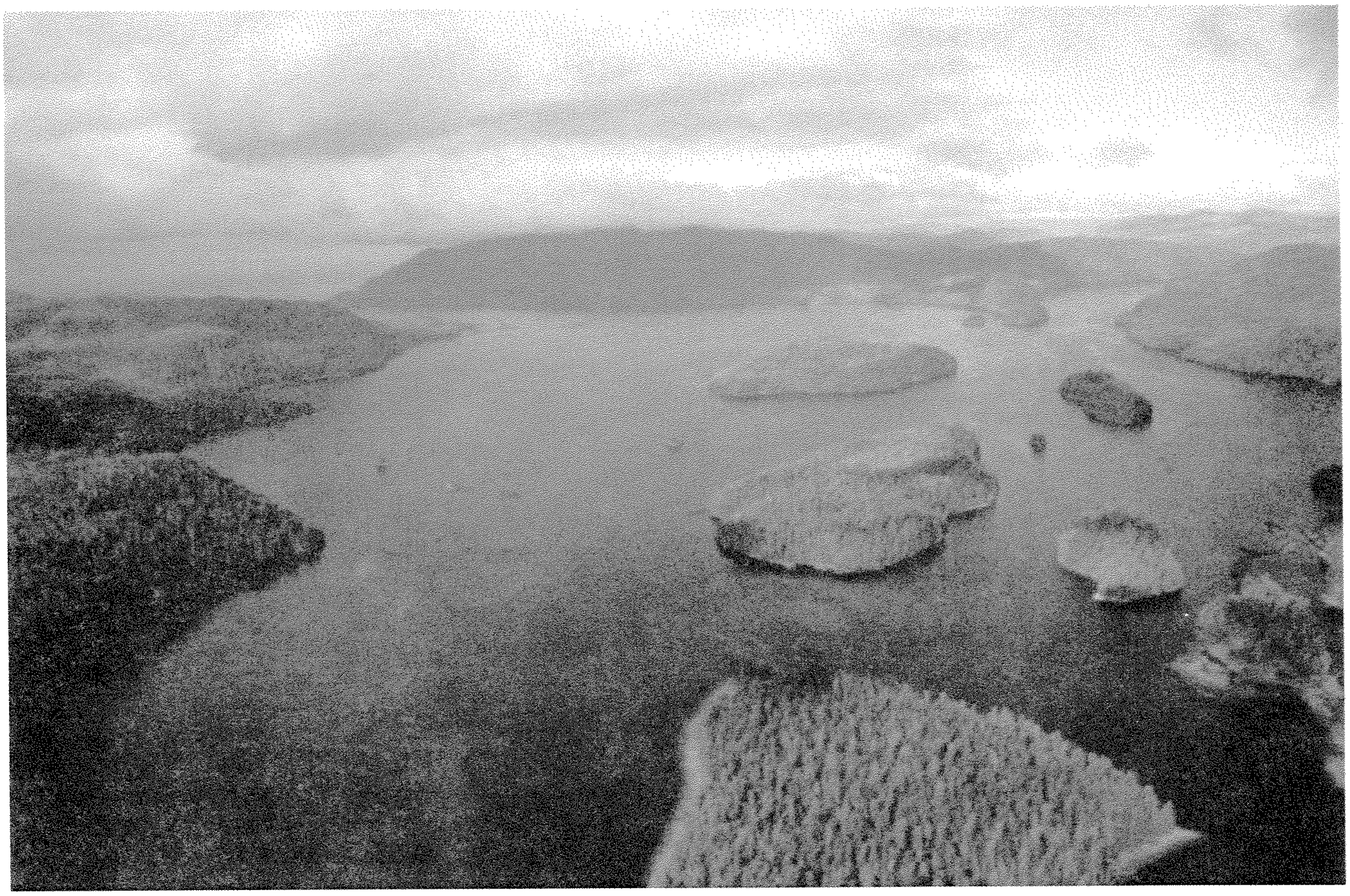
ALASKA'S FORESTED KARSTLANDS

by William R. Elliott, Ph.D.

Visualize a thousand forested islands packed along a rugged coastline that is cut by glacial fiords and channels. The lush, moist, ancient forests on those islands teem with Sitka deer, bears, salmon, and bald eagles. Within those forests lie deep sinkholes; hidden caverns with archaic bones, logs, and ice; Native American artifacts and cave art; and cave streams feeding a profusion of springs and salmon runs. These karstlands are comprised of islands within islands— blocks of cavernous limestone and marble separated by less soluble rocks. The dark, lustrous rocks originally were deposited as tropical limestone islands. Much later the islands were rafted across the sea on tectonic plates, colliding with North America, piling into each other, metamorphosing, fracturing— a process of hundreds of millions of years that has not ended. The caves were later hollowed by groundwater dissolving out fractures. The caves contain cryptic signs of multiple past lives— enlargement by solution, then filling with glacial rubble, then rebirth by means of new streams. Cave and sinkhole development is intense, aided by rainfall of 60 to 250 or more inches a year. The forest, the karst, and the peat lands thrive on each other in intricate chemical and biological ways. It is all a three-dimensional landscape, abounding with natural time capsules hidden below the forest. What wonders lie here to be discovered? Slowly at first, but increasingly in the last five years, hardy cavers have come to explore and study one of the least-known karst areas of North America— a frontier on the frontier.

Where are these karstlands, and who owns them? They exist in Southeast Alaska in the Tongass National Forest, our nation's largest forest— and they belong to you and me.

The U.S. Forest Service, which manages these old-growth temperate rainforests (some of the last left on earth), recently took a bold step in supporting a study that demonstrated the national and international significance of the Tongass karstlands (Aley, Aley, Elliott, and Huntoon, 1993). The study was carried out by a team of four scientists in the summer of 1993. The study grew out of a karst management seminar held in Ketchikan, Alaska, in February, 1993. The seminar, co-sponsored by the Forest Service and the American Cave Conservation Association (ACCA), was enthusiastically attended by 65 diverse souls from federal and state agencies, conservation groups, and industry. Jim Baichtal, the Forest Service's geologist-speleologist from Ketchikan, hosted the meeting and showed stunning slides of caves and karst. Tom Aley discussed karst waters and their interaction with forests. The writer lectured on cave faunas of North America and cave management. Topics from forestry to archeology were covered by numerous speakers. Paul Griffiths, from British Columbia, gave two hours of slides showing the environmental destruction of 20 years of harvesting the forested karst of Vancouver Island. Griffiths showed caves and sinkholes plugged with slash and sediments, underground stream paths now forced aboveground by the plugging, and "blowdowns" of timber left in inadequate buffer zones around cave entrances. Some of the same was beginning to happen on a smaller scale in the Tongass. Experts agreed that the consequences of



The Alexander Archipelago of Southeast Alaska. Photo by Tom Aley.

logging and roading were too often destructive of such landscapes.

At the conclusion of the three-day seminar the Forest Service asked for input on study needs for the karst of the Ketchikan Area, the southern part of the Tongass. The idea of a "blue-ribbon panel" study was discussed. The Southeast Alaska Conservation Council followed up with a review paper on the karst resources of the area (Streveler and Brakel, 1993).

Temperate rainforest karst is a set of "new resources" — new because it had been only recently recognized in the United States. These resources had received some rough handling since the beginning of a fifty-year timber contract with the Forest Service in the 1950s. It also looked as though karst sometimes had been "high-graded"— preferentially cutting on the karst because some of the biggest Sitka spruce and Western hemlocks were there. Most of those valuable trees were pulped to make rayon and paper.

The Forest Service had been supporting Baichtal's studies and volunteer cavers in the field for several summers (Baichtal, 1992 and in press; Allred, Allred, Lewis, and Fritzke, 1993). Much had been learned but there were hundreds of square miles of karst yet to examine and not enough time before harvest would reach many areas. An overview of the problem was needed, so a scientific panel was selected in a competitive process. Proposals for the work were developed by competing teams; one was selected that encompassed the broadest spectrum of aspects of the problem with the greatest number of skills possessed by team members.

The contract for the "Karst Resources Panel" was awarded to the Ozark Underground Laboratory, headed by Tom Aley of Missouri, a karst hydrologist and forester who is also President of the ACCA. Peter Huntoon, Professor of Geology at the University of Wyoming, was the team's karst geomorphologist. Cathy Aley served as water chemist and ecologist. The writer, William R. Elliott, a Research Fellow with the Texas Memorial Museum in Austin, was the cave biologist. Our panel members all had many years of experience in far-flung karst areas, and our skills overlapped well so that we could critique each other's work. Our field liaison was Jim Baichtal, tireless caver and quintessential mountain-man-geologist.

In our three-week field study in July-August, 1993, we studied karst and 24 caves on five islands, concentrating on Prince of Wales and Heceta islands; and we observed karst on three other islands. We viewed 1,500 miles of terrain by float plane, helicopter, boat, truck, and on foot. We reviewed stacks of scientific reports; dye-traced groundwater flow paths; gathered forest, stream, and cave ecology data; and took 1,000 photographs. We talked with cavers, foresters, road engineers, biologists, resource managers, loggers, and administrators. The field work was followed by weeks of reading, analyzing, and

Intensley developed epikarst, Dall Island.

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writing, culminating in a long report to the Forest Service. Our panel's findings were delivered orally to the Forest Service before leaving the field. Public meetings were held in Ketchikan and Juneau in October, at which Tom Aley gave reports illustrated by slides. The final written report was completed in December.

The resources surprised us— we were not prepared for the breathtaking karst development that we witnessed or the opportunities for exciting scientific discoveries in the Tongass karstlands. Epikarst is the highly solutional modified upper zone of the bedrock. The quality of the epikarst is surpassed only by some tropical epikarst in China, Papua New Guinea, and Madagascar. Vertical shafts and caves are abundant. Some areas have sinkhole densities estimated at 3,000 to 10,000 per square mile, far more than the previous record-holder in the United States (1,122 per square mile in southern Indiana). The deepest pit in the U.S. occurs in the area— El Capitan Pit at 600 feet deep.

We found that numerous "muskegs" (peat lands) are intimately associated with karst areas. Sphagnum and other mosses form these squishy meadows and feed acidic waters (pH as low as 2.4) to karst downhill, causing rapid dissolution of the rock; the waters can drill pits in the deep fractures.

On Heceta Island we discovered blind amphipod crustaceans in a cave— the most northern troglobite (cave-adapted animal) in the Western Hemisphere. We initially thought this to be a new species, the usual outcome when studying a remote karst area. We were surprised to learn it was *Stygobromus quatsinensis,* a species previously known only from caves on Vancouver Island far to the south. This discovery raised interesting biogeographic questions— was there a continuous fresh groundwater system fed by glaciers along the entire Pacific Northwest coast that allowed this species to range widely? Today we have found troglobites only on the outer islands of the Alexander Archipelago, but not the inner islands, which were more heavily glaciated during the last glacial epoch.

Large littoral (sea) caves occur just above sea level and contain rare cave art, ancient logs, and bone material. The sea caves rose above sea level after the melting of massive weights of glacial ice, which had depressed the land surface until 10,000 years ago. Geologic uplift also may have been involved. One sea cave contained beautifully preserved paintings of unknown age. Ritual animal burials were found in another cave. Bones of brown bears, extinct on Prince of Wales Island, have been found in caves there. The cold, protected environment of the caves results in excellent preservation. There are logs up to 7,000 years old, and a marmot tooth that looked fresh turned out to be 30,000 years old. Mini-glaciers, possibly of great antiquity, occur in deep pits and may contain bones, logs, and possibly humans. At least 30 archeological and paleontological cave sites are known. Some anthropologists theorize that Asians colonized the Americas by boating along the coast. The caves of Alaska may hold valuable evidence of such early migrations.

Moonmilk is a complex, white, finely crystalline mineral that is like cream cheese. Microbial activity has been tied to moonmilk by some researchers. Large expanses of moonmilk flowstone and underwater moonmilk occur in the Tongass caves on a scale unseen elsewhere in the nation. I wondered if the moonmilk could be related to forest soil microbes and therefore easily damaged by changes in surface vegetation.

The forest on the karst is phenomenal. The bare, alpine epikarst illustrates the deeply fissured terrane that

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Above: Stygobromus quatsinesis (about 5 mm long), a cave-adapted amphipod from Nautilus Cave, Heceta Island. This species was previously thought to occur only in two caves on Vancouver Island, B.C.

Left: Bill Elliott examines a perennial ice mass, Starlight Cave, Prince of Wales Island.

Cathy Aley

lies hidden under the forested areas. The rock is typically so pure (up to 99.5 percent calcium carbonate) that little mineral soil has developed. The forest soil really consists of a lush carpet of mosses over a thin humus. This carpet holds moisture and allows the shallow tree-root systems to spread over the epikarst. Gaps in the vegetation can allow storms to attack these shallow-rooted trees, resulting in large blowdowns. Once exposed to the sun and wind, the moss carpet desiccates and rinses down the closest sinkhole or fracture, usually just a few feet away. Despite the abundant rainfall, such areas can dry out and take a long time for trees to reestablish, if there is any soil left in that spot. Replanting would not help where the soil is absent. In lower elevation karst, which has more soil, we found the opposite problem: clearcuts cause regeneration that is too thick, resulting in poor quality timber and areas unusable by humans. Throwing these forests out of balance results in problems for wildlife too. For example, Sitka deer utilize subalpine forests but depend on low-elevation forests for food and winter shelter from deep snows.

In karst, sediments can be transported long distances in cave streams to points that are not apparent based on surface conditions, for instance salmon streams fed by springs. At least two caves shelter salmon during their annual spawning run. The springs and streams are also water sources for the residents of the area, and could be affected by rotting plant materials, soil erosion, fuel and oil spills from equipment, and septic systems. The traditional conservation practice of protecting streams with strips of trees (as required by the Tongass Timber Reform Act) has not been applied to large karst fields, which can be thought of as three-dimensional stream banks. The size and shape of karst water systems cannot be predicted by looking at surface drainages. Also, surface topography and geology do not accurately predict the direction of water flow in the karst. It surprises many people to learn that a karst system does not always discharge water at one spring but can discharge from several springs, depending on the water level in the system. This can be illustrated by taking a plastic water jug and poking holes in it at several levels. Tom Aley describes a better model of a real karst system, which can be made by setting many capped and uncapped water jugs at different levels and connecting them with hoses.

In some cases karst features are not adequately protected, in other cases they are. Problems in the Tongass karst include: blowdowns in buffers that were too small around caves; roads, quarries, and clearcuts contributing dirty runoff to caves; and caves discovered too late to modify plans for cutting or road construction. We found slash in many sinkholes, evidence of skidding logs and tearing up the soil across cave entrances and sinkholes, a road built directly over a known cave entrance, a road collapsing into a sinkhole where material had been bulldozed in, and inadequate consideration for karst features unless they were large cave entrances. The size of a cave entrance does not determine the importance of its contents. In other cases the Forest Service had adequately protected caves; some areas had been removed from cutting plans to insure protection of cave resources. We felt they were doing a good job of supporting field studies and cave exploration.

We found many values to the Tongass karst. There is a unique opportunity to study evolution and adaptation of cave invertebrates in an archipelago having a complex geologic and glacial history. In the Tongass caves bats hibernate to an extent not seen so far north, and large mammals such as bears, deer, wolves, and otters use caves to an extent no longer seen in the rest of the nation. Some rare plants seem to occur preferentially on the karstlands. The opportunity to do world-class cave

Karst Resources Panel Conclusions:

- The karst and caves of the Ketchikan Area are internationally significant in many respects.
- The karst and caves are nationally significant in many other respects.
- Significant karst resources are likely to extend into the two other management areas of the Tongass (Stikine and Chatham).
- Karst resources are being degraded by timber harvesting; road location, construction, and operation; and quarry construction and inadequate closure.
- Resource management must recognize the archipelago setting of the area and its ecosystems. (This means that an entire island or karst block should not be cut all at once.)
- Unique karst-specific conditions require management of karstlands to follow a different track than that in nonkarst areas. The karst should be managed as islands within islands.
- The Panel was concerned about reforestation conditions on the karstlands which degrade the karst resources— too slow and thin in subalpine areas, too thick at lower elevations.
- Karstlands are of critical importance to the fisheries of the area. Maintenance of long-term high productivity in these streams will be a major benefit from improved karstland management.
- Cave resource protection actions by the Forest Service have been laudable, but have commonly not provided adequate protection for cave features.
- Management of karstlands should involve: (A) inventories of karst features, B) delineate recharge areas with dye-tracing, (C) vulnerability mapping, and (D) incorporation of results from items A though C into planning and land management decisions.
- The Forest Service should identify one or two high quality, but minimally impacted, karst areas for possible designation as a Research Natural Area.
- Ten future study topics were identified and prioritized. These studies should be done concurrently if possible. Top priority should be given to:
    - Protection and study of archeological and paleontological deposits because they are fragile and irreplaceable.
    - Testing and implementation of dye-tracing studies for delineating recharge areas, followed by related vulnerability mapping. Vulnerability mapping is a way of assessing the risk of damaging resources from land management.
    - Cave resource inventories and mitigation assessments should be expanded and enhanced to ultimately insure that they reflect the entire range of karst resources.
    - Karst and cave resources on other areas of the Tongass National Forest are largely unknown and may be comparable to those in the Ketchikan Area; they should be assessed.

exploration in an exciting frontier setting has drawn cavers from as far away as New Zealand. Certainly the beauty of the forested karstlands offers first-class aesthetic experiences for anyone. Recreation in the form of sightseeing, kayaking, fishing, hiking, camping, nature study, and photography could provide new jobs. Evaluation, study, and protection of the contents of many caves will be needed, as required by the Federal Cave Resources Protection Act.

The very fact that the Forest Service was willing to take a hard look at their own practices and compliance with several federal laws encouraged us to hope for constructive changes in the management of the Tongass. The Forest Service has accepted the challenge of integrating karstland management into general land management. This is in line with recent efforts by the Forest Service's Ecosystem Management Office in Washington to manage forests as sustainable ecosystems, and not strictly as tree farms. Our study was not intended to stop all timber harvest in the karstlands of the Tongass National Forest. Conceivably, there are economically feasible ways to harvest timber at a reasonable rate without destroying the multiple values of the karstlands, which after all, belong to all Americans.

Cave and karst resources are receiving greater attention and protection by agencies such as the National Park Service, the Bureau of Land Management, and the Forest Service. In this field the Ketchikan Area clearly has established itself as a leader.

The Karst Resources Panel in old-growth forest on Flicker Ridge, Prince of Wales Island. Left to right: Pete Huntoon, Bill Elliott, Jim Baichtal, Cathy Aley, Tom Aley. Photo by Dee Casey.