
1 tube of silicon caulk or Permatex
4 or 5 books or blocks of wood for elevation
Large pitcher
Food coloring

Procedure

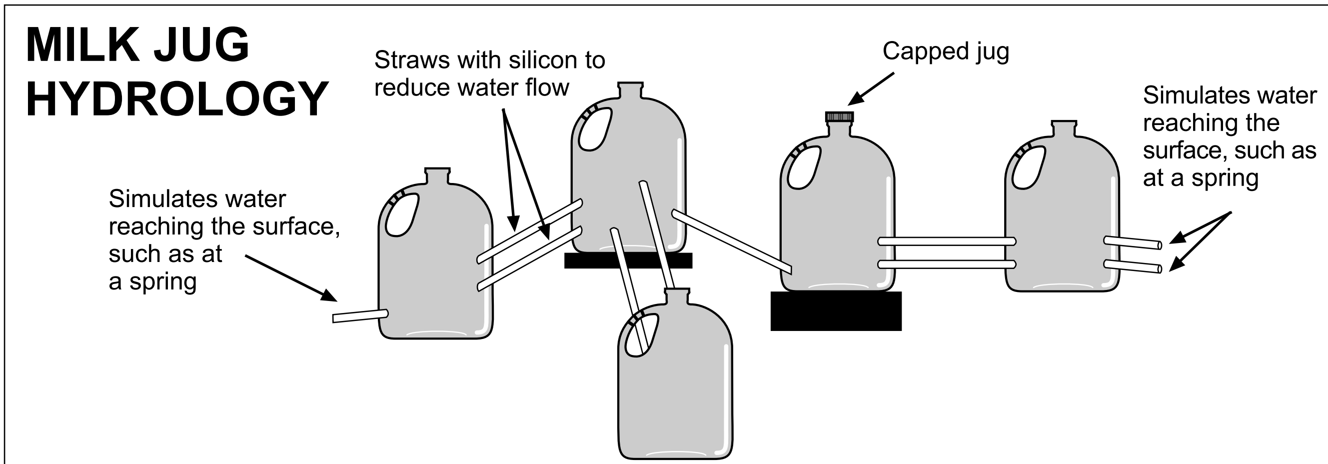
1. Select 10 straws and place some silicon caulk in each to slow the flow of water. (Do not stop the flow, just reduce the amount to about half or less.) This step must be done early so that the caulk will have time to dry.

2. Exact placement of the holes and straws is required. The two end jugs (1 and 5) will have fewer holes and straws than the three jugs situated between the outside two. *Use the diagram as a guide for placement of the jugs and straws.*

   a. Jug 1 should have one of the silicon straws sticking out, away from the rest. This straw should be in the middle of the outside and about 2 inches from the bottom.
   b. Rotate jug 1 by 180 degrees to the side opposite the first straw. This side will have two straws, one a little above the first. Drill the first hole near the center, (left to right), about 2½ inches from the bottom. Drill the second hole about 2½ inches above the first hole, slightly to the left or right
   c. Place the third jug on a book or block to elevate it, and slide the unit up close to the second jug so that the straws which were placed in the second will come in contact with the third jug. Level the straws sticking out of the second jug, and drill a hole where they come in contact with this jug.
   d. Continue the same process with the next two jugs. Be careful to vary the height of the other connections, and the use of the block or book for elevations. Do *not* drill any holes above half the height of the jug.

3. After the jugs are connected with the straws, place a small bead of silicon around each straw at the hole to prevent it from leaking.

4. After the silicon has had several hours to dry, take a pitcher of water and pour it into one of the end jugs to simulate the effect of a local rain storm on one end of the cave system. Students should observe how and when each "jug cavern" fills, and record their observations in the Results section #1.



Straws represent water passageways between cave chambers. Jugs may be placed in any order. Place one to three jugs on blocks to vary their elevations. To simulate a local rainfall, pour water in any single jug. To simulate an areawide rain, pour water into three or more jugs at the same time.

5. Water may be added to each of the containers, or just the three middle ones, to simulate the effect of a hard regional rain. (Note that flood waters such as this do the most to expand the cave system rapidly.) Students should again observe the filling pattern, and record their observations in the Results section #2.

6. Extension Activity: What occurs when waters of different temperatures are added to the cave system? Try these variations.

a. Add about a half-gallon of warm water, colored with a food coloring, to each end of the jug system, only after the four gallons of water have been introduced to the system. Observe and record in the Results section #5. a.

b. Add about a half-gallon of warm water, colored with a food coloring, to the middle-most jug, after the four gallons of water have been introduced to the system. Observe and record in the Results section #5. b.

c. At the same time, add about a half-gallon of warm water, colored red, to one end of the system, and a half-gallon of ice water, colored green, to the other end of the system. Observe and record in the Results section #5.c.

Results and Conclusions — Milk Jug Hydrology

1. Describe the simulated effect of a local rain storm on the cave system.

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2. Describe the simulated effect of a regional rain storm on the cave system.

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3. What conclusions can you draw concerning the influence of storm events on cave systems?

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4.a. What is the relationship between points of water injection into the system and points of discharge, such as springs?

4.b. What is the implication of this situation with regard to pollutants and cave systems?

5. What influence does water of different temperatures have on the cave system and its hydrological processes?

5.a.

5.b.

5.c.

Assessment

1. Theoretical: Create a milk jug model to describe a local cave and its dynamic to a younger audience.

2. Practical: Visit the same cave after a storm event and simulate it with a jug model to help explain the stabilizing conditions of the ground surface and vegetation.

ALASKAN STUDENT PERFORMANCE STANDARDS

All Alaskan students will understand scientific facts, concepts, principles and theories.

Students who meet this standard will …

(4) Understand observable natural events such as tides, weather, seasons and moon phases in terms of the structure and motion of the earth (Earth).

(15) Use science to understand and describe the local environment (Local Knowledge).

All Alaskan students will understand and develop the skills of scientific inquiry.

Students who meet this standard will …

(1) Use the processes of science, including observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting and experimenting.

(2) Design and carry out scientific investigation using appropriate instruments.

All Alaskan students will understand the nature and history of science.

Students who meet this standard will …

(2) Know that scientific knowledge is validated by repeating specific experiments which may conclude in similar results.

ACTIVITY

DEW OR RAIN?

GRADE LEVEL: 5-8

Goal

Outline the role of condensation in the water cycle and the role that weather plays in karst landscapes and associated ecosystems.

Objectives

At the end of the laboratory activity, the student should be able to: understand the factors underlying the process of condensation; understand how and when dew forms; understand how the dew point is measured; understand the relationship between dew and rain formation.

Background

Condensation is the changing of a gas (vapor) to a liquid state. This change can be triggered by a drop in temperature: for example, when water vapor in the air condenses as dew. Warm air holds more water vapor than cool air, so that as the air cools, it becomes saturated, and the relative humidity reaches 100 percent. As air cools beyond the saturation point, water vapor begins to condense on surfaces. The temperature at which the air is saturated is known as the dew point, and the water that condenses below that is called dew. (The following activity is designed for groups of three students.)

Materials

Each group of three students will need:
A metal can
A thermometer
Ice cubes
A stirring rod
Water at room temperature
A beaker
3 balloons
A piece of aluminum foil

Procedure

1. Introduce this activity by discussing weather, the water cycle, condensation and surface tension.

2. As a preliminary activity, have students blow into the air and ask them what they see (usually nothing). Have them breathe on a piece of aluminum foil or a mirror. They should see some mist on the mirror or foil. Now have the students blow up ballons and ask them what is happening and what is collected in the balloon. If students understand that air can be collected, it will be easier for them to grasp the concept that air holds water vapor that can be collected. Students should continue to observe the water droplets on the foil or mirror. Discuss how this moisture got on the surface of these items and why it remains on the surface.

3. For the main activity, open a discussion with the following questions. Where does the water from the ocean go when it evaporates? Where does the water from a bathtub or shower go when it evaporates? Where does the water on plants, cars, and houses that we see in the early morning come from? What type of temperature change must occur before condensation or dew forms? Finally, ask them what they think the dew point is.

4. Now, fill the can half full with water. Add four to six ice cubes to the water, stir and put the thermometer into the water.

5. To see the condensation when it is first forming, continually wipe the side of the can with your finger until you feel moisture or you see a path left by your finger through the condensation forming on the outside of the can. When you forst notice the condensation, quickly measure the temperature and write it down. This temperature is very close to the dew point.

6. All groups in one room will usually get temperature readings very close to each other. After seeing condensation form on the cans, students should be able to visualize how dew forms in our environment. Be sure they do not form the impression that the vapors penetrated to the outside of the can. Emphasize that condensation on the can came from water vapor in the air around the can.

7. Have each group read their dew points to the class. Explain that both the temperatures of the surrounding air (which varies around the room) and the temperature of the ice water affect the dew point.

8. Finally, ask students what they think happens to dew when the temperature continues to drop. From their observations of this activity, can they guess how rain forms?

Assessment

1. Theoretical: Determine the factors that influence condensation in differing climatic zones, including the continental edge in Southeast Alaska.

2. Practical: Assess the level of rainfall in karst landscapes by comparing weather station gauges and field runoff tests.

(*Based on an activity from* **Water, Stones, and Fossil Bones.** *Permission granted for reproduction for the purpose of classroom or workshop instruction.*)

ACTIVITY

SOIL COMMUNITIES

GRADE LEVEL: 7-12

Goal

Soil is a combination of living organisms, minerals and decaying organisms.

Objectives

At the end of the laboratory activity, students should be able to: describe the operation of the Berlese funnel; name the major groups of cryptozoan organisms that inhabit soil communities; compare the cryptozoan populations of several different sites; and offer an explanation for any differences in population size and species composition.

Background

Soil is a complicated and variable mixture of living organisms and nonliving matter. Soil composition varies greatly among different terrestrial ecosystems. Organisms which live in soil are called cryptozoa and form underground microcommunities. Certain physical conditions of soil are similar to those of cave environments, such as a lack of sunlight. Thus, studying soil organisms helps our understanding of small cave organisms. Indeed, research in karst areas has indicated that some cave systems host relic invertebrates, representative of soil fauna from past geologic and climatic conditions.

Because sunlight does not penetrate into soil, the dark environment does not support photosynthetic organisms. However, dead organic material is constantly deposited on and in soil, which provides a rich source of nutrients for soil organisms. Bacteria, other microorganisms and small invertebrates feed on this matter, called detritus, and extract the remaining energy from the organic debris. The decomposers may, in turn, be consumed by small predators. Eventually, dead soil inhabitants also become part of the detritus. When no more energy can be removed from the organic material it is called humus, which is also an important part of soil.

ALASKA STUDENT PERFORMANCE STANDARDS

All Alaska students will understand scientific facts, concepts, principles, and theories.

Students who meet this standard will …

(9) Know about the transfers and transformations of matter and energy that link living things and their physical environment, from molecules to ecosystems (Flow of Matter and Energy).

(12) Distinguish the patterns of similarity and differences in the living world in order to understand the diversity of life. Understand the theories that describe the importance of diversity for species and ecosystems (Diversity).

(14) Understand the interdependence between living things and their environment. Know that the living environment consists of individuals, populations, and communities. Recognize that a small change in a part of the environment may affect the whole (Interdependence).

(15) Use science to understand and describe the local environment (Local Knowledge).

— Cont'd next page

Materials

Coffee can, 10 cm diameter (or other suitable container)
Trowel
Plastic bag
Marking pencil or pen
Gummed labels
Large tray
Forceps
Isopropyl alcohol (rubbing alcohol) with glycerin
Cheesecloth
Berlese funnel apparatus
Light source
Collecting vials
Dissecting microscope
Watch glass
Dissecting needles or fine brush
Identification Guides for Invertebrates

Procedure

Field Collection

Due to the fragile cave environment, do not select caves as one of the sampling sites. Rather, select several above-ground sites for collection. Choose different environments which support different biological communities. For example, contrast the forest edge environment with the deep forest environment; or contrast an open habitat with a forested habitat; or compare all these environments. Then choose three to five locations within each site for collecting samples.

1. Describe the sites in Question 1 of the Evaluation.

2. Collect soil samples in a coffee can. Push it into the soil to a depth of 5-6 cm. Use a trowel to dig out the soil and place the soil in a plastic bag for transport to the classroom. Include the litter—the loose organic material on the surface of the soil.

3. Label the bags with the date, collection site, location and name of student. Samples may be stored in the refrigerator for a week, if necessary.

All Alaskan students will understand and develop the skills of scientific inquiry.

Students who meet this standard will …

(1) Use the processes of science, including observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting and experimenting.

(2) Design and carry out scientific investigations using appropriate instruments.

(3) Understand that scientific inquiry often involves different ways of thinking, curiosity and exploration of multiple paths.

(5) Employ ethical standards, such as unbiased data collection and factual reporting of results.

All Alaska students will understand the nature and history of science.

Students who meet this standard will …

(2) Know that scientifc knowledge is validated by repeating specific experiments which may conclude in similar results.

In the Classroom

1. Spread the contents of the bag from each site on a large tray. Using a pair of forceps, remove the larger organisms and place them in a jar of isopropyl alcohol with several drops of glycerin. If the soil is particularly wet, allow it to dry until it is crumbly but not totally dry.

2. To separate the smaller organisms from the soil, place the sample inside the Berlese funnel.

3. Place the collecting vial, containing isopropyl alcohol, under the funnel. Place a light source several centimeters above the sample to drive the organisms into the collecting vial. Allow one or two days for collecting. Check for evaporation of the alcohol and replace alcohol as needed.

4. Repeat for each site. Use a separate collecting vial for each site.

5. After collecting the specimens, classify them into "look-alike" groups. Use a dissecting microscope to aid the classification process. Place the sample of organisms in a watch glass and use dissecting needles or a fine brush to sort them into groups according to their structures.

6. Identify each group with a letter or number. Sketch a representative from each group. Count the number of individuals in each group. Record this information in Question 2 of the Evaluation.

7. As an extension for older students, use animal identification keys to classify the organisms into major taxonomic groups, such as *Arachnida* (spiders), *Insecta* (insects), *Chilopoda* (centipedes), *Diplopoda* (millipedes) and *Crustacea* (crustaceans).

Results and Conclusions: Soil Communities

On the following evaluation form, record the results of the exercise in parts 1 and 2, and respond to part 3 for the conclusion.

Part 1: Description of Sites

Describe the sites used for this investigation and the reason for selecting these areas.

	Description	Reason for Selection
Site #1		
Site #2		
Site #3		
Site #4		
Site #5		

Part 2: Organism Identification

In the space below, sketch a representative organism from each group in each site studied and note the total number collected.

Part 3: Site Comparison

Compare each site with regard to population size and type of organisms found. What does this indicate about the different terrestrial communities? ______________________________________

____

____

____

Assessment

1. Theoretical: Determine the biodiversity at the cave site with a non-invasive technique inventorying organisms.

2. Practical: Apply the adaptations of cryptozoan organisms in soil to cave organisms and write a Leave No Trace ethics booklet for local caves.

ACTIVITY

ARCHAEOLOGICAL SITE FORMATION PROCESSES

GRADE LEVEL: 7-12

Goal

Sites are created over time through disturbance of the natural landscape by human processes (digging, creating middens, making fires) and natural processes (flooding, erosion, cave spalling) and the sites have characteristic stratigraphic and non-stratigraphic profiles.

Objectives

At the end of this activity, students should be able to: identify site formation processes; identify specific agents of change affecting site composition; describe accurately and clearly the possible effects of each site change agent; and record their observations.

Background

The idea is to start with a simple campsite, just abandoned by its former inhabitants. The campsite may have been occupied by modern campers or by a group of prehistoric hunters long ago. We want to show how the campsite with all its features and artifacts in place is transformed by various agents (plants, animals, water, soil chemistry, later people) into the archaeological site that the archaeologist finds today. And we want to think about how we use the archaeological evidence to build a picture of past cultures.

Materials

Rocks for a hearth site or campfire
Modern camping debris such as a tent stake, tin can lid, plastic bottles, cartons, plastic wrap
Deer or other animal bones

Alternate materials—Campsite debris from early peoples, such as:
Stone tools
Debitage (discard from stone tool manufacturers)
Animal bones
Remains of wooden implements

ALASKA STUDENT PERFORMANCE STANDARDS

All Alaska students will understand and develop the skills of scientific inquiry.

Students who meet this standard will …

(1) Use the processes of science; including observing; classifying; measuring; interpreting data; inferring; communicating; controlling variables; developing models and theories; hypothesizing; predicting and experimenting.

(2) Design and carry out scientific investigations using appropriate instruments.

(3) Understand that scientific inquiry often involves different ways of thinking, curiosity and the exploration of multiple paths.

(4) Understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort and logical reasoning are all aspects of scientific inquiry.

(5) Employ ethical standards, such as unbiased data collection and factual reporting of results.

(6) Employ strict adherence to safety procedures in conducting scientific investigations.

All Alaska students will understand the nature and history of science.

Students who meet this standard will …

(6) Understand that scientific discovery is often a combination of an accidental happening and observation by a knowledgeable person with an open mind.

Procedure

1. Students divide into work groups and each group designs a campsite, including its features and artifacts.
2. Students write descriptions of the inhabitants and their activities.
3. Students then build replicas of their group campsites.
4. Each student takes a role in modifying the campsite. For example, one will be a bear, another a windstorm, etc.
5. Students go to the site and take away or move things, according to their roles.
6. Students in pairs or trios then visit each site and carefully record the site, using measurements, illustrations and a narrative.
7. Each group should meet and discuss each site, including:
   a. The original inhabitants and their activities.
   b. Agents (natural and human) that modified the site and the effects of these agents.
8. Every group writes up their scenario for each site.
9. A class discussion should focus on describing realistic possibilities and on why some scenarios are more likely than others, based on the evidence provided.

Results and conclusions

All students should hand in descriptions of their own sites, their roles in altering it and the impacts of change processes on the final conditions of the site.

Each group should hand in an analysis of each site. Each member of every group should be responsible for a section of the report, utilizing input from group members.

Assessment

1. Theoretical: Determine the human behaviors and their artifactual correlates that can be applied to past events as they related to cave use.

2. Practical: Examine your own material cultural world (garbage, antiques, embellishment) and determine what will be left for future archaeologists to propose behavioral theories. What behaviors don't leave behind tangible clues?

ACTIVITY

ARCHAEOLOGICAL SITE DISTURBANCE PROCESSES

Grade Level 7-12

Goal

Sites are created over time through disturbance of the natural landscape by human processes (digging, creating middens, making fires) and natural processes (flooding, erosion, cave spalling) and the sites have characteristic stratigraphic and non-stratigraphic profiles.

Objectives

At the end of this activity, the student should be able to: identify site-altering disturbance processes, and record and discuss observations.

Background

Disturbance processes are mechanical and chemical factors that change the context of the archaeological record and affect the way the locations and condition of artifacts and features are interpreted by archaeologists. Some disturbance processes are animal burrowing; tree root growth; freezing and thawing of water in the sediments; and movement of sediments and artifacts by running water. This exercise provides an example of simulated floralturbation. Floralturbation is the disturbance caused by plants. In this activity, we study the disturbance caused by the growth of tree roots and treefall.

Materials

Cardboard tube
Construction paper
Aluminum foil
Cardboard disk
Box
Flour
Soil

ALASKA STUDENT PERFORMANCE STANDARDS

All Alaska students will understand and develop the skills of scientific inquiry.

Students who meet this standard will …

(1) Use the processes of science, including observing; classifying; measuring; interpreting data; inferring; communicating; controlling variables; developing models and theories; hypothesizing. predicting; and experimenting.

(2) Design and carry out scientific investigations using appropriate instruments.

(3) Understand that scientific inquiry often involves different ways of thinking, curiosity and the exploration of multiple paths.

(4) Understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort and logical reasoning are all aspects of scientific inquiry.

(5) Employ ethical standards, such as unbiased data collection and factual reporting of results.

(6) Employ strict adherence to safety procedures in conducting scientific investigations.

Procedure

1. Construct a scale model of a tree with its root wad. Use common materials such as a cardboard tube, construction paper and tin foil. Attach some form of disk at the base of the tree to represent the root wad.

2. Provide a box or contained surface to plant the tree.

3. Using alternating layers of dirt and flour, cover the root wad of the tree with layers of soil and flour. Flour represents midden from a habitation site.

4. Place artifacts both within the layer and on the surface of the soil layers.

5. Observe what happens when the tree topples.

6. Record all observations made by students regarding the changes in layering, and the positioning of the artifacts.

7. Discuss students' observations regarding the impact of the *floralturbation process* on archaeological investigation.

Results and Conclusions

All students should describe in writing, with illustrations as appropriate, their observations regarding the site before and after the site disturbance—i.e., before floralturbation. Students should describe the impact this process may have on archaeological analysis of this site.

Variation

Select several groups of students to be the inhabitants of a site over several different time periods. Let each group successively deposit midden until the root wad is covered. Ask the students to pictorially record the placement of artifacts and midden as it occurs. Challenge the last group, who did not watch the layering occur, to successfully recreate their own pictorial version of the layering process, midden deposits, and artifact placements during an archaeological excavation. Compare the pictures from before and after floralturbation.

Assessment

1. Theoretical: Determine the human behaviors and their artifactual correlates that can be applied to past events as they related to cave use.

2. Practical: Examine your own material cultural world (garbage, antiques, embellishment) and determine what will be left to help future archaeologists to propose behavioral theories. What behaviors don't leave behind tangible clues?

CAVE & KARST LANDSCAPE **WORD FIND**

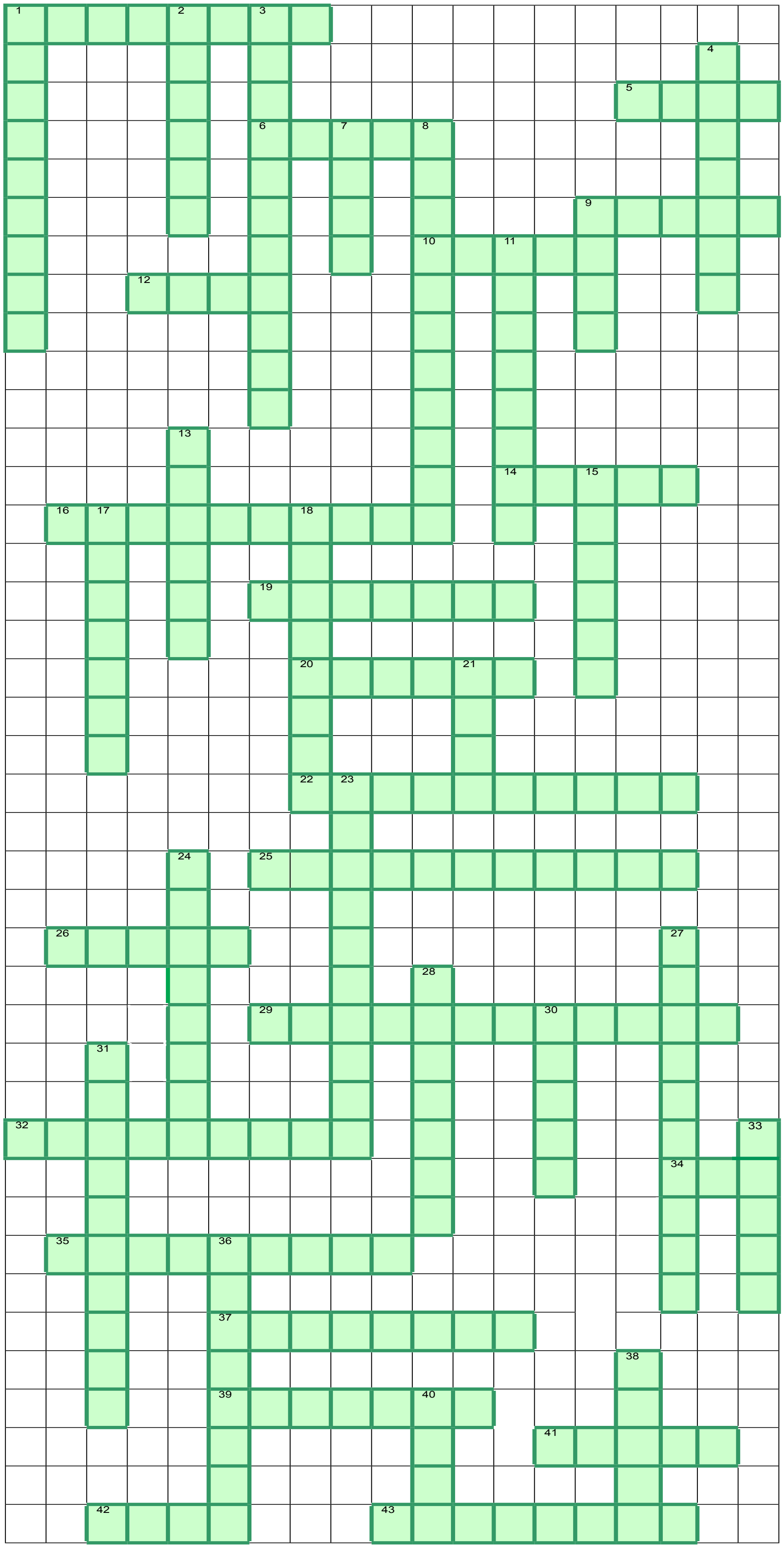
We've hidden 35 words that are related to El Capitan Cave on Prince of Wales Island or to karst landscapes and life forms in this area. The hidden words read right to left, left to right, upward, downward and diagonally. Can you find 35 hidden cave and karst landscapes words?

S	M	U	S	K	E	G	S	E	I	R	R	E	B	C
R	I	V	E	R	B	E	D	A	K	S	A	L	U	U
I	S	T	A	L	A	C	T	I	T	E	A	L	L	B
V	T	I	F	N	A	T	I	P	A	C	L	E	C	C
E	A	L	T	N	R	E	F	D	L	E	I	H	S	B
R	L	A	R	K	C	A	L	C	I	U	M	L	L	E
O	A	D	O	G	A	S	I	R	F	O	N	A	I	A
T	G	Y	G	K	V	S	C	L	U	B	M	R	V	R
T	M	F	L	W	E	T	P	T	N	B	U	T	E	T
E	I	E	O	C	R	Z	Y	R	A	A	L	F	D	I
R	T	R	P	U	N	E	E	T	U	T	O	A	I	F
P	E	N	H	K	S	A	E	V	A	C	C	T	K	A
T	R	O	I	A	R	U	A	N	M	U	E	O	E	C
R	E	T	L	H	E	M	L	O	C	K	A	R	S	T
O	F	E	E	G	A	B	B	A	C	K	N	U	K	S
G	E	P	O	W	V	Q	A	F	E	R	N	T	W	W
L	N	I	D	T	V	N	Y	T	U	N	M	O	R	A
O	O	K	A	N	I	A	R	A	S	I	R	N	E	R
B	T	A	E	T	I	M	L	E	T	D	T	G	I	T
I	S	R	T	C	M	A	A	E	F	M	I	A	E	S
T	W	S	R	N	S	A	N	E	N	R	U	S	F	A
E	O	T	A	K	I	R	R	A	T	B	E	S	D	D
B	L	R	A	H	O	N	A	U	G	J	I	E	A	O
D	F	T	R	O	G	L	O	X	E	N	E	T	D	S

Hidden-word list on page 116

Victoria E. Houser, USDAFS Craig Ranger District / With Moe McGee and Jennifer MacDonald

CAVE & KARST LANDSCAPE **CROSSWORD**



ACROSS

1. Limestone's skin layer
5. Fossils of these found in P.O.W. caves
6. P.O.W. caves are made of this
9. ______ tectonics
10. Bat poop
12. Otter evidence on gate
14. River _____ use caves in winter
16. Ceiling hanging feature
19. 1 of 2 things removable from El Cap
20. Another name for a pool of water
22. Type of fault line in the cave
25. Another name for the twilight zone
26. No remains of this species in El Cap
29. Winter den site
32. Abundant calcified limestone in cave
34. Opposite of dry; S.E. Alaska is very ___
35. Small stalactites filled with calcium
37. Old dead tree on the forest floor
39. S.E. Alaska's most abundant tree
41. Bear's _____; a fungus on trees
42. Cave ____; a troglobyte
43. We use to light our way in the cave

DOWN

1. Alaska's largest known cave
2. State in which El Cap is located
3. Alaska state tree
4. El __________
7. Liquid precipitation
8. Part-time cave dwellers
9. Initials of island El Cap's on
11. Cave invertebrate; i.e., cave shrimp
13. Stalactite + Stalagmite =
15. No taste buds on the cave version
17. America's largest national forest
18. This feature is not 'identical'
21. Peek
23. Perennial cave dweller
24. Cave _______; we joke we can fund cave tours with these.
27. Green __________; a calciphile
28. This isn't 'hung' in the cave like our domestic version.
30. 'Yellow' type stairway made of
31. 'New' visitors to the cave
33. Lime_____; 96% pure in El Cap
36. An opening in the karst surface
38. _____ Room; El Cap control room
40. A subterranean feature; El Cap

Crossword answers on page 116

Victoria E. Houser, USDAFS
With Moe McGee and Jennifer MacDonald

El Capitan Cave Management Plan

Abstract

El Capitan Cave is located on north Prince of Wales Island within the Thorne Bay Ranger District, part of the Ketchikan Area of the Tongass National Forest. The Cave is a large, maze-like system with more than one entrance, numerous side passages, many deep pits, tight crawlways and a well-defined main passageway. The total surveyed passage is 11, 885 feet and the cave is 428 feet in depth. There are still some areas of the cave which have not been mapped.

El Capitan Cave has been recognized for its outstanding attributes as a recreational cave and significant for research purposes. Previous visitation and unregulated use has resulted in vandalism and degradation of fragile cave formations, particularly in the first several hundred feet. Areas in remote regions of the cave still remain pristine. In 1993, Thorne Bay Ranger District installed a gate 150 feet within the cave for protection of the remaining pristine portions and for protection of visitors from known dangers, such as flooding and deep pits.

Installation of the gate accomplished the protection criteria needed for the cave but without further management direction, visitation would be restricted to the area before the gate. This plan develops the strategy and defines the criteria for allowing visitation beyond the gate. Commonly used cave management techniques have been employed as well as the Revised Tongass Land Management Plan proposed Karst and Cave Resource Management Standards and Guidelines. Chapter 5 describes the initial policy and procedures for managing El Capitan Cave.

For management purposes, the cave has been divided into four sections:

1) **The entrance to the gate (150 feet).**
2) **The gate to Hatfield's Pit (600 feet).**
3) **Hatfield's Pit to the Alaska Room (600+ feet).**
4) **The Steam Room (Side Passage at 250 feet).**

Note: Side passages not mentioned here are temporarily closed pending further resource evaluation.

Section 1. Available year round for visitation. Permits and/or guides are not required.
Section 2. Available seasonally from the end of May through August for guided groups of 6 through the main passage to Hatfield's Pit. Guided tours are available Wed. - Sun. and last approximately 1 hour and 45 minutes. Tours are available 8am-10am, 10am-12pm, 12pm-1pm closed for lunch, 1pm-3pm, and 3pm-5pm. The seasonal operating period may vary from year to year due to weather. For example, road closures may occur due to early spring storms making access to the site diffcult or impossible. Additionally, the seasonal operating period may change due to public demand. In general, a summer season operating period will be implemented.
Section 3 and the numerous side passages mentioned above will be temporarily closed pending further evaluation. Guided visitation to these areas may be available in the future. These areas may be accessible for research and exploration by approved groups or individuals.
Section 4. Limited to administrative entry for research and monitoring purposes. No recreational caving will be allowed.

TABLE OF CONTENTS

Chapter 1.
EL CAPITAN CAVE MANAGEMENT PLAN

1.1 Introduction

El Capitan Cave is one of many nationally and internationally significant caves discovered on Prince of Wales Island. In 1992, Thorne Bay Ranger District decided to provide for public visitation in El Capitan Cave. With this decision, a development strategy was implemented which included installation of a gate within the cave approximately 150 feet past the entrance. Plans for surface developments include an improved access trail and parking area, sewage and sanitation facilities, and interpretive displays. Further developments may occur as the need arises.

Cave management techniques used in this plan are commonly used by the Forest Service and National Park Service. Cave managers and specialists employed by these agencies were solicited for examples of plans and procedures already in use. This information was further developed to reflect conditions specific to Southeast Alaska. Additionally, public comment was incorporated in the plan. Public comments and documentation of public meetings are filed at Thorne Bay Ranger District.

1.2 Administration

El Capitan Cave is located on the Tongass National Forest and lies within the management jurisdiction of the U.S. Forest Service in the Ketchikan Area of Southeast Alaska. Thorne Bay Ranger District is responsible for the development, maintenance, operation and general administration of this cave.

1.3 Purpose and Need

A. Purpose

Tremendous cave resources have developed on, and within the soluble bedrock limestone of Prince of Wales Island. Over three hundred caves have been discovered with projections of hundreds more to be found. In a report prepared by the Ozark Underground Laboratory titled Karst and Cave Resource Significance Assessment, a panel of four karst resource professionals stated that the karst and cave resources of Prince of Wales Island have attributes of international and national-scale significance. El Capitan Cave was recognized for its outstanding attributes as a recreational cave and significant for research purposes.

The purpose of this document is to guide management of El Capitan Cave so that preservation of this significant non-renewable resource will be maintained while allowing recreational caving and research. Increased visitiation to El Capitan Cave associated with the recent popularity of caving, as well as a growing scientific interest in the cave has increased the potential for resource damage. This plan is intended to provide consistency in management, protection, use, and development. It identifies management actions, priorities for research, and emergency actions inherent in managing cave resources.

Much of the direction for this plan is found in the Forest Service Manual (Part 2356), Standards and Guidelines in the Tongass Land Management Plan Revision, the Tongass Land Management Plan Amendment (1985-1986) and numerous Federal Laws and regulations. The

Tongass Land Management Plan Revision provides more direction for managing caves than the 1985-86 Amendment. In the Revision, El Capitan Cave is included in a proposed Geologic Special Area. Within this land use designation, resource values are available for study, use, or enjoyment when adequate provisions for protection are available and the resource is suitable for the activity. Additionally, the Revision requires that Cave Management Plans be developed for Class 1: Sensitive Caves, Class 2: Undeveloped Caves and Class 3: Directed Access Caves. El Capitan Cave is being managed as a Class 3 Cave in which the following applies:

> Class 3: Caves with directed public access and are developed for public use and enjoyment. These caves are shown on maps or have signs directing visitor access. Regardless of the level of development, public visitation is encouraged. These caves could have improved access, developed trails, artificial lighting, and guided tours. Interpretive materials about these caves may be available. The caves may have sensitive resources that need to be protected. Access may be through a reservation.

B. Need

As mentioned earlier, people are attracted to El Capitan Cave for reasons ranging from scientific study to recreational exploration. Recreationists, school and youth groups, the media, scientists, explorers, international travelers and early man have visited El Capitan Cave in varying degrees. Recently, requests for visitation to the cave have increased. It is an attraction that provides an excellent opportunity to expand recreation and enhance the economy of Prince of Wales Island, however, visitation must be managed to prevent user conflicts and destruction of the cave. Prior to installation of the gate, monitoring has revealed that approximately 75 percent of the formations in the first 600 feet of the cave have been destroyed or damaged. The gate now provides a measure of protection for the remaining resources in the cave but without management direction, the gate prohibits visitation. Consequently, the need to develop a management plan is tied primarily to allowing controlled visitation beyond the gate.

1.4 Existing Condition

El Capitan Cave has no internal developments other than one gate. There have been no changes to the natural appearance of the cave except for slight modifications of the ground at the cave entrance. Ground modification occurred with the development of an access trail. The majority of the known cave has been mapped however, a few segments of the cave have not been completely finished. Previous visitation in the cave has resulted in vandalism and degradation of fragile cave formations. Most vandaliam has occurred within the first 600 feet of main passage. Human waste, litter and grafitti have been found. Cigarette smoking and pets in the cave are recognized problems. The passage beyond Hatfield's Pit, and most side passages of the cave (see Appendix A) have pristine qualities with little to no resource damage. The degree of damage in El Capitan Cave may be due to easy accessibility to the main passageway, knowledge of the cave location, and a lack of understanding about the fragile and non-renewable nature of caves. Regardless of the vandalism, El Capitan Cave contains many outstanding resources which are unique and fragile. It is an excellent recreational cave which provides the visitor varying degrees of challenge and aesthetic appeal. Valid research of the cave has been very limited. See Chapter 2 for a more detailed description.

1.5 Desired Future Condition

El Capitan Cave is developed for public use and enjoyment while natural diversity and primitive quality is retained. It is better understood, protected and preserved through research, education, and monitoring. Visitation does not detract from the natural character of the cave.

1.6 Proposed Action

El Capitan Cave is a large, maze-like system with varying degrees of resource and safety concerns. It has a well defined main passageway with numerous horizontal and vertical side passages. Some side passages have not been mapped and a complete inventory is lacking. Installation of a gate at approximately 150 feet past the entrance instituted a fixed division of the cave. Analysis by volunteer cavers and Forest Service Specialists in Recreation and Geology, resulted in the apparent need to divide the cave according to differing resource concerns, recreational uses, and hazards. Portions of the cave cannot be accessed without climbing skills and rope (Section 3). Other sections are relatively safe (Section 1), while all sections contain outstanding resource values. It was also recognized that a control or off-limits area (Section 4) would be advantageous for monitoring resource degradation and comparing areas of variable use. For these reasons and for management purposes at this time, a proposed action to divide the cave into four sections follows:

1) The entrance to the gate (150 feet).
2) The gate to Hatfield's Pit (600 feet).
3) Hatfield's Pit to the Alaska Room (600+ feet).
4) The Steam Room (Side Passage at 250 feet).

Note: Side passages not mentioned here are temporarily closed pending further resource evaluation. See Appendix A for a map of El Capitan Cave.

Section 1 will be available year round for visitation. Permits and/or guides are not required however, visitors will be encouraged to sign a visitor register located at the entrance to the cave.

Section 2 will be available seasonally from May through September for guided groups of 6 through the main passage to Hatfield's Pit. The seasonal operating period may vary from year to year due to weather. For example, road closures may occur due to early spring storms making access to the site diffcult or impossible. Additionally, the seasonal operating period may change due to public demand. In general, a summer season operating period will be implemented.

Section 3 and the numerous side passages mentioned above will be temporarily closed pending further evaluation. Guided visitation to these areas may be available in the future. These areas may be accessible for research and exploration by approved groups or individuals.

Section 4 will be limited to administrative entry for research and monitoring purposes. No recreational caving will be allowed.

This is an initial management strategy. Management will likely change as the strategy is fine-tuned and more is learned about El Capitan Cave through monitoring and research. For detailed management policy and procedures see Chapter 5.

1.7 Management Objectives

Cave resources present unusual management challenges because of the nonrenewable nature of cave contents and the sensitivity of cave ecosystems to human visitation. Management of El Capitan Cave focuses on protecting important cave resources while allowing recreational use. Strategies which preserve the cave resources and maintain the recreational opportunities are sought. Strategies may involve winter closures for protection of hibernating bats while maintaining recreation opportunities throughout the remaining year.

Primary Objectives

1. Perpetuate El Capitan Cave in a natural or nearly natural condition. As much as possible, protect and preserve aesthetic values of the cave.

2. Provide opportunities for visitors to enjoy, appreciate, explore, and learn about El Capitan Cave. Encourage and promote organized school visits as a means of educating young people about the fragile nature of caves.

3. Protect fragile biological and geological cave features including cave adapted species and their habitat. Protect archeological, historical and paleontologic sites.

4. Prevent contamination of important water supplies which drain into, issue from, or are contained within El Capitan Cave.

Secondary Objectives

1. Provide opportunities for scientific study of El Capitan Cave which will promote understanding, appreciation, and improved management. Encourage studies of cave ecology, geology, paleontology, archeology, and history which are consistent with the protection objectives listed above, and applicable laws and regulations.

2. Identify and monitor resources in El Capitan Cave to assess the effects of visitation to see if established visitaiton levels are appropriate.

3. Provide for public health and safety while recognizing that El Capitan Cave can never be completely safe, and that risk-taking is a part of the caving experience.

4. Develop interpretive signs to assist with education and safety.

1.8 Policy

The national policy for managing caves on Forest Service land is found in the Forest Service Manual (FSM) 2356.03 and reads as follows:

1. Manage caves as a nonrenewable resource to maintain their geological, scenic, educational, cultural, biological, hydrological, paleontological, and recreational values.
2. Classify caves containing outstanding values as Geological or Historical Areas (2372).
3. Emphasize wild cave management with few or no facilities to aid or facilitate use.
4. Develop management prescriptions for caves of significant value.
5. Coordinate surface and cave resource management activities.
6. Protect threatened, endangered, proposed, and sensitive, species in accordance with the Endangered Species Act (16 U.S.C. 1531) and FSM 2670.
7. Protect cultural sites and deposits in accordance with FSM 2361.03 and federal laws.
8. Develop and foster communications, cooperation, and volunteerism with interested publics, Federal agencies, and State and local governments.

1.9 Authority

The principal laws affecting management of El Capitan Cave follows.

1. <u>The Organic Administration Act of June 4, 1897, (16 U.S.C. 551).</u>
   This Act authorizes the Secretary of Agriculture to regulate occupancy and use of the National Forests. Regulations issued under the Act authorize the protection of cave resources from theft and destruction (36 CFR 261.9a, 9b, 9g, and 9h). Under 36 CFR 294.1, classification is authorized for special interest areas that are managed for recreation use substantially in their natural condition. Special closures are authorized under 36 CFR 261.53 to protect threatened cave resources.

2. <u>Antiquities Act of 1906 (34 Stat. 225; 16 U.S.C. 431 et seq.).</u>
   This Act provides for the protection of historic or prehistoric remains or any object of antiquity on Federal land. Criminal sanctions are authorized for destruction or appropriation of antiquities. Scientific investigations of antiquities on Federal lands are permissible subject to permit and regulations. Uniform rules and regulations pursuant to this Act are in FSM 1530.12.

3. <u>Archaeological Resources Protection Act (ARPA) October 31, 1979 (16 U.S.C. 470aa).</u>
   This Act clarifies and defines "archaeological resources," prohibits the removal, sale, receipt, and interstate transport of archaeological resources obtained illegally from public lands. The Act authorizes confidentiality of site location information, authorizes permit procedures to enable study and investigation of archaeological resources on public lands by qualified individuals; provides for substantial criminal and civil penalties, forfeiture of equipment used in the crime, and rewards for citizens who report the crime. The Act supplements but does not replace the Antiquities Act of 1906.

4. <u>Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531).</u>
   This Act describes the process for determining endangered and threatened species, establishes prohibited acts, prescribes penalties, mandates a recovery plan, and defines interagency and State cooperative relationship requirements.

5. <u>Federal Cave Resources Protection Act of 1988</u>
   This act provides specific authority to protect cave resources on federal lands. The Act establishes that "... Federal lands be managed in a manner which protects and maintains, to the extent practical, significant caves." (Section 2(c)). The two purposes of the Act (Section 2(b)) are:

   - to secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people; and

   - to foster increased cooperation and exchange of information between governmental authorities and those who utilize caves located on Federal lands for scientific, education, or recreational purposes.

Chapter 2.
Background and Description

2.1 Location

El Capitan Cave is located on north Prince of Wales Island in southeast Alaska, USGS Petersburg quad (A-4), T.66S.,R.78E., Section 11, CRM. According to the Prince of Wales Island Area Plan, lands on both east and west sides of the project area in Sections 10 and 11 are either privately owned or proposed for state selection. A Forest Service Work Camp is located approximately 1000 feet down a steep slope, west from the cave entrance.

2.2 Discovery

It is unknown who or when El Capitan Cave was first discovered. In September of 1985, Forest Service Geologist, David Hatfield and crew penetrated several difficult and remote regions of the cave and were apparently the first to drop into what is now known as Hatfield's Pit (see map). In August of 1987, Kevin and Carlene Allred, National Speleological Society (N.S.S.) members (Glacier Grotto Branch), were the first cavers to investigate and officially name El Capitan Cave.

Since the Allred's first visit in 1987, cavers continue to inventory and map El Capitan Cave. A Challenge Cost Share Agreement between the Forest Service and the N.S.S. has been in effect since 1987. Under this Agreement, N.S.S. members are requested to inventory and map caves on the Thome Bay Ranger District. Much resource information about El Capitan Cave has been provided by the N.S.S. to the Forest Service.

2.3 General Description

El Capitan Cave is the longest known cave in Alaska with a total 1993 surveyed passage of 11,885.5 feet and 428.6 feet in depth (275.2 feet above the entrance and 153.3 feet below the entrance). Structurally, it is both horizontal and vertical. There are many branching passages, deep side pits, crawlways, and over-hangs. The main passage is mostly horizontal, of walking height or larger, and contains areas of adjoining spongework maze which are generally more vertical and/or smaller; roughly two to three feet in diameter. Many side passages are filled with sediments nearly or completely to the ceiling. It is a phreatic tube with a cobble floor of stones football size or larger. The Cave has three horizontal entrances located on a steep slope above a well defined gully. It is approximately 95 percent pure limestone and has been formed through weathering and dissolution processes, i.e., water containing carbon dioxide derived from rain and soil moves downward and dissolves the limestone. The cave contains a sump located in a large room (roughly, 85 feet wide, 230 feet long, and 116 feet high) in the lower portion of the cave. Dives were taken through the sump in the summer of 1993. On the other side of the sump at approximately 60 feet is a large room 45 feet in diameter and 70 feet high.

Speleothems within the cave consist of soda straws, stalactites, drapery, flowstone, small helictites, small crystals, stalagmites, mud stalagmites or hoo-doos, conulites, and moonmilk. Notable speleogens are splash cups, boxwork and scallops. Undamaged cave formations become more abundant further into the cave.

Portions of the cave cannot be accessed without specialized caving skills and equipment. There are many deep pits and rises which require climbing skills. Areas of the cave are prone to flooding however, rapid flooding does not occur within the main passage up to approximately 600 feet.

2.4 Cave Weather

As a general rule, a cave's physical environment varies less than the surrounding surface environment. Physical conditions vary over time, between caves and between areas within a cave.

The temperature in El Capitan Cave approximates the mean annual temperature of the region; 40 degrees F. In regions far from the entrances, the temperature scarcely varies at all with greater variations near the entrance. Temperature fluctuations of several degrees has been recorded throughout the main passage. As external temperatures vary from season to season, air currents within the cave change temperatures throughout the system.

Relative humidity rarely falls below 80 percent. The cave is constantly damp and dripping with water. During extended periods of low surface precipitation, cave waters drop, however relative stability is usually the pattern.

2.5 Previous Visitation

Humans visited El Capitan Cave over 3,000 years ago (R. Carlson, 1993). Visitation over the last 100 years is likely to have coincided with other human activity in the area such as mining, logging and fishing. Accurate documentation of visitors per year does not exist. Primary use in the last five years has been by volunteer cavers working for the Forest Service and local residents of Prince of Wales Island. Prince of Wales residents have been visiting the cave for many years. Visitation has increased since 1989 when harvest activity provided easier access and caves became more publicized locally.

2.6 Vandalism

The extent of existing vandalism varies throughout the cave. Severely damaged areas are primarily restricted to the main passage of the cave which is easily accessible to visitors and within the first 500 to 600 feet from the entrance. Extensive vandalism is seen within the first several hundred feet of the cave. Broken formations, littering, and graffiti have been the major forms of vandalism noted in the cave.

2.7 Installation of a Gate

Through internal and external analysis with experienced El Capitan cavers and Forest Service personnel, the need for a gate was apparent. During the summer of 1993, a gate was installed approximately 150 feet from the entrance. Installing a gate was intended to serve two primary purposes; protection of the pristine portions of the cave and protection of visitors from known dangers, such as flooding and deep pits.

The gate has been designed to allow bats safe ingress/egress from the cave. Already, bats have been seen beyond the gate by cavers and Forest Service personnel. The decision to place a gate within the cave, build a trail to the cave and develop interpretive signs was disclosed in an environmental analysis completed January 11, 1993 and meets the requirements of the National Environmental Policy Act.

CHAPTER 3.
INVENTORY, RESOURCE EVALUATION, HAZARD RATING AND CLASSIFICATION

3.1 Introduction

As mentioned in Chapter 1.6 under Proposed Action, El Capitan Cave has been divided into four sections for management purposes. This chapter provides inventory results, evaluates cave resources, rates hazards and classifies the cave according to the following four sections:

1) The entrance to the gate (150 feet).
2) The gate to Hatfield's Pit (600 feet).
3) Hatfield's Pit to the Alaska Room (600+ feet).
4) The Steam Room (Side Passage at 250 feet).

3.2 Cave Inventory Procedures

Inventory and evaluation of El Capitan Cave continues. Substantial inventory work has been conducted by volunteers, universities, research facilities such as the Ozark Underground Laboratory, and Forest Service personnel. The first step in the inventory procedure is to create a map of the cave. Specialized survey equipment and computer programs are used to develop the maps. Sketched details of floors, ceilings and other features are included. A standard of "mapping as you go" has been established rather than exploring the cave and then mapping. All persons involved in inventory are made aware of the spectrum and fragility of cave resources and are required to abide by rules which protect and conserve cave resources. Inventory reports which accompany cave maps are required as part of the inventory procedure. Reports provide an initial written commentary on the cave, it's condition, and resources. Inventory work is and should continue to be coordinated by Forest Service employees with cave management responsibilities and duties.

3.3 Resource Inventory

This section describes the known values of recreation, visual quality, biology, geology/mineralogy, cultural resources, paleontology and hydrology for El Capitan Cave This information has been compiled from various inventory reports.

Recreation

El Capitan Cave has outstanding recreational values for experienced cavers, novices and other recreationists. Different challenge levels exist throughout the cave. Climbing and cave diving opportunities are present.

Much of the recreational success for the individual depends upon the kind of experience being sought. The primary experience opportunities include the following:

1. Obtaining privacy, solitude, and tranquillity in an underground setting.
2. Experiencing a natural karst ecosystem unmodified by human activity.
3. Gaining a new mental perspective in a dark, fragile environment.
4. Learning more about nature, especially natural processes which form caves, human relationships with nature, and how to live in greater harmony with nature.
5. Self-testing and risk-taking for self-development and sense of accomplishment.

Visual Quality

Visual quality is based upon inherent scenic characteristics of the resource, degree of alteration of the resource, and amount of use of the scenic resource generated by visitation. The over-all inherent scenic quality is high and very diverse. Outstanding feature attractions and distinctive variety in form, line, color and texture or combinations thereof exist throughout the cave. Numerous formations are present. Visual quality of cave formations increase the farther one goes into the cave. The limestone of El Capitan Cave is as much as 95 to 99 percent pure, making the rock a appear whitish or clear. Marble is present and exhibits itself as white striations in the rock. Numerous patterns can be seen in the placement of the rocks. An intricate system of mazes and side passages create a myriad of shapes and form that are both interesting and unique, often resembling statues and other familiar figures and representations.

Moon milk, fans and draperies, soda straws, flow stones, pop corn, hot fudge sundae, stalactites and stalagmites are some of the formations present. Prehistoric bear claw marks can be found on the walls along with hundreds of fossils of various shapes, sizes, and origins. Most of the formations in the back of the cave are not broken or marred while numerous formations in the first several hundred feet have undergone degradation. Such degradation has resulted in broken stalactites, stalagmites and soda straws and discoloration of flow stones. Some graffiti has occurred but to date, all has been removed. Often, visitors leave trash around the entrance and in the first portions of the cave with the highest volume being cigarette butts which detract from the over-all scenic quality.

Public visitation and subsequent use of the scenic quality has been relatively moderate. Measurements of use are reflected through such mechanisms as return visitation and photography. Approximately 30 to 35% of first time visitors return to El Capitan Cave annually. Often, visitors engage in scenic photography as a main function of their trip. Professional and amateur photographers and writers have come from near and far to take pictures of the cave and document the marvels of El Capitan's underground. Numerous videos have been filmed for local and national television broadcasts.

Biology

Significant populations of invertebrates unique to El Capitan Cave exist in areas ranging from the entrance twilight zone to deep cave zones such as the Alaska Room. Many invertebrate collections are currently being sent to taxonomic specialists to verify their unique identities.

In 1988 approximately 5 fungus gnats (order Diptera, family Mycetophilidae, genus: Speolepta) were collected from an area near Hatfield's Pit, some 700 feet within El Capitan Cave. Rod Crawford, Entomologist of the University of Washington identified them as an undetermined species of fungus gnat. They were the first recorded species of fungus gnat found in the state of Alaska.

In May of 1990, a preliminary survey of El Capitan Cave was conducted to help determine the biologic components found within the cave. This survey was conducted for a three week period and does not represent a complete biological survey or inventory, as different life forms may be present at other times and places which were not sampled. (Allred, 1990).

Numerous invertebrates were found during this survey. Beetles, gnats, harvestmen, stone fly nymphs, segmented worms, flat worms, nymph exoskeletens, pupas, mosquitoes, flies, a white millipede, spiders, a sow bug, and a thin centipede were found. Life was most abundant in the twilight zone or cave entrance. Apparently, most of these samples were lost in transit to the University of Connecticut where they were being sent for identification purposes. Consequently, there are no verifiable invertebrate species documented as a result of this study. Vertebrate collections included the first three bat skulls found and some deer hair. Two of the bat skulls were positively identified by Dr. Fred Grady of the Smithsonian Institution in Washington , D.C., as Myotis californicus.

Other biological investigations have been limited. Kent Carlson, Cave Entomologist from West Virginia, and Doreen Baichtal, graduate student at the University of Fairbanks studying bats, have conducted some surveys in El Capitan Cave. The following is a compilation of their work.

Bats - Myotis bats have been documented in El Capitan Cave. They have been found using the cave in winter. The most bats counted at one time in the cave has been twelve. Myotis lucifugus have been discovered beyond the gate. Whether there is a significant population of bats in El Capitan Cave is unknown. Whether the cave represents a critical resource particular for the bats survival is not known.

Fish - There have been no reports of fish in El Capitan Cave streams. Nearby Salmon Fry Cave, however, does have populations of salmon fry that reside in the cave stream. Sampling of streams with monnow traps in El Capitan (Upper and Lower Rockwell River) has been unsuccessful.

Other Vertebrates - At one time or another, the cave has been shelter for a variety of large mammals (see paleontology). Currently, only rodents inhabit the entrance portions of the cave.

Invertebrates - Numerous collections of terrestrial, aquatic, and aerial invertebrates have been made in many parts of El Capitan Cave by Kent Carlson in July of 1992 and 1993, and February of 1993.

Typical terrestrial fauna collected from El Capitan Cave in July of 1992 include Onychiuran collembolans (Onychiurus ramosus), Entomobryiad collembolans (Hetermurus nitidus), Isotomid collembolans (Folsomia ozeana), Rhagid mites (Rhagidia sp.), and Enchytraeidae worms. The collembolans identified above have not as yet been found in surface collections. They are unique to only cave systems on Prince of Wales and Dall Islands. Out of all caves sampled on Prince of Wales Island, two species, Heteromurus nitidus and Folsomia ozeana, are unique to El Capitan Cave. Surface collembola specimens collected at the El Capitan Work Center bear Familia resemblance to those in El Capitan Cave but not Generic or Species similarity. Neither cave nor surface collembolan species have been previously reported from southeast Alaska. One surface species of collembolan found at El Capitan Work Center has only been collected previously from a glacier in Washington State (Mt. Rainier).

Aquatic fauna collected during July of 1992 are representative of epigean (surface) environments. These include various species of Tricoptera, Plecoptera, and Ephemeroptera insects, as well as Planorbid snails (Mentus sp), Tricladida flatworms (Polycelis sp), and Lumbriculid worms (Rhynchelmis sp). The cave environment probably represents a sheltered environment in which to finish their development (migration into the cave?) or a collection site from specimens washed down from above. It is not known if any species complete their entire cycle in the cave.

Aerial invertebrates collected during July of 1992 are also representative of epigean environments. These include Diptora (Speleolepta sp and Antocha sp) to name a few. Again it is not known if any species complete their entire cycle in the cave.

Threatened or Endangered Species - No known threatened or endangered vertebrates have been found to date. At present it is unknown whether the invertebrate specimens collected could be considered for federal or state, threatened or endangered species listing.

Geology/Mineralogy

No comprehensive geologic studies have been or currently are being conducted in El Capitan Cave. Most investigations have been informal. No study plans for study in the cave have been received and limited reports are available.

Various types of pristine speleothems have been found in El Capitan Cave. Some of these, (conulites), are relatively rare in southeast Alaska.

Glacial striations have been discovered 50 feet east of the cave's resurgence. Recent erosion of glacial drift (clay, gravel, and cobbles) has exposed incredibly well preserved glacial scouring and plucking features in the pure limestone. The clay has preserved these very old glacial features to a remarkable degree: the scour marks are still white and fresh looking. Glacial movement was westward.

Deposits of light gray banded clay suspected of being from glacial origin have been found in the cave. If these deposits are glacial, high parts of the cave were active at least prior to the last glacial advance. According to Connor and O'Haire in Roadside Geology of Alaska, the area has experienced many glacial episodes, at least one being in excess of 3000 feet deep on eastern Prince of Wales Island. Much glacial activity occurred in Alaska during the Pleistocene time of 10,000 years ago.

Cultural Resources

Between September 14 and 30, 1993 all accessible cave passages were inspected to a point approximately 600 feet into the cave. Where sediments were present test pits were excavated to bed rock. This project was directed by Forest Service archaeologists David Johnson and Marty Tagg who have extensive experience in cave archaeology and cave management in the southwest United States. No cultural material was identified by this survey. Additionally, D.Johnson and M.Tagg were asked to make a determination of the eligibility of a previously identified cultural resource site for inclusion to the National Register of Historic Places. The previous archaeological site was found by Ketchikan Area archaeologists and is known as 49-PET-189. A survey and literature search was conducted which resulted in 40-PET-189 being considered an isolated find and "not eligible" for inclusion to the National Register of Historic Places.

Paleontology

During the summer of 1992, a chamber of El Capitan Cave was excavated under the guidance of Dr. Timothy Heaton, Department of Earth Sciences and Physics, University of South Dakota and Dr. Frederick Grady, Department of Paleobiology, Smithsonian Institute.

The excavation yielded the remains of at least three grizzly bears and four black bear. The grizzlies range in age from 12,295 +/- 120 yr. B.P. to 9760 +/- 75 B.P. The black bears dated at 11,565 +/- 115 yr. B.P., 11,540 +/- 110 yr. B.P., 10,745 +/- 75 yr. B.P., and 6,415 +/- 130 yr. B.P. Grizzly bear are no longer present on Prince of Wales Island. Given the dates from the individuals recovered from these deposits, grizzly bears and black bears coexisted on Prince of Wales Island for at least 1,800 years. These discoveries also confirm that by at least 11,500 yr. ago, both grizzly and black bear had migrated into southern Southeast Alaska (J.Baichtal, 1993).

Associated with the grizzly and black bear were the remains of red fox, ermine, bat, otter, and other small mammals. The floor consisted of a thick layer of fish bone thought to be the remains of decomposed otter scat.

Hydrology

El Capitan Cave consists of a complex hydrological system situated in a karst aquifer of Silurian Heceta limestone of marine origin. Three vertical zones can be distinguished: (1) an upper, dry zone (inactive vadose); (2) a periodically flooded zone (active vadose); and, (3) a lower continuously flooded zone (phreatic). The cave had phreatic beginnings with extensive vadose modifications. The water-filled phreatic zone contains ground water which has the sea as its hydrological and erosive base. Characteristic of the vadose zone is the permanent or temporary presence of atmosphere. The limestone has been largely altered by water movement into marbleized breccia (rock composed of sharp-angled fragments cemented in a fine matrix).

Flooding is prevalent in certain areas such as Lower Rockwell River and the Ball Bearing Crawl. There are signs of past violent flooding evidenced by deeply dished-out areas of large football sized cobbles in constricted passages and numerous scallops. The scallops often lack consistency in size and presentation suggesting greatly fluctuating flow rates and patterns. There are many spongework side passages ranging from 100 feet above to 85 feet below the entrance. This gives evidence, along with various fill deposits scattered throughout, of changing flow patterns as certain main water conduits have become clogged, forcing formation of new smaller ones through corrosion and erosion. Much of the lower part of the cave is known to flood with the exception of the main passage to Hatfield's Pit (Section 1 and 2) and higher sections. Flooding may occur throughout the year whenever rainfall is high and/or during snow melt. A hydrological survey was done for El Capitan Cave in May, July, and August of 1990. Results of the survey linked cave flooding and resurgence water flow (CFS) to general weather fluctuations. Inches precipitation and total drainage area were not linked to the study. This limited the surveys' use as a predictive model.

There is a cave resurgence stream known as Rockwell's River, in what is called Lower El Capitan Cave. This river represents a water thoroughfare (and possibly reserve) for the water used in the El Capitan Work Center, a Forest Service field camp located 1500 feet below the cave. (see Vicinity map in Appendix A). The average yearly flow is estimated at 2692 gallons per minute.

The main entrance to El Capitan Cave is 360 feet above sea level. Located high on the mountain above El Capitan Cave is a series of sinkholes, uvalas and small caves. One deep sinkhole located at approximately 1000 feet in elevation is Slate Cave. It has been dye traced to show hydrologic connections with El Capitan Cave.

3.4 Resource Evaluation Rating for El Capitan Cave

A relative system for evaluating resources in El Capitan Cave is presented below. This system has been proposed as Karst and Cave Resource Management Forest-wide direction and standards and guidelines for the Revision of the Tongass Land Management Plan. Table 3.1 at the end of this section gives the rating for El Capitan Cave. Over time, resource ratings may change as new information becomes available. In some cases, one feature or a singular resource aspect may be so unique that it alone determines the rating for that resource. For example, bats, alone, may determine the rating for biological resources.

Recreation

For evaluation purposes, recreation resources are divided into three categories: challenge, social encounter and visual quality.

Challenge

POOR: Requires no experience or skill in caving. Offers little or no degree of challenge or risk. The cave is horizontal in structure. There is a single well-defined passageway < 1000 feet with no lateral passages. No passageways are less than 3 feet in diameter and step-type drops not over 3 feet. There are no loose ceiling rocks and few loose rocks on the cave floor. The cave is accessible, or can easily be made accessible, to pedestrian traffic.

FAIR: Requires no experience or skill in caving. Offers a low degree of challenge and risk. The cave is primarily horizontal in structure. The main passageway is well-defined with only dead-end lateral passages present. No crawlways are less than 2 feet and no step-type drops are over 10 feet. There are no loose ceiling rocks and some loose floor materials. The cave is accessible, or can easily be made accessible, to pedestrian traffic.

GOOD: Special caving expertise and equipment may be required. Offers a moderate degree of challenge and risk. The cave is horizontal and vertical in structure. There may be hazards and other safety concerns Passageways are multiple with connecting passages. Some crawlways are less than 2 feet and vertical drops are up to 50 feet. Ceilings with loose rocks are over 6 feet high. Floors contain loose materials. The cave may not be easily accessible. Major safety hazards and management concerns are not easily remedied. Rapid flooding may occur. Hypothermia compounds the other risks present.

VERY GOOD: Special caving expertise and equipment are required. Offers a high degree of challenge and risk. The cave is horizontal and vertical in structure. There may be major hazards and other safety concerns. Some passageways may be mazes. Vertical drops may be over 50 feet. Some crawlways are less than 2 feet in diameter. There may be loose materials on ceilings and floors. Rapid flooding may occur. Hypothermia compounds the other risks present.

OUTSTANDING: Special caving expertise and equipment are required. Offers a high degree of challenge and risk. The cave is generally vertical in structure. There may be major hazards and other safety concerns. Passageways, vertical drops, crawlways and loose materials on ceilings and floors are the same as in "*GOOD*" above. In addition, conditions may be present which require more specialized equipment to protect the caver. Such conditions may include rapid flooding, passages requiring diving, frozen passages, or other extremely hazardous conditions. Hypothermia compounds the other risks present.

Social Encounter

POOR: The opportunity for solitude is not likely. Use is high. Group sizes may range from 2 to over 20. Social encounters with other groups are common.

FAIR: The opportunity for solitude is low. Use is moderate to high. Groups are generally 6 or larger with with social encounters of other groups likely.

GOOD: The opportunity for solitude is moderate. Use is moderate. Groups are generally limited to 6 or less with social encounters of 1 to 4 other groups likely.

VERY GOOD: The opportunity for solitude is moderate to high. Use is low. Groups are generally limited to 5 or less with social encounters of 1 to 2 other groups likely.

OUTSTANDING: The opportunity for solitude is high. Use is low or non-existent. Groups are generally limited to 4 or less with the likelihood of other social encounters non-existent.

Visual Quality

POOR: Little or no scenic or other aesthetic appeals. Resources such as formations, animal species, artifacts, water falls, rivers, pools, fossils, etc. within the cave are limited and do not provide much diversity. There is little variety in form, line, color and texture or combinations thereof. There is little photographic appeal. There may be a high degree of alteration.

FAIR: Scenic and other aesthetic appeals are low. Resources may be present but are limited and not very diverse. Some variety in form, line, color and texture may be present. There is limited photographic appeal. There may be a moderate degree if alteration.

GOOD: Scenic and other aesthetic appeals are moderate. Resources are present and moderately diverse. There is a moderate combination of form, line, color and texture present. There is good photographic appeal. There may be a low degree if alteration.

VERY GOOD: Scenic and other aesthetic appeals are high. A wide diversity of resources are present. Form, line, color and texture is appealing. Photographic opportunity is very good. There is no or a very low degree of alteration. .

OUTSTANDING: Scenic and other aesthetic appeals are outstanding. A wide variety of diversity is present with resources protraying unual and unique qualities. The combination of form, color, line and texture is very appealing. This is a cave of regional significance. Photographic opportunity is outstanding. There is no degree of alteration.

Biological Resources

POOR: Biological components are lacking.

FAIR: Biological components are present, of low apparent significance and show low sensitivity to disturbance. Opportunities for scientific study are few.

GOOD: Biological components are present and moderately sensitive to disturbance. Fauna present is common in other sites. There are abundant opportunities for scientific study. These opportunities also exist at other sites in the area.

VERY GOOD: Biological components are numerous and/or very sensitive to disturbance. Fauna present is uncommon in other sites and may include rare, threatened, and endangered species. Habitat found in the cave is also important to these species occurring on a local level. Research opportunities at the site are uncommon in the area and may be regionally significant.

OUTSTANDING: Biological components are very numerous and/or very sensitive to disturbance. Fauna present is limited to few other sites and includes rare, threatened and endangered species. Habitat found in the cave is also critical to these species occurring on a regional level. There are unique opportunities for scientific study. These opportunities are usually significant for the region.

Geologic/Mineral Resources

POOR: Geologic and mineral features are few or lacking. If present, these features cannot be destroyed, further damaged, or removed from the cave without great effort.

FAIR: Geologic and mineral features are present but resistant to disturbance. Some formations have been damaged and there are few opportunities for scientific study.

GOOD: Geologic and mineral features are present and of moderate sensitivity to disturbance. Features are of such size or in a position to be susceptible to breakage and vandalism. Most features are not damaged. Some of the damaged formations can be restored. There are abundant opportunities for scientific study.

VERY GOOD: Geologic and mineral features are numerous and very sensitive to disturbance.

OUTSTANDING: Geologic and mineral features are rare, valuable, numerous and/or of great sensitivity to disturbance. Features may be of regional significance. There is little or no damage. There are unique opportunities for scientific study, which may be of regional significance.

Cultural Resources

POOR: No cultural resources are known and the potential for them being present is low or lacking.

FAIR: Cultural resources are lacking or those found are regionally common. The potential for these resources being present is low or moderate. The possibilities for research are few.

GOOD: Cultural resources are present or implicated by historic records. The site may be eligible for the National Register of Historic Places. There are abundant opportunities for research. These opportunities are also found at other sites in the area.

VERY GOOD: Cultural resources are present and sensitive to disturbance. The site is eligible for the National Register of Historic Places. Research opportunities at the site are uncommon in the area and may have significance on a regional level.

OUTSTANDING: Cultural resources are present and highly sensitive to disturbance. The site is designated or is eligible for the National Register of Historic Places. There are unique opportunities for research. Research possibilities are usually significant on a regional level.

Paleontological Resources

POOR: No paleontological resources are known and the potential for them being present is low or lacking.

FAIR: Paleontological resources are lacking or those found are regionally common. The potential for these resources being present is low or moderate. The possibilities for scientific study are few.

GOOD: Paleontological resources are present or implicated by previous research. There are abundant opportunities for scientific study. These opportunities are also found at other sites in the area.

VERY GOOD: Paleontological resources are present and sensitive to disturbance. Scientific study opportunities at the site are uncommon in the area and may have significance on a regional level.

OUTSTANDING: Paleontological resources are present and highly sensitive to disturbance. There are unique opportunities for scientific study. Research possibilities are usually significant on a regional level.

Hydrological Resources

POOR: There is little or no influence of the water moving into, within, or out of the cave to the resources of the cave or to other features (including ground water) in the watershed.

FAIR: The influence of the water moving into, within, or out of the cave is limited to the cave itself and has no effect on the resources of the cave. Research opportunities are few.

GOOD: There is moderate influence of water moving into, within, or out of the cave to the resources of the cave or to other features (including ground water) in the watershed. Research opportunities are abundant but may be common in the area.

VERY GOOD: The water moving into, within, or out of the cave greatly influences the resources of the cave or other features (including ground water) in the watershed. The possibilities for scientific study are uncommon to the area and may be regionally significant.

OUTSTANDING: In addition to the characters in "*GOOD*", the influence of water to the cave resources or other features of the watershed are regionally significant. Scientific study opportunities are unique. These opportunities are usually significant on a regional level.

Table 3.1: Resource Rating for El Capitan Cave

	Section 1 Entrance to Gate (150 feet)	Section 2 Gate to Hatfield's Pit (600 feet)	Section 3 Hatfield's Pit to End (600+ Feet)	Section 4 The Steam Room (@ 250 Feet)
Recreation				
Challenge	Fair	Fair	Very Good	Fair
Encounter	Poor	Fair	Outstanding	Good
Visual Quality	Fair	Good	Outstanding	Very Good
Biology	Very Good	Outstanding	Good	Good
Geology	Fair	Good	Outstanding	Good
Cultural	Poor	Fair	Poor	Outstanding
Paleontology	Poor	Poor	Outstanding	Outstanding
Hydrology	Poor	Very Good	Outstanding	Outstanding

3.5 ROS

The Recreation Opportunity Spectrum (ROS) classification system is used extensively for above-ground recreation management on Forest lands, however, the spectrum has application to all lands regardless of ownership or jurisdiction. The ROS is based on three principal components: the activities, the setting, and the experience. ROS classes are identified so that an initial classification can be perpetuated. For example, a cave with a rating of primitive would be managed to perpetuate pristine conditions. The intended output is satisfactory experiences.

The activities, setting and experience components of the ROS include spatial relations (i.e., size of passages), presence and intensity of fragile cave resources, evidence of humans/social interactions and hazards such as pits and flooding.

For management and conceptual convenience, possible mixes or combinations of activities, settings, and probable experience opportunities for above-ground recreation on Forest lands has been divided into six ROS classes arranged along a continuum. For cave recreation management, five classes are used. An entire cave may receive one ROS designation or portions of the cave may receive different class designations due to differing opportunities and settings.

The following ROS Classes have been proposed as Karst and Cave Resource Management Forest-wide Standards and Guidelines for the Revised Tongass Land Management Plan.

Developed: In general, visual quality and cave resources may range from poor to outstanding. The challenge level is generally poor. Caves in this class are developed to allow access to visitors without special equipment. Hard surface walkways, steps, handrails, and lighting systems have been installed to maximize the comfort of the visitor. Guides usually accompany large groups and social interaction is high. Interpretive brochures and advertising are common, as well as an admission fee. Parking lots and toilets are usually available on the surface.

Developed Natural: In general, visual quality and cave resources may range from fair to outstanding. The challenge level is generally poor to fair. Caves in this class are minimally developed to allow visitors a relatively safe and informative visit, while not detracting greatly from the natural character of the cave. Examples are steps and barriers that use native materials, enlarged passages, and interpretive and directional signs. Brochures containing educational and interpretive information may also be available. There may be some opportunities for visitors to experience some risk and challenge while encountering natural obstacles (such as uneven floor surfaces and low ceilings), although no special caving equipment is required. A host may be stationed at the entrance and may also have lights and helmets to loan to visitors. Social interactions are typically of family or educational groups, and social encounters with other groups are common. Resources are likely to be highly impacted since the character of the cave's natural state is maintained (or restored) to provide maximum interpretation and educational benefits.

Natural: Most cave resources and visual quality range from good to very good. The challenge level may range from fair to good. Caves in this class are not developed. Visitors must provide all necessary equipment required for safe exploration. Usually obstacles within this class of cave will not require technical skills such as rock climbing. Visitor registers may be used to monitor visitation and brief interpretive signs may be placed near the cave entrance. Trail markers and monitoring instruments will be used only when needed to preserve fragile resources or warn of hazardous conditions. In general, however, the cave will be kept as natural appearing as possible. Social interactions are typical of small groups of families or friends, and the chance of encountering other such groups is moderate. Use by experienced recreation cavers will normally represent a minor portion of total visitation.

Primitive: Cave resources and visual quality are good to outstanding. The challenge level ranges from good to very good. Caves in this class are not developed. Visitors must provide all necessary equipment required to safely explore the cave. Technical skills (such as rock climbing) may be required. A visitor has a good chance of experiencing risk and self-sufficiency through the application of caving skills. Visitor registers with conservation messages are likely to be installed just within the entrance, but other management devices will not be installed unless their use is warranted by the presence of fragile resources or extreme hazards. Social interactions are usually between members of a small group of experienced recreational cavers. Social encounters with other groups are very rare because visitation is very low or regulated.

Protected Primitive: Cave resources and visual quality are very good to outstanding. The challenge level may range from good to outstanding. Most, or all, of the formations are not broken or marred. Introduced dust and mud is limited to established travel ways. Traffic patterns have also been limited to reduce floor destruction. Caves in this class are not developed. Visitors must provide all necessary equipment required for safe exploration. Technical skills (such as rock climbing) may be required, and there is usually an opportunity to experience risk and self-sufficiency. Visitor registers with conservation messages are likely to be installed just within the entrance. Other management devices (such as trails and signs) are used to preserve the pristine character of resources within the cave. Social interactions are typically between members of a small group of experienced cavers. Visitor encounters with other groups are very rare because visitation is low or regulated.

Table 3.2. ROS Classification for El Capitan Cave

	Section 1 Entrance to Gate	Section 2 Gate to Hatfield's Pit	Section 3 Hatfiled's Pit to Alaska Room	Section 4 The Steam Room
ROS Class	Developed Natural	Natural	Protected Primitive	Protected Primitive

3.6 Classification System

The following cave classification system has been proposed as Karst and Cave Resource Management Forest-wide Standards and Guidelines for the Revision of the Tongass Land Management Plan. Use of the system helps identify caves needing priority management and facilitates comparisons to other cave resources Forest-wide. Management classes provide direction to protect the cave resource and the public. It should be noted that El Capitan Cave requires multiple classifications for the four divisions of the cave mentioned earlier. Table 3.3 at the end of this section displays the classification rating for El Capitan Cave. Note, any part of El Capitan's cave classification may be changed upon new discoveries in the cave

Improved These caves are managed for public use and enjoyment. They are shown on maps and have signs directing visitor access. Improvements may include hard surfaced trails, handrails, electric lights, sanitation facilities, concession services, and elevators. A variety of media such as electronic self-guided tours, interpretive displays, and guided tours may be used. Most visitors can tour these caves without special clothing, equipment, knowledge or skills. Large numbers of visitors may tour the cave daily.

Guided Minimally developed and managed to provide relatively easy access with minimal modification to the cave's resources. Development normally consists of a designated trail that provides a natural cave experience. Exploration may require crawling and/or vertical work. Visitors are responsible for all necessary equipment and should have minimal caving experience when vertical work is required. Permits may be required and they can only be visited with a guide..Arrangements to visit the cave must be made in advance. The guide will act as interpreter and will insure the cave is left undisturbed for future visitors. Volunteers may be certified as guides. Volunteers will help meet the demand for guides, and will ensure protection of the cave resource. The cave may contain sensitive resources which have undergone resource analysis for protection. Access may be through a reservation system.

Non-guided These caves are undeveloped and are suited for persons who are properly prepared. Permits and trip leaders may be required. Trip leaders must have "in cave" instruction to identify routes, methods of travel, areas of special concem, and monitoring requirements. Individual Cave Management Plans will set background requirements for trip leaders. Resources within the cave are not easily impacted. Sensitive resources must undergo resource analysis for designating protection measures. These caves vary from easy to very difficult and may require crawling or vertical expertise. Visitors are responsible for all necessary equipment. Evidence of incompetence, previous cave abuse, or disregard for Forest regulations constitutes denial for a permit. These caves fulfill the wild caving experience. Access may be through a reservation system.

Temporarily Closed These caves are closed to general use pending further evaluation and designation in another management class. Cave entry is approved for minimum administrative purposes, research and inventory. They are temporarily closed because: 1) they are newly discovered and require further exploration/inventory to evaluate how they should be managed, 2) they have have not been sufficiently inventoried, 3) on-going research is being conducted in which visitation may adversely impact, and 4) they have pending resource results. These caves are generally pending reclassification as Improved, Guided or Non-guided.

Limited Entry Are closed to all use except the minimum required for administrative entry. These caves are closed to general use because: 1) their pristine condition, unique and/or fragile resources are difficult to enter without causing irreparable damage, 2) they are of special scientific value, 3) they contain endangered species that could be threatened by visitor use, 4) they contain archaeological and/or paleontological significance, and 5) they are extremely hazardous. These caves are not shown on maps or discussed in publications intended for general public use such as magazines and interpretive brochures. Administrative entry to monitor research activity and impacts upon these caves is allowed, however, even low level visitation may impact these caves. Physical closure through gating may be necessary.

Table 3.3: Classification for El Capitan Cave

	Section 1 Entrance to Gate	Section 2 Gate to Hatfield's Pit	Section 3 Hatfiled's Pit to Alaska Room	Section 4 The Steam Room
Management Class	Non-guided	Guided	Temporarily Closed	Limited Entry

3.7 Hazards

El Capitan Cave contains many hazards. These hazards are dangerous to novice cavers as well as experienced southeast Alaska cavers. Numerous pits of varying depths line the main and side passageways. Just beyond the main entrance to the cave, at 15 to 30 feet, a 12 foot pit drops vertically from the main floor. Many large boulders at the entrance form open pockets and small pits, and a low, jagged ceiling makes the first 10 to 15 feet of passage difficult and hazardous. Low ceilings and large boulders present risk of injury..

Flooding is a major concern in the cave when people are present. Unpredictable weather adds to this danger. Cave users may not be aware of torrential rains on the surface. The cave may flood at any time of year depending on rainfall, run-off and snow melt. The main passage and upper side passages to Hatfield's Pit do not flood.

The cold wet conditions and cool temperatures (38-44F) create a high potential for hypothermia, especially if a person is unable to move around such as in when an injury has occurred and rescue is under way.

The cave contains an intricate system of extensive maze passages. These passages branch in every direction within the cave and contain many deep pits. The potential for people getting lost is high.

Loose and falling rocks are a hazard throughout the cave. Rocks from the ceiling may dislodge at any time while loose rocks on the floor make travel difficult.

Tests for radon have been conducted in the cave. Radon is a colorless, radioactive, inert gaseous element which at high levels can be dangerous to humans. High levels considered to be dangerous to humans were detected in the back portion of the cave in 1988. Radon detectors were washed away by flooding before a complete analysis could be done. Further tests are needed to determine the radon levels in the cave. Since there is good air flow in the cave, radon may not be of high concern.

3.8 Cave Hazard Rating System

The Cave Hazard Rating rates the potential hazard to cavers who practice safe caving techniques. These ratings range from low to extreme. The Cave Hazard Rating evaluates the complexity and size of passages, drops and climbs, stability of floors and ceilings, water hazards, and biological hazards. It should be realized that hypothermia is inherent in all caves in Alaska regardless of the following hazard ratings. This rating system has been proposed as Karst and Cave Management Forest-wide Standards and Guidelines for the Revised Tongass Land Management Plan.

Low These caves are horizontal in structure. Exploration should be conducted by no less than three cavers and the following basic equipment: hard hats, three light sources per person, boots with non-skid soles, and protective clothing.

The following are general low hazard characteristics:

- Single, well defined main passageway, with no lateral passages.
- No passageways less than one meter in diameter.
- No step-type drops over one meter.
- No loose ceiling rocks
- Few loose rocks on floors.

Medium Caves which contain moderate hazards, and are mostly horizontal in structure. Exploration should be conducted by no less than three cavers, one of which is experienced, and the following basic equipment: hard hats, three light sources per person, boots with non-skid soles and protective clothing.

The following are general characteristics of Medium Hazard caves.

- Well defined main passageway, with dead-end lateral passages.
- No crawlways less than 60 centimeters (24 inches).
- No step-type drops over three meters (ten feet).
- No loose ceiling rocks.
- Few loose rocks on floors.
- Not prone to rapid flooding.

Medium-High These caves contain hazards which may relate to horizontal and/or vertical conditions. Exploration should be conducted by no less than three cavers, two of which have moderate caving experience (including vertical descent and climbing), and use the following basic equipment: hard hats, three light sources per person, boots with non-skid soles, vertical ascending and descending gear, and protective clothing. Each caver should have a complete set of climbing equipment.

The following are general characteristics of Medium Hazard caves:

- Multiple passageways, with straight connecting passages.
- Crawlways less than 60 centimeters (24 inches).
- Vertical drops up to 15 meters (50 feet).
- Loose rocks on ceilings over two meters in height.
- No loose rocks in passages less than two meters.
- May be prone to rapid flooding.

High These caves are most hazardous from a vertical standpoint. Exploration should be conducted by no less than four cavers, all of which have considerable caving and vertical experience and use the following basic equipment: hard hats, three light sources per person, boots with non-skid soles, vertical ascending and descending gear, and protective clothing

The following are general characteristics of High Hazard caves:

- Maze type passages.
- Vertical drops over 15 meters.
- Loose ceiling rocks on crawlways under two meters.
- Prone to rapid flooding.

Extreme These caves are extremely hazardous due to characteristics such as air bome diseases, dangerous gases, flooding, unstable entrances, mid-cliff entrances, passages requiring cave diving, and any other hazard which requires special equipment to protect the caver. These caves should only be entered by qualified cavers with special equipment, expertise and training and only if there is a real necessity for information which is deemed valuable in relation to the risk involved. The minimum party should consist of six cavers, with two remaining on the surface or outside of the hazardous area(s). Extra precautions should be taken, and special communications and rescue capabilities available.

Table 3.4: Hazard Rating for El Capitan Cave

	Section 1 Entrance to Gate (150 feet)	Section 2 Gate to Hatfield's Pit (600 feet)	Section 3 Hatfield's Pit to End (600+ Feet)	Section 4 The Steam Room (@ 250 Feet)
Hazard Rating	Medium	Low	Medium High	Medium

CHAPTER 4.
ANTICIPATED USERS AND USE

4.1 Anticipated Users

Experienced Cavers - people with special knowledge and expertise of recreational caving with varying degrees of skill. Generally, they are skilled in climbing and survival. Most are probably not interested in guided trips.

Developed Users - Casual users specifically seeking cave exploration with a relative degree of safety and comfort through development. Generally not skilled in climbing and limited to Sections 1 and 2. Also, considered to be "guided" and "non-guided" publics. See the section below, Use Control and Operations for guided and non-guided Forest Service tours.

Schools and other Youth Groups: - all ages from 1st Grade to College and Universities. May come from lower 48 although not likely. Primarily local youth and school groups from Ketchikan and Prince and Wales Island.

Researchers - may be independent, affiliated with Universities, Institutes and/or Societies such as National Geographic and the Smithsonian, or Forest Service employees from the Forestry Sciences Range and Experiment Stations in Juneau, Alaska, and/or the Pacific Northwest.

Media - could vary from newspaper and magazine to radio and television.

Concessionaires - may include small operators who sell or rent equipment and small souvenirs to larger concessionaires who take on sole operation and maintenance of the cave. Fees are associated with all concession use.

Outfitters and Guides - Mostly local outfitters and guides currently in operation who may or may not be associated with a lodge and overnight accommodations. Lodge outfitters and guides cater primarily to people interested in hunting and fishing, and indicate that caving would offer the minority of clientele something else to do. Some interest from individuals who are not currently permitted as Outfitter or Guides who wish to guide in the cave has been expressed.

Other: People recreating on the island for purposes other than visiting El Capitan Cave; they visit the cave for "something else to do". They may include hunters, hikers and backpackers, sightseers, campers, boaters, fishers, flight seers, photographers, or those employed in the area.

4.2 Anticipated Use

Regardless of the level of development of El Capitan Cave, public visitation and use will occur. Visitations and exploration occur as a day-use activity in which an individual or group may enter the cave one or more times and spend from 30 minutes to 12 hours; no overnight camping requests are anticipated.

Accurate documentation of people entering the cave does not exist. A cave register located at the entrance to the cave has helped to record some use but it is known that many people do not register when entering the cave. The vast majority of use occurs during the summer months. In 1992 and 1993 use dramatically increased and could be correlated with increased media coverage. Numerous articles appeared in local, regional and national newspapers, and magazines. Radio and Television aired programs about El Capitan Cave. Even with the extensive media coverage of the cave, use remains relatively low especially when compared to such high use caves as Mammoth and Carlsbad Caverns which can have up to 900,000 Recreation Visitor Days (12 visitor hours aggregated continuously, intermittently, or simultaneously by one or more persons) per year. In the years prior to 1992, RVD's at El Capitan Cave are estimated at <150 per year. In 1992 and 1993, estimated RVD's increased to 200 and 300, respectively. In 1994, use is anticipated to go up. A 10 to 15% per year increase is anticipated.

Guided trips and outfitting is anticipated from the private sector. Requests for permits from private sector outfitter and guides in the first 3 to 5 years is estimated at less than 5 on an annual basis. During May to September outfitter and guides are expected to request approximately 10 to 20 days.

School and/or youth groups could be limited to < 5 per year as there are relatively few schools in the area. School and/or youth group visits may occur any time throughout the year.

Researchers may conduct studies throughout the year. Simultaneous research activities may occur. Research may increase over the next few years and with studies lasting from 1 month to an indefinite time in the future.

Media trips ranging from simple interviews to complex videos are anticipated. No more than 5 to 10 media trips per year are expected for the summer months.

A large scale, fully owned and operated concession could occur, however current interest is lacking. A small scale concessions business which sells equipment, food and souvenirs may also formulate.

Cruise ship operators have requested permission for their passengers to visit El Capitan Cave. Some operators may make El Capitan Cave a destination while others include the cave as part of their tour package. Some operators may also request their own cave guide.

CHAPTER 5.
MANAGEMENT STRATEGY

5.1 Introduction

This Chapter describes the initial policy and procedures for managing El Capitan Cave. These policies and procedures include commonly used cave management techniques (see Appendix B), reservation requirements, fees, permitting, user limits, seasonal closures, etc. As with any management strategy of this nature, fine tuning of the policies and procedures may be needed. For all practical purposes, however, this Chapter sets the stage for managing El Capitan Cave.

5.2 The Visitor Register

Currently there is one cave register at the entrance to the cave. A second cave register will be placed in Section 3 at the entrance to the Alaska Room. Both Cave Registers will contain conservation messages about the cave which address such topics as protection of bats, fragile resources, water quality, etc.

5.3 Education/Interpretation

Public education will play an important role in protecting cave resources. The Thorne Bay Ranger District will use education and interpretation to aid the public in understanding the intrinsic value of cave resources. Portable interpretive displays, slide shows, videos, brochures, and lectures will be offered to schools and special interest groups. Cave conservation brochures will be available at Thorne Bay Ranger District and may be included in mailings to interested publics.

Interpretive signs will be developed and displayed at El Capitan Cave. A kiosk board at the entrance to the cave and at the parking area may be used to display signs. Messages and themes will be developed through an interpretive planning process. Informing the public about El Capitan and its non-renewable cave resources by instilling a sense of personal responsibility will be the ultimate goals of interpretation.

5.4 Brochures and Handouts

Interpretive brochures, handouts and freestanding exhibits will be developed for use by the general public addressing archaeology, biology, geology, paleontology, and recreation. They will provide information about the operating period, guided tours, fees, reservation procedures, accessibility, etc. Safety and conservation messages as well as a brief history of El Capitan Cave and amenities available at the site will be included. A map of the cave and directions to get there will also be displayed. Cave maps will not include all areas which require special resource protection, i.e., cultural and paleontological sites.

5.5 Distribution of Information

General inquiries about the operating period, user limits, reservations, etc. will be answered by Support Services personnel (i.e., front desk receptionists)., This includes both oral and written requests. An information sheet will be provided. Specialized questions from researchers, media, and experienced cavers should be forwarded to cave managers at Thorne Bay Ranger District. If no one is available, the name and number should be taken so that the call can be returned.

5.6 Publicity and Advertising

Publicity and advertising of El Capitan Cave will be designed to maintain use at appropriate levels for resource protection. Publicity and advertising can cause a high demand for recreational use of the cave. Currently, only one other cave is available for public use. This is known as Cavern Lake Cave. The recreational opportunities at Cavern Lake are quite different than those at El Capitan. Cavern Lake Cave is a much smaller system with one large room and a creek flowing through it. Access to Cavern Lake Cave is by an improved gravel trail which leads to a viewing deck overlooking the cave entrance.

5.7 Cave Trails

No internal trails are currently planned. Cave trails may be developed in the future as monitoring and research provide information. Elaborate boardwalk trails and/or other hardened trails are not likely. Simple trails lined on either or both sides with marking ribbon or other materials could be used to help direct traffic away from fragile areas.

5.8 Permits

The Tongass National Forest, in accordance with the Federal Cave Resources Protection Act of 1988, must: 1) secure, protect and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people; and 2) foster increased cooperation and exchange of information between governmental authorities and those who utilize caves located on Federal lands for scientific, educational and recreational purposes.

To help gather use data, and for establishing guidelines for protection of El Capitan's non-renewable resources during research and inventory work, permits will be required for certain cave related activities in several sections of the cave.

Evidence of incompetence, negligence, disregard for personal safety, previous cave abuse, or non-compliance of Forest Service regulations will be cause for permit denial.

A. Types of Permits

1. **Recreational Entrance Permit** - A cave entrance permit required for recreational use.

2. **Research Permit** (exploration or scientific) - a research permit for exploration or science study including air quality, biology, climatology, cultural, geology, hydrology, mineralogy, paleontology, or recreation.

3. **Dig Permit** A dig or excavation permit for the purpose of discovering hidden passages.

4. **Special Use Permit** Permits for outfitter and guides, filming, concessionairing and other commercial activities. Examples of such use include filming, photography, guiding, teaching, transporting persons, or providing equipment or supplies. For any such use, the person must submit a written request to the District Ranger. If the use is determined to be "commercial", or has the potential to cause resource disturbance or conflict, then a permit will be required.

B. Permit Requirements and Procedures

Research, Dig and Special Use permits are required for research and inventory work in all sections of the cave. No recreational use permits are currently required. If in the future, recreational use is allowed in Section 3 or other side passages of the cave, excluding Section 4, recreational use permits would be required. All permits will be considered for approval on a case by case basis and require advance notice.

Section 1 -Research, Dig, Special Use Permit required, open to recreational use.
Section 2 -Research, Dig, Special Use Permit required, open to recreational use through a guided tour, 6 person group limit.
Section 3 - Research, Dig, Special Use Permit required, closed to recreational and/or commercial use pending further evaluation. Trip leaders or guides required, 3 person group limit.
Section 4 - Research, Dig, Special Use Permit required, closed to recreational use, limited entry for monitoring purposes, 2 person group limit.

1. Recreational Entrance Permit

As mentioned, recreational permits are not currently required, however, recreational use permits may be available in the future for access to Section 3 and side passages. Specific criteria will be developed when this decision is made. In general, the following criteria would apply:

a. Requires advance notice and prior approval.
b. Permits must be carried with permittees while in the cave.
c. Requires an approved guide or trip leader.
d. May call or write in advance for permits and subsequent reservations.
e. A cave calendar will be used for scheduling. The cave calendar will provide available dates. Visitors should list three dates of choice. Dates will be assigned on a first-come, first-served basis. User limits and operating periods apply.
f. Fees may be required.
g. Permit requests should be stamped with the date received by Thorne Bay office personnel.
h. Minors must obtain parental approval prior to entry.
i. Specilized caving skills and/or equipment may be necessary.

2. Research Permits

Caves can be extremely valuable research tools. The ability of caves to preserve organic and inorganic materials offers a unique opportunity to study past flora, fauna, climates, and geological events. However, collection of cave resources for study can be destructive. Several types of archaeological, paleontological, geological and biological resources occur within El Capitan Cave. Collection of one type of resource, even with the best techniques, can disturb the physical or situational character of the other resources, severely reducing their value to future researchers. Inconsiderate or unaware researchers and recreational cavers can permanently damage valuable cave resources simply by traveling through a sensitive area.

Further research and monitoring of El Capitan Cave is needed however, Thorne Bay Ranger District is not authorized to conduct research and does not receive funding for research activities. All researchers are encouraged to provide their funding through grants, proposals, etc. Assistance from Thorne Bay Ranger District may be available for minor support such as housing and transportation. A priority for research has been established and is based on current knowledge of the cave

Research Priorities:

Air Quality. - Determine if there are gases harmful to humans present in the cave, particularly radon; quantities, and variation of presence. Note: No harmful gases have been detected in Sections 1 and 2.

Water quality - Determine if visitation adversely affects the water quallity of the cave. Note: Water originating in a river within the cave is the drinking water supply for a Forest Service administrative camp located below the cave.

Bats - Determine when bats are using the cave; if there are maternal colonies; if bats are roosting or hibernating; what species are present. Initial studies should focus on behavior, population dynamics, and physiology. Taking specimens will be reviewed on a case-by-case basis. Winter visits to areas of El Cap Cave where bats hibernate will be severely restricted; permission must be obtained from the District Ranger to enter the cave in winter. Bat research should be conducted to allow optimum preservation for different studies by different experts.

The criteria for research is as follows:

a. All research conducted within El Capitan Cave requires prior approval by the District Ranger, a research permit and NEPA review. Approval to conduct research will be made on a case-by-case basis. A proposal or study plan will be required. If collection of specimens is requested, the researcher will be further required to apply for a research collecting permit. In some cases, additional collecting permits are required by other Federal and State agencies.

b. Permit applications to undertake research studies or collections must be addressed to some over-all guidelines and an overview panel should conduct the initial evaluation of the applications. A two person local panel would include an official responsible for cave management at Thorne Bay Ranger District and someone familiar with the other resources involved (i.e., wildlife for Biology, Archaeology for Cultural Resources, Soil Scientist for Soils, etc.) General guidelines include the following:

    1. Could it be done better outside of caves?
    2. Does it build on previous studies done in caves and in the general discipline involved (e.g. does the applicant show familiarity with the literature, are they experienced, etc.)?
    3. Has such a study been done before locally, elsewhere, in less detail or with a different approach?
    4. Does it overlap or compliment on-going studies by others?

c. Researchers should use non consumptive research techniques wherever possible. To summarize, multiple use by multiple experts with multiple approaches is the keynote requirement (Poulson, 1975).

d. A limited number of people will be involved in the actual "in-cave" research which adheres to the capacity limit set for the cave. They may be able to enter the cave at any time during the year as long as prior approval has been made, however, every attempt should be made to conduct research outside the operating period set for public visitation. Researchers will be adequately briefed on cave conservation techniques and should sign the cave register and permit issued to the researcher. The principle investigator will be responsible for the actions of the entire party.

e. The researcher will be required to assess the impacts through a written environmental analysis on all significant cave resources prior to approval of the permit. The researcher must determine to what extent the research will affect cave biological, geological, recreational, hydrological, mineralogical, archaeological, and paleontological resources.

f. A report will be required by all investigators regardless of the findings. A copy of all scientific papers submitted to Thorne Bay Ranger District is also required. Should it be necessary for any scientific reports or papers to maintain confidentiality, the researcher is required to use vague locations when submitting papers to anyone other than Thorne Bay Ranger District.

g. Persons conducting research in El Capitan Cave will not totally deplete any cave resource within the cave. Researchers shall make every possible attempt to leave studied portions of the cave resource untouched and insitu for future researchers. The researcher will make all possible efforts to maintain the ROS class of a cave. It is felt that future researchers using advanced techniques will be able to learn much more from carefully preserved cave sites.

h. Cave reconnaissance may not normally be combined with research activities. Researchers may conduct cave reconnaissance as a non-research activity and will be subject to the Management Strategy outlined in this Chapter. No collecting of any kind will be allowed on any trips specifically determined to be cave reconnaissance. Collection of any resources must be a carefully planned activity.

i. In some situations, conflicts may arise between recreational use and research activities. If a researcher anticipates a conflict, a temporary closure of the cave may be requested for the period during which field research is taking place. Typically, this period shall not exceed 30 days. During this period, only the research group will be given permission to visit the cave (according to capacity). Extensions of the closure exceeding 30 days may be granted, provided progress reports indicate a longer closure is necessary. At the end of the closure, the researcher must insure that no resources within the cave are more vulnerable than they were prior to the research activities (e.g., new trails leading to the cave, publicity about the resources or their location, open excavations within the cave, etc.).

j. Cave excavation, testing, or removal of archaeological and paleontological resources must be conducted by qualified archaeologists, paleontologists, institutions, organizations and individuals, and will be evaluated and approved by the District Ranger. Permits will be issued in accordance with the Antiquities Act of 1906 (16 U.S.C. 4312 et seq.), The National Historic Preservation Act of 1966 (16 U.S. C. 470 et seq.), and the Archaeological Resources Protection Act of 1979 (16 U.S.C. 470aa). All appropriate NEPA requirements will be completed prior to the approval of the permit.

k. Prior to touching, moving, or collecting a cave resource, researchers shall map and photograph all cave resources which they will be touching, collecting or moving. A map of the cave showing the locations and photographs of resources in-site shall be submitted to the District Ranger on completion of the field research. Photos and maps should be generated before and after the research activity.

l. Thorne Bay Ranger District may require that a representative of the District accompany the research trip.

m. A library of general cave reference and technical books, journal publications, published technical reports, and theses completed at the site will be established by the Thorne Bay Ranger District for visiting scientists, cave managers and interested publics. Copies of slides and topics of talks given to lay audiences by researchers would also be compiled and are very helpful to a researcher interested in starting work in the area. Reference files should be maintained for unpublished material. Reports may need to be separated into confidential material for closed files and material available to qualified investigators in an open research file. In general, the closed file includes correspondence about and reviews of research projects, copies of grant requests, restricted information pertaining to cultural resources, restricted cave locations and summary data. The open file should contain correspondence about identification of specimens and location of natural areas, annual reports of the investigators, and outlines of on-going research projects.

n. Other specific conditions may be added as necessary to an individual research or collecting permit.

3. Dig Permits

Often cave passages are filled with sediments and cobbles which make passage through these areas impossible without removal of the fill material. Valuable information may be received from exploring these hidden passages however, care should be taken in order to protect fragile resources. For all proposed dig activity, the following criteria will apply:

a. A written proposal is needed to approve dig permits.
b. Approval of dig permits will be contingent upon completion of a resource analysis and biological and cultural clearance review.

4. Special Use Permits

Thorne Bay Ranger District will evaluate special use requests in accordance with the Special Use Authorization as identified in Forest Service Manual 2750. The definition of a special use permit is "A permit, term permit, temporary permit, lease, or easement, or other written instrument that grants rights or privileges of occupancy and use subject to specified terms and conditions on National System lands." Upon receiving a permit, the holder will be required to have it in their possession during the identified cave activity.

a. Outfitter and Guides

Commercial use of El Capitan Cave may offer opportunities that Forest Service sponsored trips cannot provide. The demand for non-commercial recreational use will be considered along with the demand for commercial activities. Use of the cave for commercial gain will be considered for approval by the District Ranger based on a submitted written request. Written requests will include the nature of the venture, duration, effects on other cave resources, and benefit of services offered to the client. Prior to approval, the District Ranger will determine if the venture is compatible with District policy and cave prescriptions. Appropriate resource specialists will also be consulted, and NEPA documentation may be required. If approved, a special use permit will be issued. A fee, a rehabilitation bond, and insurance may be required as specified in Forest Service Manual 2700.

In general, the criteria for outfitter and guides are as follows:

1. Will be considered after a Special Use Application Report has been received and evaluated.
2. Guides must obtain in-cave orientation, and training in cave ethics and safety.
3. Allocations among different operators will be assessed as applications are received. A prospectus may be needed to determine allocations of use and distribution of availabilty, i.e., dates of intended operation.
4. Available only 2 days per week on days when Forest Service guided trips are not being offered.
5. Applications must be received in writing 6 months in advance.
6 Currently restricted to Sections 1 and 2.
7. May be required to submit an operating plan, a certification of insurance and a reclamation performance bond.
8. Requires NEPA review.

b. Concessionaires

To date, there has been no documented interest for a concessions operation. Informal requests/conversations from local lodge owners have revealed that there may be some interest, however, during the public scoping process and internal analysis, numerous concerns were raised about concessions at the cave. The possibility of a small concession in which equipment and souvenirs are sold or rented may be desirous with little to no effect on the cave or the caving experience. Due to these concerns and the apparent lack of interest, this plan does not contain direction for concessionaires. If interest increases, a prospectus can be developed. The prospectus will include restrictions and specific guidelines for use of the cave.

c. Media

Media requests range from television and radio to newspaper and magazines. If the intent of the media coverage is for commercial gain such as in selling articles or promoting a business, permits will be required. In general, the following criteria will apply:

1. One month advance notice in writing.
2. Written request required outlining intent of visit, commercial gain, etc.
3. Copies of all finished media productions are required. Copies will be sent to Thorne Bay Ranger District.
4. Approval by District Ranger.
5. Dependent upon availabilty of personnel to assist.
6 Requires a Forest Service approved guide.
7. User limits apply.
8. Restricted to Sections 1 and 2 pending further evaluation.

5.9 Fees

Under current direction, no fees will be charged for recreational entrance permits. Fees may be charged in the future for operation and maintenance purposes.

Research Permits and Dig Permits will be developed in accordance with FSH 1509.11. Special Use Permits will be developed in accordance with Forest Service Handbook 2709.11. An appropriate fee will be determined for these uses. Sometimes fees are waived depending on the special use application.

5.10 Reservations

Visitors may explore to the gate (Section 1), without a guide or a reservation, however guided tours will be available for trips beyond the gate, through Sections 1 and 2 (See map Appendix A), while Sections 3, 4 and side passages are temporarily closed except for adminsitrative purposes. Advance reservations are requested for all guided tours, however, there will be opportunities for visitors who have no reservations to accompany already scheduled tours. This may occur only if the established group size is not exceeded, i.e., a group size of 6 visitors plus 1 cave guide. A minimum of 14 days is required to process written reservations. Written requests may be verified over the phone by calling Thorne Bay Ranger District or visitors may wait to receive by mail, a verification notice. Call-in reservations may be processed within 2 days or at the time of the call. Reservations will be made in the order they are received and marked on a cave tour calendar. The reservation system will be administered by front desk personnel responsible for answering phones and processing mail. All written requests should be addressed as follows: Thorne Bay Ranger District, El Cap Tours, P.O. Box 19001, Thorne Bay, Alaska 99919. Three dates should be listed in order of priority in case one of the dates is already reserved. Reservation information will be transmitted to El Cap Work Center via radio and/or personal communcation. Dates and user limits will be marked on the calendar. The calendar will provide publics with available dates and disclose when the six person limit is reached. Persons who show up at the cave are given second priority to those who have made reservations. Reservation requests when received at Thorne Bay Ranger District should be stamped with the date received.

Reservations for Special Interest Groups.

School/Youth Groups, garden clubs, Rotary members, and others may make reservations for special tours beyond the gate through Section 1 and 2 only, however group size will be limited to 6 per tour. All minors should be accompanied by group leaders. In general the following criteria will apply:

1. One month advance notice.
2. All visits must be accompanied by a Forest Service and/or approved guide. Pre-approval by the District Ranger for non-Forest Service guides is required.
3. During May to September, groups are offered guided trips which adhere to the established daily and weekly operating period and user limits.
4. During Jan. to April, and October to December, guided trips may be offered to school groups provided 14 day advance notice is received and personnel are available. Pre-approval by the District Ranger is required.
5. Temporarily closed sections of the cave may be available in the future pending further evaluation. Group size limits may vary. 14 day advance notice required. Special caving skills and equipment may be necessary. Guided only with pre-approved guides.
7. Minors must have parental approval prior to entry.

5.11 User Limits/Group Size

User limits are a measure of the maximum number of people who can obtain given kinds of recreation experiences at an established site within the constraints of resource capability. It is a function of how a particular combination of physical and social factors interact to absorb or screen the sights and sounds of human activity and absorb physical use. Lower capacities generally exist where landscapes are fragile or contain little vegetative or geologic screening while higher capacities generally exist where landscapes have more screening and are resistant to physical use. In underground landscapes the physical setting often requires lower capacities.

User limits for El Capitan Cave primarily address group size and have been established for Section 2 only. Further evaluation and monitoring is needed before group size can be established for other sections. Determination of group size in other sections will be established in two years.

Group size is based on local conditions within the cave, the cave management classification system, ROS and public involvement. Establishing a user limit or maximum group size is intended to protect cave resources, reduce conflicts between users such as competition for space and inappropriate behavior or activities, and to protect visitors from hazards. Additionally, the group size should remain relatively small so that everyone can hear and see the guide as well as providing the guide with better control.

Table 5.1. User Limits for Sections 1, 2, 3 and 4.

	Section 1 Entrance to Gate	Section 2 Gate to Hatfiled's Pit	Section 3 Hatfiled's Pit to Alaska Room	Section 4 The Steam Room
ROS Class	Developed Natural	Natural	Protected Primitive	Protected Primitive
Mgt. Class	Non-guided	Guided	Temporarily Closed	Limited Entry
Group Size	To be determined	1 to 6/group	To be determined	To be determined

5.12 Seasonal Closures - An Operating Period.

An operating period is needed for allocating and controlling seasonal use, as well as for protecting and preserving the cave. Establishing an operating period will help reduce user conflicts, protect fragile resources and for safety reasons.

Section 1 of the cave is open year-long. The Operating Period may change in the future. Closures may be needed to protect resources. Research and monitoring will dictate the need for future closures in this section.

Section 2 is guided only and will generally operate on a monthly, weekly, daily and hourly basis as follows:

May through August
Thursday through Sunday
Guided tours:
9 a.m., Noon and 2:30 p.m.

NOTE: Tours last approximately 1 hour and 45 minutes which includes hiking the steep access trail to the cave entrance. The cave is closed from noon to 1pm for lunch.

Changes to this schedule may occur as supply and demand of cave related recreational activities increase or decrease. Changes and/or other closures may be needed for safety concerns, to protect fragile cave resources, research needs and education purposes.

5.13 Guides

Forest Service personnel or volunteers will be used to guide publics through Section 1 and Section 2, and to help monitor resource degradation, educate publics, and for safety reasons.

The Forest Service will offer guided tours beyond the gate and will include interpretation through Sections 1 and 2 and based on the established operating period and group size limit (See Section above). A Forest Service employee or volunteer will be stationed at El Capitan Work Center. During cave operations, the employee/volunteer would be available for cave tours. Guided trips will be offered every other hour except for noon to 1pm for lunch. Guides will be equipped with a Forest Service radio and emergency rescue and first-aid equipment. They would not necessarily need to be trained in rescue but they would be required to have basic CPR and advanced first-aid training provided by the Forest Service. Basic cave orientation and cave ethics training would also be required and provided by Forest Service Cave Specialists/Managers and other cave volunteers. Orientation training would include site specific information on El Capitan Cave, the karst ecosystems of Prince of Wales Island, and Forest Service Cave Management programs. The Guide(s) will keep a daily diary for developing better management of the cave and they will document visitor use. A script will be developed by the El Capitan Cave Manager for guided tours.

Guides and/or the Forest Service will provide hard hats for public use. Visitors are required to have at least one light source per person and warm clothes. Guides are required to have at least three light sources, and a helmet. Guided groups must adhere to the established capacity limit set for the cave, i.e. no more than 6 per group. Slight fluctuations of the capacity limit may occur to accommodate families and groups.

Safety meetings will be held on a regular basis and will address such items as the cave environment, use of cave equipment, prevention of accidents, etc. A minimum of 3 persons will be used on trips into the cave requiring technical rope work.

All personnel involved in cave management will receive comprehensive training so that they can perform their duties in the safest, most efficient manner. Vertical practice, in a tree, rock pit or cliff will be completed before new personnel or gear are used in the vertical sections of the cave.

5.14 Cave Gates

As mentioned, a gate has already been installed within the cave. The primary reasons for installing the gate are for resource protection and safety. It may be necessary to install another gate at the entrance if unacceptable levels of resource damage occur to Section 1. Monitoring and further analysis is needed before this determination can be made.

5.15 Volunteers

The Thorne Bay Ranger District will continue to utilize the volunteer program to its maximum authority as granted in the National Forest Act of 1972 (FSM 18300. Volunteers will be offered the opportunity to assist Thorne Bay Ranger District with the management of El Capitan Cave. The volunteer program will continue to support cave management activities including but not limited to, cave restoration, photo monitoring, gate construction, cave maintenance, mapping, inventory, office work, guiding and public education. Thorne Bay Ranger District will provide supervision and technical training for volunteers assisting in El Capitan Cave management. The Forest Service will utilize individual volunteers, partnerships, Memorandums of Understanding, and Cost Share Agreements. A Volunteer Agreement (FS-1800-7 and/or FS-1800-8) will be used to document volunteer work. Each individual's hours of volunteer work will be recorded. The tracking of this information will be used to complete the yearly Human Resource Programs Accomplishment Report (FS 1800-AR).

5.16 Training and Orientation Program.

The gate is a barrier which if not vandalized, provides a means of controlling use. Those allowed beyond the gate must abide by rules and exhibit proper cave ethics. It is important to provide an orientation to all users about caving ethics and safety. This should be done by Forest Service personnel and approved guides to all groups in all sections of the cave. All guides will practice ethical caving and protect the natural resources found within the cave. In-cave training by qualified Forest Service personnel is required prior to guiding activity. Training will emphasize safety, education of the cave resources and preservation. Videos, and slide shows will be used to help train guides.

5.17 Protection of Sensitive Resources

As mentioned, a gate has been installed to help protect sensitive features and pristine portions of the cave. Strict management controls such as implementing an operating period and limiting the numbers of people allowed in the cave at one time is intended to help protect sensitive features. Known cultural and paleontological resources have been removed. Seasonal closures will help protect hibernating bats in the winter. Other measures used to protect features include establishing criteria for various user groups, including Outfitter and Guides, researchers and media, employing a Forest Service guide for interpretation and education on the fragile nature of caves, training guides and hosts about caving ethics, and providing registers and interpretive signs with conservation messages. Additionally, interpretive programs in the form of slide shows and video hosted talks will be given at local schools, Forest Service districts and throughout southeast Alaska to interested publics.

No rock, mineral formation, stalactites, stalagmites, phenomenon of crystallization, or other natural, historical, archaeological, or paleontological specimen of any kind should be touched, damaged or removed from the cave except if specifically authorized by separate research and collection permits approved by the District Ranger. Cave visitors should consider caves as natural museums and observe, rather than handle, cave resources. Photographs and other non-touching observations which do not harm cave resources are allowed.

Camping, cooking, smoking cigarettes or tobacco products, and open fires (other than carbide lamps) are prohibited within the cave or cave entrance. Due to confined conditions present in the cave, cave resources can be easily damaged by these activities.

Foot traffic should be confined to non-delicate areas. Cave visitors should stay on established foot paths and every attempt should be made to prevent damage to easily trampled cave resources. If it is necessary for safety reasons to cross pristine flowstone floors, cave visitors should remove boots and proceed in stocking feet. If it is necessary to travel through areas with thick silt, mud or delicate speleothems on the floor, cave visitors should proceed in single file and follow in established foot falls, or trails. Destruction of significant features simply for the sake of "pushing new leads" is prohibited.

All equipment, supplies, and other materials taken into the cave by a party should be removed from the cave by that party at the completion of the trip. This includes carbide residue if carbide lamps are used. Users in sections requiring vertical expertise will be required to present experiences exhibiting climbing and survival gear. A portable sanitation bag or bottle is required in all sections of the cave if users are not being guided for recreational purposes. Cave registers and travel aides may be left within caves if approved prior to the trip by the District Ranger. Examples of travel aids which could be approved are bolts and pitons, where safe natural riggings are not available, and plastic surveyor's tape to mark trails through delicate areas. Hand and foot holds should not be created by breaking, blasting or other means unless approved by the Forest Service.

No modification of any feature for the purpose of water collection is allowed. The cleaning of anything or the use of soap or detergent (including biodegradable) in any cave water is also prohibited. Naturally occurring water may be used for drinking if found in sufficient quantity. However, water within rimstone-lined pools should not be used since this may stunt or stop the growth of the rimstone. Purification is recommended for drinking water. Purification treatments should only be added to water containers and not to cave waters.

5.18 Public Safety

It is understood that El Capitan Cave can never be completely safe and that risk-taking is part of the caving experience. The Forest Service is addressing public safety in El Capitan Cave through various means. Strict management controls such as the gate, restricting the group size, establishing an operating period and providing a guide are being employed. A hazard warning sign is currently installed at the entrance to the cave. Other signs may be installed if necessary. for a hazard rating of El Capitan Cave, see Chapter 3.

Cave search and rescue (SAR) operations will be initiated in accordance with the Ketchikan Area Emergency Action Plan and the Forest Service Manual (FSM 1599.03). The Alaska State Troopers maintain the ultimate authority for search and rescue on all lands within Alaska. However, the Forest Service has an obligation to the public and must take an active role to assure immediate and quick response to search and rescue requests and at the same time provide for the protection of forest resources. The Ketchikan Area Safety Officers and the Law Enforcement Program Coordinator are responsible for interagency coordination, developing and maintaining a close working relationship with the Alaska Troopers, and acting as liaisons on search and rescue operations occurring in El Capitan Cave. The Forest Service will be responsible for the overall management of the search and rescue operations until the Troopers take over. Upon transferring the leadership role to the Troopers, the Forest Service shall assume a supportive role and provide assistance to the fullest extent possible.

Thorne Bay Ranger District has local expertise to help deal with search and rescue. District Cave Specialists and local cavers' knowledge and close proximity to the cave will help to expedite cave rescues. Qualified Cave Specialists and cavers should be involved in cave search and rescue by assisting to locate cave passages, provide initial contact with the victim, provide cave expertise to prevent unnecessary cave resource damage and evaluating the situation.

5.19 Law Enforcement

Regular patrols at El Capitan Cave will be developed utilizing law enforcement, cave specialists, and recreation personnel to establish Forest Service presence. Prevention through education will be a primary law enforcement tool. Educational prevention signs will be erected. All 36 CFR violations involving caves will be immediately reported to the District Law Enforcement Officer.

5.20 Risk and Liability

Civil liability for wrongful death or injury is a complex subject. The duties the Forest Service owes an invitee include the duty to learn of unsafe conditions, the duty to use reasonable care to inspect and discover dangerous conditions, and the duty to take reasonable steps to put the land in safe condition. A simple management plan which includes a policy for limiting use and a means of informing cave users of known dangers is probably the best solution for liability.

5.21 Signage

No signs are currently planned for installation in the interior of the cave. Interior signs may be necessary for directional purposes, and for displaying "off-limits" areas. An "Off Limits Area" sign may be used at side passages which are closed or where resource protection is needed. One or two signs may be developed in Section 2 to interpret cave formations and protection procedures.

5.22 Maintenance

Operation and maintenance of El Capitan Cave is the responsibility of Thorne Bay Ranger District. Maintenance functions will be accomplished through a combination of force account work and contracted or volunteer services.

Estimated Annual Cost of Operation and Maintenance

Administration	7,000
SCA volunteer	6,000
(GS-5 @ 130 days)	17,000
Subsistence for guides	4,200
Site Operations (trails, toilet, parking)	3,000
Vehicles	8,000
Supplies and Safety Equipment	1,000
Total Annual Maintenance Cost	$46,200

CHAPTER 6.
ACCESS TRAIL, PARKING, SANITATION AND LIGHTING

6.1 Access Road and Parking Area Location

The access road to El Capitan Cave is known as Forest Road 15. It is connected to the main road system on Prince of Wales Island which links vehicle traffic with the Alaska Marine Ferry in Hollis. The parking area is approximately 100 feet off Forest Road 15, directly across from El Capitan Work Center and is 1500 feet from the cave entrance. See Appendix A, Parking and Trail Access Map.

6.2 Access Trail/Accessibility Design

An access trail to the cave has been developed and leads to the entrance of the cave. This trail is rated difficult with a steepness averaging 30 to 60 percent. The tread is a mixture of gravel on the lower end (first 250 feet), and wooden boardwalk trail (550 feet) and wooden stairway (275 feet) on the upper end near the entrance to the cave. The wood portions of the trail are built of locally milled Alaska yellow cedar. The trail head is at the parking area described above. A wooden viewing deck is planned as part of the trail and will be connected to the upper end of the trail, at the cave entrance. Several small platforms are located along the trail and serve as rest spots or viewing areas. The trail provides an excellent view of the ocean area known as El Capitan Passage. The trail width was designed for two-way pedestrian flow. The combination of slope, tread type and trail width makes this trail not accessible to physcically challenged individuals (does not meet Challenge Level I or 2 in the USDA Design Guide for Accessible Outdoor Recreation).

6.3 Cave Trail Placement and Design

There are currently no plans to install or design a trail within the cave. Monitoring will determine the need for an internal trail. Internal trails may be needed to direct the traffic flow away form fragile areas. If an internal trail is needed, survey and design will be completed prior to development of the trail.

6.4 Sanitation and Sewage Disposal

There are no sanitation and/or sewage disposal stations located within El Capitan Cave. People are required to pack out whatever it is they have packed in. Funding for a two-hole Sweet-Smelling Toilet has been awarded in FY 1994. Installation of the toilet is currently under contract. The toilet will be located at the trailhead and parking area.

6.4 Lighting Design

There are no plans to install any form of lighting in the cave or on the access trail to the cave. The cave has a ROS rating that ranges from natural to protected primitive. These ROS classes require that the cave be kept as natural appearing as possible. Lighting would not be appropriate for the selected ROS classes.

CHAPTER 7.
MONITORING

7.1 Introduction

Monitoring will be conducted by Forest Service Specialists for relating visitor use to degradation of cave resources. The impact of various types and intensities of visitor use must be carefully and systematically documented so that acceptable levels of use can be anticipated and altered if necessary. Complete records of monitoring activity will be kept in a file for El Capitan Cave at Thorne Bay Ranger District. A brief description of monitoring activities follows.

7.2 Photo Monitoring

Photos of vulnerable or indicator resources (e.g., actively growing speleothems, narrow trails, stalactites and stalagmites within reach of human contact, and colored flowstone) are taken to determine if these resources are being impacted. These photos provide a comparative record of changes occurring in the cave. Qualitative and quantitative documentation of the cave through photography will document the need for cave restoration, research and inventory projects, the impact of visitation, vandalism, and naturally occurring environmental changes on the cave resources. Caution will be exercised to insure that photo monitoring does not become an impact itself.

7.3 Biological Monitoring

El Capitan Cave is known to have been used by bears, bats, otters, and other small mammals. Systems to determine periods of wildlife use and type of wildlife use will be established. In particular, sites used by bats will be monitored and protected. Wildlife monitoring will not interfere with wildlife use, and will be coordinated through a Forest Service Wildlife Biologist familiar with cave fauna. In addition to bats, rare and unusual species of fauna may dwell within El Capitan Cave. Monitoring may identify their presence and lead to their protection. Identyfying management for these types of cave biota will require the expertise of a biologist familiar with cave fauna and technical caving skills.

7.4 Hydrological Monitoring

Hydrological systems within the cave are vulnerable to visitation and surface disturbance. Seemingly minor actions on the surface can cause impacts on the cave below. Changes in water quantity will be monitored to ascertain if there is blocking or changing of natural water percolation due to visitation or surface activity. Monitoring of water flow within the cave will be developed to provide information on flooding and fill rates which may be important to visitor safety, critical mineral growth and/or cave fauna. Turbidity, pH, microorganisms, human waste, temperature, and other parameters that are likely to be altered by human activity will be monitored periodically to quantitatively measure any change within the cave.

7.5 Impact Mapping

Utilizing a detailed map of the cave, an impact map will locate trails, tracking of mud or sediment, pristine areas, visitor impact areas, and sensitive resources. Cave resources that are easily susceptible to disturbance are considered sensitive. Sensitive cave resources include bat roosts, archaeological sites, paleontological sites, and fragile geologic features such as soda straws, conulites, helictites, pristine flowstone, and moonmilk. The impact maps will delineate areas of the cave's floor, walls, and ceiling which are impacted or non-impacted. To ensure the cave ecosystem can handle the current use, the impact maps will be periodically reviewed, and updated to determine if resources are disappearing or impacted areas are increasing in extent.

7.6 Visitor Use

Visitor use data for Section 2 will be collected by guides. Electronic sensors could be installed at the cave entrance to collect visitor use data in Section 1. Section 3 and 4 visits will be docuemented by Forest Service personnel. Monitoring activities should be conducted throughout the operating season Certain activities (e.g. high impact special use permits, outfitter/guides or filming activities) need more frequent monitoring.

7.7 Cave Climate

Temperature, humidity and evaporation rate are critical to cave fauna, mineral growth, preservation of artifacts and paleontological resources. Cave temperature, humidity and evaporation rate should be monitored in the cave. Activities likely to affect cave climate include gating, reducing or enlarging the entrance, timber harvesting near the entrance, surface disturbance, digging additional entrances, operating machinery within the cave, altering water flow through the cave, and excessive visitation.

7.8 Air Quality

Concentrations of radon, hydrogen sulfide, carbon dioxide, methane, and other harmful gases have been known to accumulate in caves. Monitoring of air quality will be implemented. Specifically, radon gas will be monitored periodically to determine the potential health risks to employees who frequently visit the cave.

CHAPTER 8
ALTERING THE PLAN

8.1 Introduction

Managing El Capitan Cave will be continuous. Management strategies established in this plan may undergo slight to extreme changes from year to year. The tasks of gathering and analyzing data, evaluating management objectives and guidelines, and refining the cave management plan may proceed indefinitely. Major changes may include adjustments to visitor use and group size, re-defining the operating period, and reducing or increasing the amount of cave available for recreational use. Changes require the approval of the District Ranger and will be submitted as an amendment to this plan under a new cover sheet. All original plans should be kept in order to document why and when management changes have occurred.

8.2 Limits of Acceptable Change

Elements of the Limits of Acceptable Change (LAC) planning process will be incorporated as a method to structure adjustments to this plan. LAC involves defining a desired future condition that can be measured and managed for. It is a process for establishing acceptable resource and social conditions and prescribing appropriate management actions. The LAC process is becoming institutionalized within the Forest Service but there are no guidelines on where, when, why, and how LAC should be applied. LAC is intended to link consistent management direction between districts, Forests or Regions. Using LAC to manage caves helps focus management attention on impacts/conditions/effects rather than numbers of people. When managing a non-renewable resource, this approach is essential.

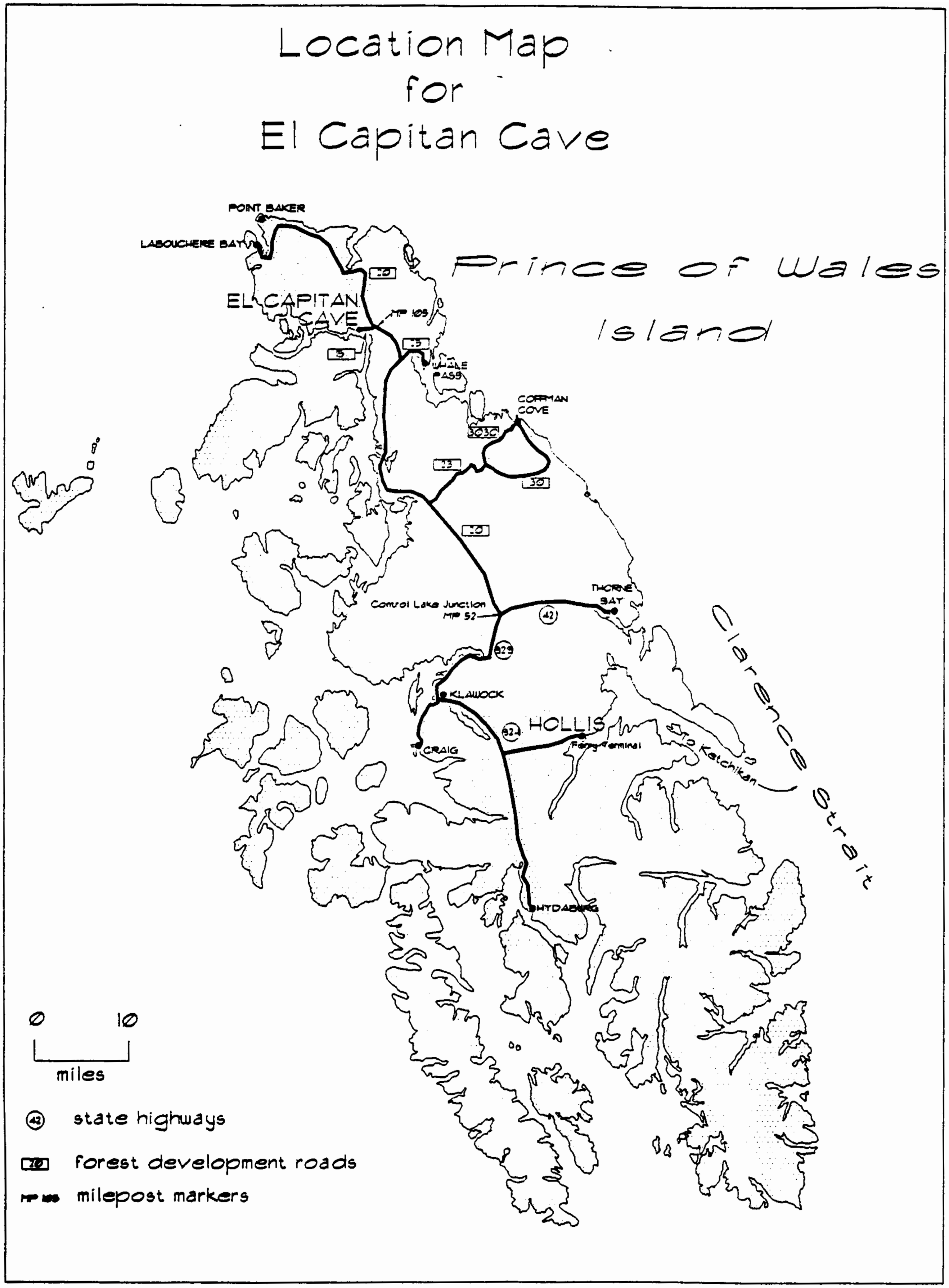
LAC requires managers to develop strategies for extensive/intensive public involvement, monitoring, and selection of resource and social condition indicators. Chance for public involvement will be provided through public meetings, visitor response forms and questionaires.

Quantifiable monitoring will help determine if problems really exist and will focus on impacts, conditions and effects. The LAC process will help resolve and identify problems and issues related to monitoring requirements which may be vague or unquantifiable. Good monitoring results may lead to the need for significant changes to the plan. Several years of data may be needed before results prove conclusive.

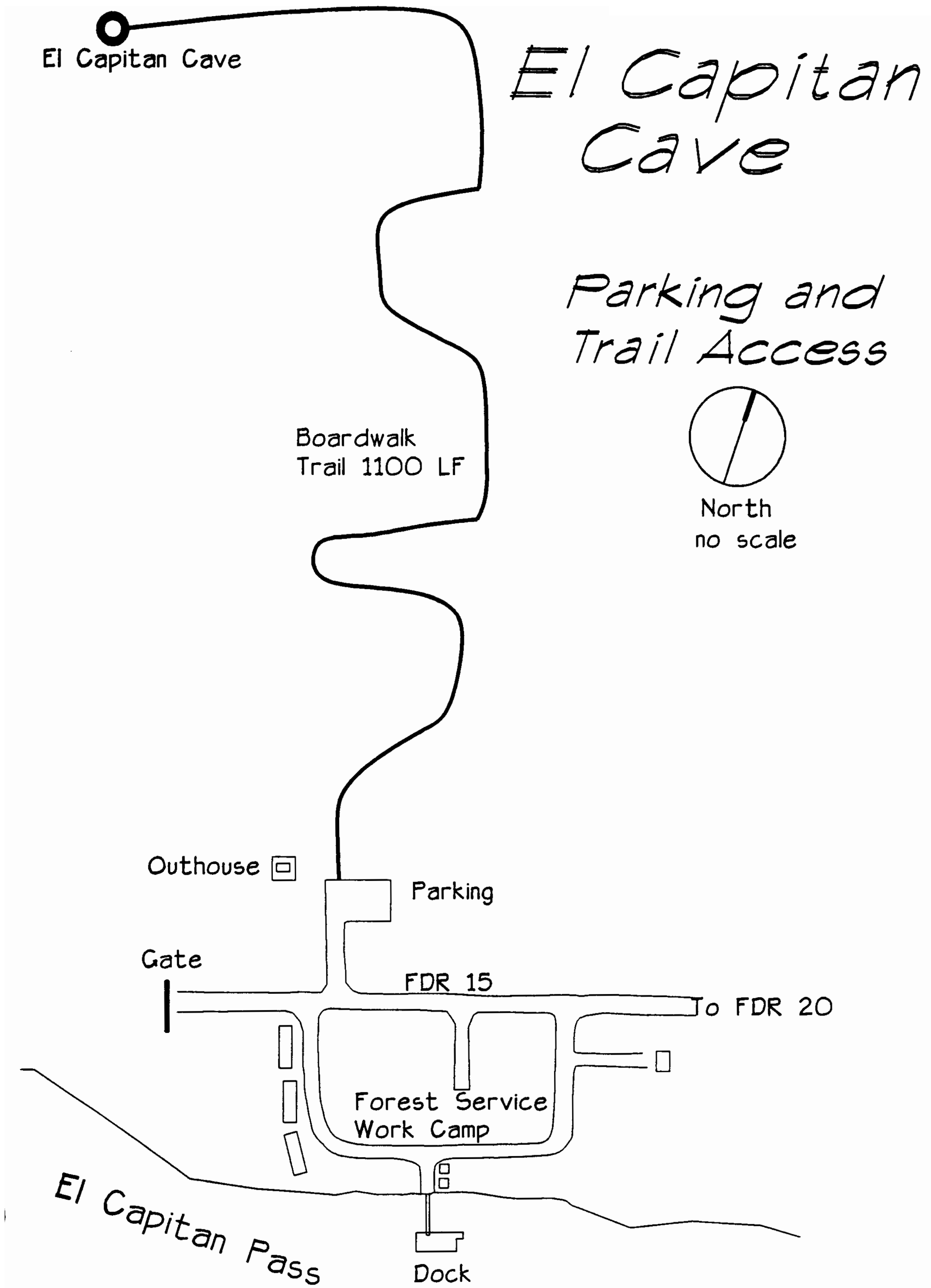
An indicator is a specific parameter that can be monitored to determine whether management objectives are being met. Indicators should be established in a specific enough manner to be monitored unambiguously. When an indicator reaches a limit of acceptible change, management should be adjusted.

The LAC process of public involvement, monitoring and identification of indicators for El Capitan Cave will be developed over a 2-year period from date of approval of this plan. All LAC results will be compiled in a project folder for El Capitan Cave and maintained at Thorne Bay Ranger District.

VICINITY MAP



ACCESS TRAIL MAP



1994 MANAGEMENT ACTIONS TABLE

MANAGEMENT ACTIONS	RESPONSIBILITY	PRIORITY	DONE ✓
1. Photo Monitoring	Rec. Staff	1	✓
2. Develop Cave Calendar	Rec. Staff	1	
3. Info. Sheet of Procedures for Front Desk	Rec. Staff	1	
4. Prepare for Guide(s)	Rec. Staff	1	
5. Training for Guide, in Cave, First-aid, CPR, etc.	Rec. Staff	1	
6. Complete cave mgt. plan	Rec. Staff	1	
7. Create messages in Cave Register	Rec. Staff	2	
8. Develop Brochure	Rec. Staff	1	
9. Install trailhead and parking area signs	Rec. Staff	2	
10. Install SST	Rec. Staff	1	
11. Cave SAR Training	Rec. Staff	2	
12. Establish LAC indicators	Rec. Staff	3	
13. Impact Mapping	Rec. Staff	1	

1995 MANAGEMENT ACTIONS TABLE

MANAGEMENT ACTIONS	RESPONSIBILITY	PRIORITY	DONE ✓
1. Prepare for Guide(s)	Rec. Staff	1	
2. Training for Guide, in Cave, First-aid, CPR, etc.	Rec. Staff	1	
3. Develop Interp. Plan for Signs	Rec. Staff	2	
4. Cave Climate Monitoring	Various	1	
5. Biologic Monitoring	?	4	
6. Hydrological Monitoring	?	4	
7. LAC	Rec. Staff	3	
8. Air quality Monitoring	Rec. Staff	1	
9. Plan Adjustment	Rec. Staff	1	

1996 MANAGEMENT ACTIONS TABLE

MANAGEMENT ACTIONS	RESPONSIBILITY	PRIORITY	DONE ✓
1. Prepare for Guide(s)	Rec. Staff	1	
2. Training for Guide, in Cave, First-aid, CPR, etc.	Rec. Staff	1	
3. Install Interp. Signs	Rec. Staff	2	
4. Cave Climate Monitoring	Various	1	
5. Biologic Monitoring	?	4	
6. Hydrological Monitoring	?	4	
7. LAC	Rec. Staff	3	
8. Air quality Monitoring	Rec. Staff	1	
9. Plan Adjustment	Rec. Staff	1	

COMMONLY USED CAVE MANAGEMENT TECHNIQUES

In order to protect valuable cave resources, a variety of management techniques can be used. These may be used in different combinations or individual techniques may be altered to produce a more desirable management. A description of common management techniques is presented below:

<u>Conservation Messages in the Visitor Register</u> - Conservation messages placed within visitor registers where use of signs would seriously affect the cave's ROS class.

<u>Interpretive Signs</u> Signs may be installed near the entrance or within caves to increase visitor appreciation of cave resources, or suggest appropriate caving techniques which will foster visitor safety and resource protection. Over-use of signs should be avoided so as not to interfere with the natural appearance of the cave.

<u>Brochures and Handouts</u> Brochures and handouts can be distributed to the general public on "highly developed" or "developed natural" caves to increase public awareness of cave resources. Brochures and handouts on caves in other classes should not be distributed to the general public since the information released could increase visitation, change the cave's ROS class and lead to resource impacts. Handouts for "natural" caves could be distributed to persons with specific information requests, and handouts for "semi-primitive" and "primitive" caves could be given out with cave use permits should visitation be regulated.

<u>Cave Trails</u> Installation of cave trails are used to protect fragile resources. Cave trails can be used to restrict damage to pristine floor surfaces or fragile non-renewable deposits (i.e., bones). Cave trails should be visible and easy to follow. Examples of cave trails currently in use include rocks lining either side of the path, plastic surveyor's ribbon strung between stakes lining both sides of the path, reflective tape lining the sides of the trail, and hardening the trail path with gravel, concrete or wood. Cave trails should be biologically inert and only permanently installed in "highly developed" caves.

<u>Permits and User Limits</u> Permits and user limits are primarily set to prevent resource damage and maintain ROS class. Permits limit the frequency of use and the number of people who can use the permit at one time. Group size limits are required where large groups would have difficulty moving through areas with fragile cave resources without causing damage. Usually, only one group at a time receives a permit.

<u>Seasonal Closures</u> Some caves may be closed seasonally to protect visitors form seasonal hazards (i.e., flooding) or conserve sensitive wildlife habitat (i.e., matemal colonies of bats).

<u>Road Closures, Upgrading and New Construction</u> Roads which lead to, or pass near, a cave's entrance may be considered for closure if closure of the road would help protect fragile resources or maintain the cave's ROS class. In general, no new roads (temporary or permanent) should be constructed to or within 300 feet of a cave with a "natural", "semi-primitive", or "primitive" ROS class. Roads leading to or very near these class caves should also, not be upgraded. Such construction or upgrade is likely to alter visitation, affect ROS an may lead to resource destruction.

<u>Cave Gates</u> Cave gates may be required for security of highly developed caves, or to protect sensitive resources and maintain ROS class for "semi-primitive" or "primitive" caves. Gates can detract from the entrance area of a cave, but usually this detraction is off set by the need to preserve very fragile, near pristine resources or keep visitation

within limits consistent with a cave's ROS class. Cave gates should no interfere with wildlife use or restrict air flow into or out of the entrance and should be maintained regularly. A permit system to enter beyond the cave's gate can be implemented when appropriate.

Guides Guides are an integral part of "highly developed" cave management, but can also be used in other classes of caves if the use of a guide does not change the cave's ROS class. Guides are frequently used in "developed natural" or "natural" caves for educational purposes. The guide can greatly enhance the interpretation of the cave. In rare cases, a guide system might be developed for a "primitive" cave should there be no viable alternative to protect fragile cave resources. A guide system for a "semi-primitive" cave would probably affect the ROS class by increasing visitation and should be avoided.

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CAVE & KARST LANDSCAPE **WORD FIND**

WORDS HIDDEN IN THE PUZZLE ON PAGE 62

ALASKA
CAVE
GUANO
MUSKEG
SITKA SPRUCE
SWORD FERN
WET
ARTIFACTS
CAVERN
EPIKARST
HEMLOCK
RAIN
SKUNK CABBAGE
TONGASS
BATS
COLUMN
EL CAPITAN
KARST
RIVER BED
SODA STRAWS
TROGLOBITE
BERRIES
DEER FERN
FLOW STONE
LADY FERN
RIVER OTTER
STALACTITE
TROGLOPHILE
CALCIUM
DEVILS CLUB
FUN
MITE
SHIELD FORM
STALAGMITE
TROGLOXENE

CAVE & KARST LANDSCAPE **CROSSWORD**

SOLUTION TO THE PUZZLE ON PAGE 63

ACROSS
1. epikarst
5. bear
6. karst
9. plate
10. guano
12. hair
14. otter
16. stalactite
19. picture
20. puddle
22. strikeslip
25. phototropic
26. human
29. hibernaculum
32. flowstone
34. wet
35. soda straw
37. nurse log
39. hemlock
41. bread
42. mite
43. headlamp

DOWN
1. El Capitan
2. Alaska
3. Sitka spruce
4. Capitan
7. rain
8. troglophile
9. POWI
11. amphipod
13. column
15. tongue
17. Tongass
18. twinpits
21. look
23. troglobite
24. diamonds
27. spleenwort
28. drapery
30. cedar
31. trogloxene
33. stone
36. sinkhole
38. steam
40.cave

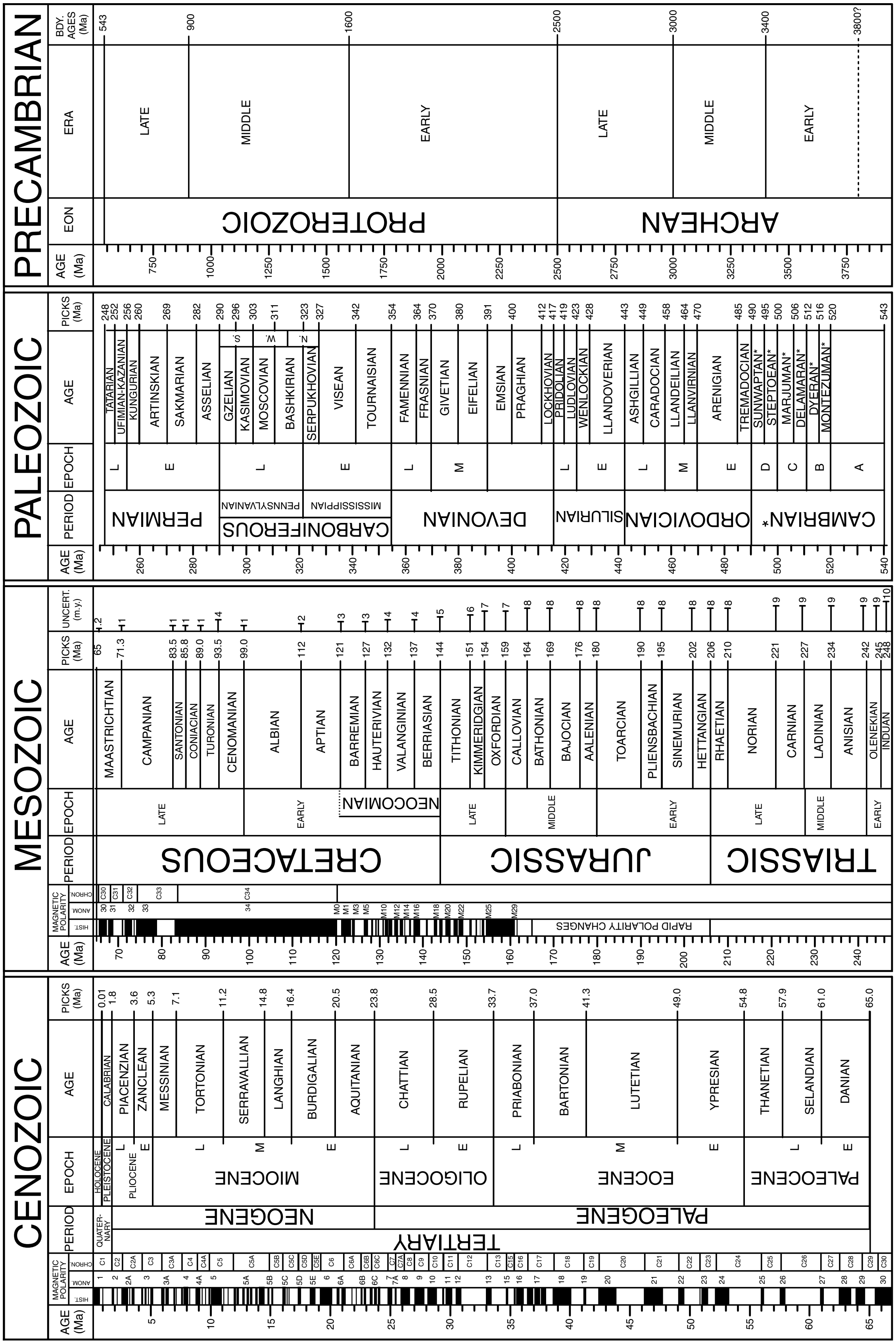
PALEONTOLOGY

Geological Time Scale

Map of fossil finds in Southeast Alaska

Top 12 fossils of Southeast Alaska

Geological Time Scale



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*International ages have not been established. These are regional (Laurentian) only. Boundary Picks were based on dating techniques and fossil records as of 1999. Paleomagnetic attributions have errors, Please ignore the paleomagnetic scale.

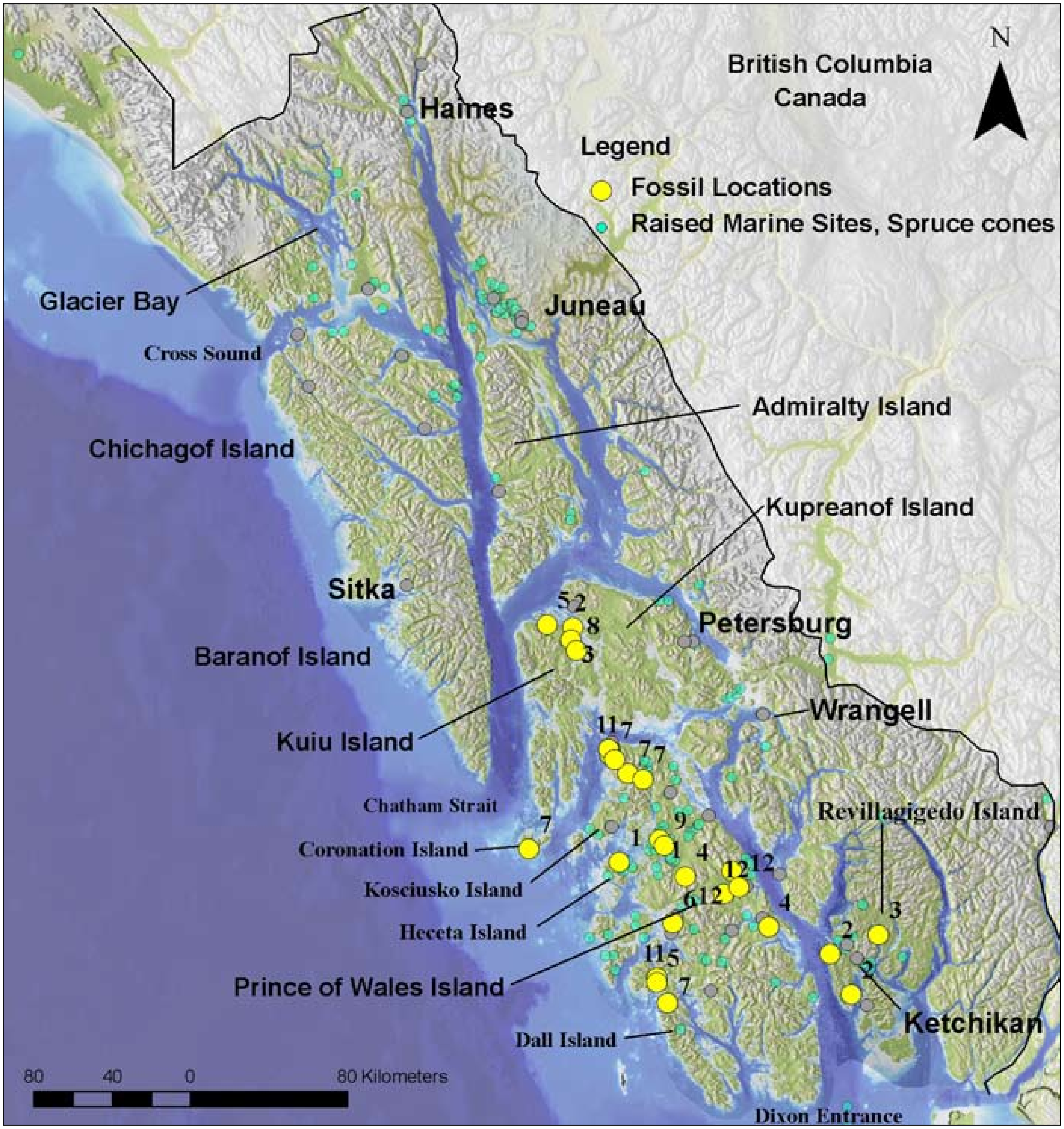
Sources for nomenclature and ages: Primarily from Gradstein, F., and Ogg, J., 1996, *Episodes*, v. 19, nos. 1 & 2; Gradstein, F., et al., 1995, SEPM Special Pub. 54, p. 95–128; Berggren, W. A., et al., 1995, SEPM Special Pub. 54, p. 129–212; Cambrian and basal Ordovician ages adapted from Landing, E., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 329–338; and Davidek, K., et al., 1998, *Geological Magazine*, v. 135, p. 305–309. Cambrian age names from Palmer, A. R., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 323–328.

GEOLOGICAL SOCIETY OF AMERICA

TOP 12 fossils of Tongass National Forest

MAP OF IMPORTANT FOSSIL FINDS IN THE REGION

Numbered circles on this map coordinate with fossils on pages 120-131 and offer a general guide to the fossils' locations. The geological time scale on page 118 helps students to understand the chronological story of the fossils.



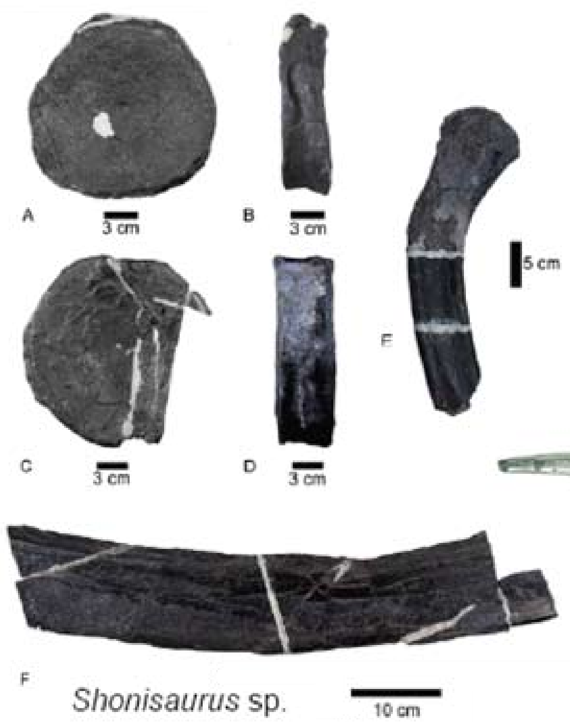
1 BIG BRACHIOPOD

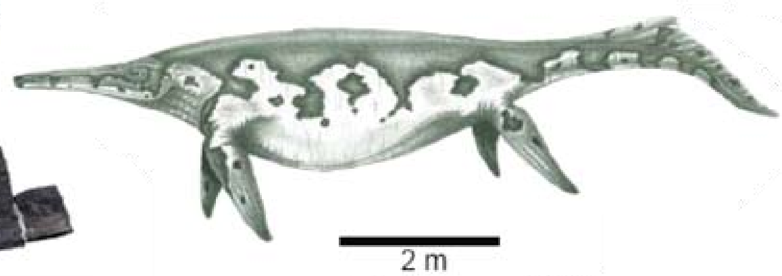
Kirkidium alaskensis
Upper Silurian Period
419 million to 423 million years ago
Found in Heceta limestone on Prince of Wales Island and surrounding islands

TOP 12 Fossils of Tongass National Forest

2 AN ICHTHYOSAUR LIKE NO OTHER

Shonisaurus
Triassic Period
220 million years ago
Found on Keku Inlet





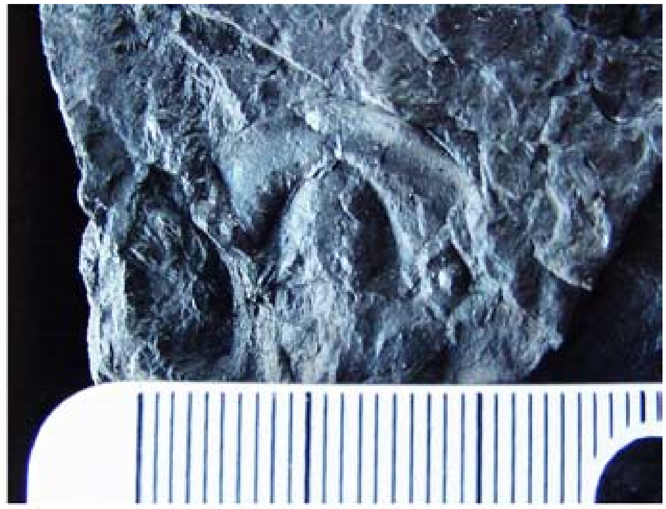
3 AMMONITES

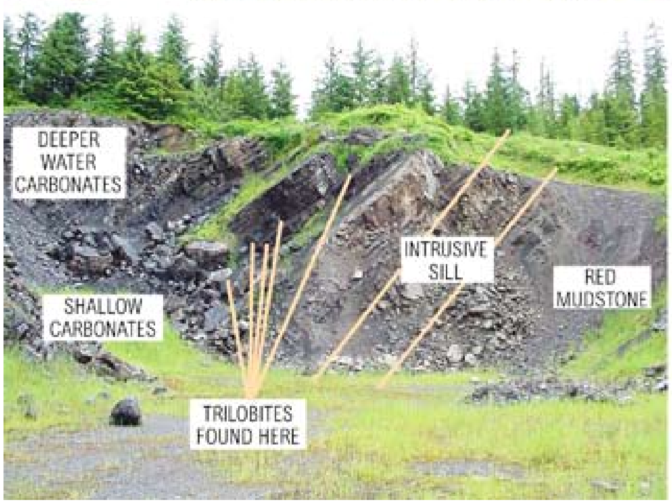
Triassic Period
Found along George Inlet on Revillagigedo Island and on Keku Inlet

TOP 12 Fossils of Tongass National Forest

4 TERRIFIC TRILOBITES

Trilobite Prygdium and *Glabela*
Middle to Upper Devonian Period
354 million to 400 million years ago
Kasaan and other sites on Prince of Wales Island





5 BRACHIOPOD BAS RELIEF

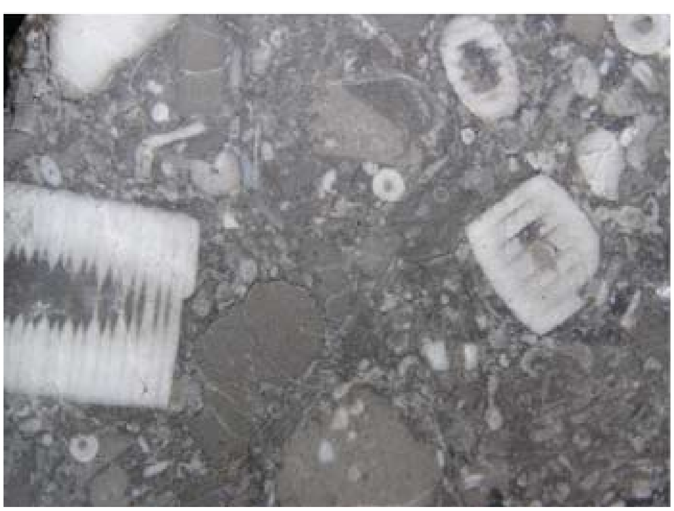
Permian Period
248 million to 290 million years ago
Found on Saginaw Bay, Kuiu Island and Suemez Island

6 GIANT CRINOIDS

Mississippian Period
329 million to 354 million years ago
Found near Klawock on Prince of Wales Island








7 GIANT BROWN BEAR

Ursus arctos
Pleistocene to Holocene
More than 57,000 to 7,205 years old
From caves on Prince of Wales Island and surrounding islands






8 METASEQUOIA

Dawn Sequoia leaves
Miocene and Oligocene Periods
21 million to 25 million years ago
Found at Port Camden on Kuiu Island



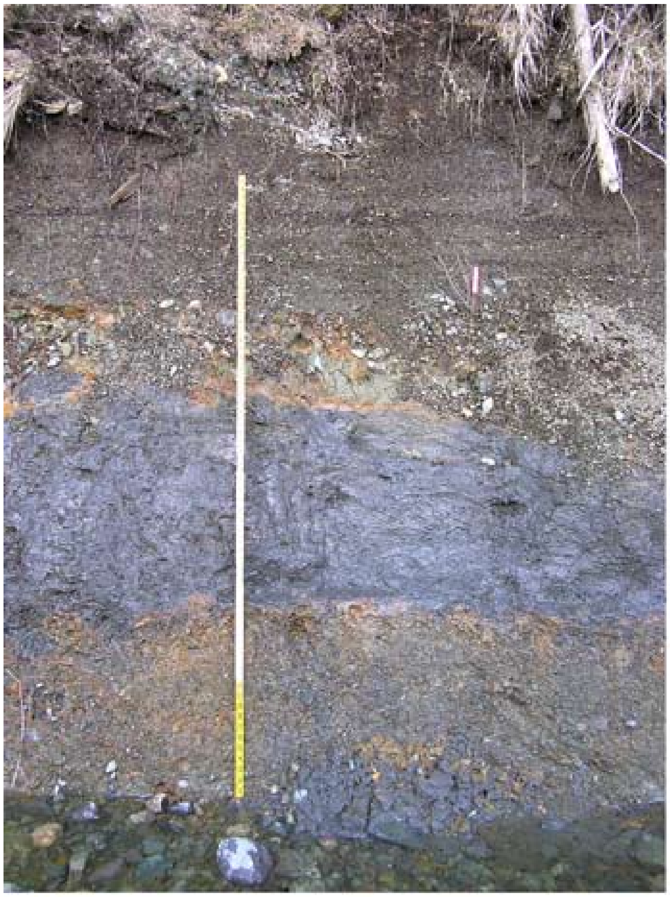


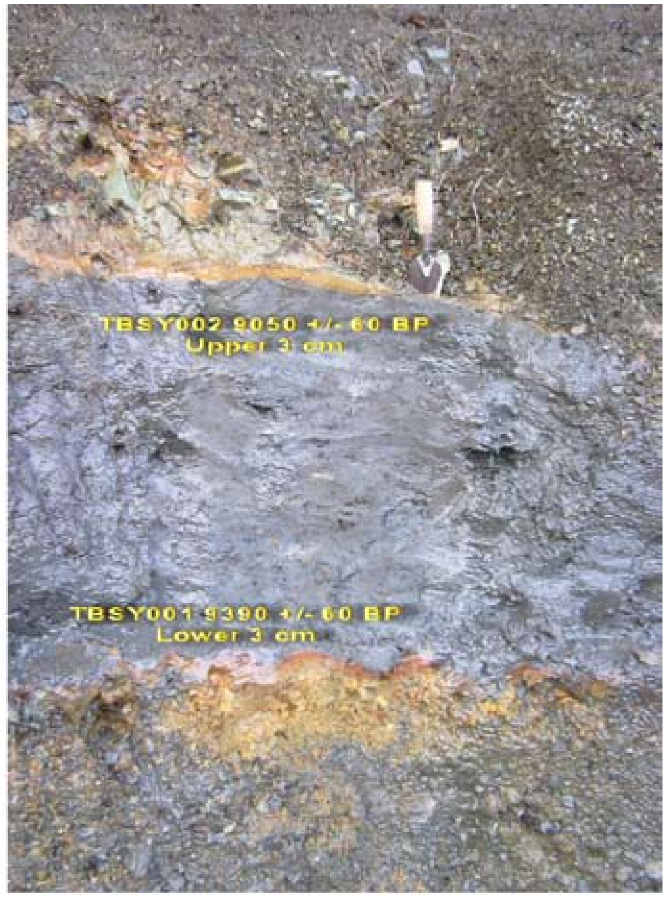
9 SNEAKY SNAILS

Trochonema naukatineman, subgen. *karenpetersenae*
Upper Silurian Period
Found in Heceta limestone near Naukati on northwest Prince of Wales Island

10 SPRUCE CONES

Macrofossils in uplifted marine muds
9,350 years old
Found near Thorne Bay on Prince of Wales Island and across Southeast Alaska





11 CRAFTY CORALS

Horn and Colonial Corals
Pennsylvanian and Permian Periods
260 million to 300 million years ago
Saginaw Bay, Kuiu Island and Suemez Island

TOP 12 Fossils of Tongass National Forest

12 GREAT GRAPTOLITES

Similar to jellyfish, with feathery arms
Ordovician Period
Prince of Wales Island and surrounding islands