Karst and Cave Ecosystems

Goal: Maintain, to the extent practical, the natural karst processes and the productivity of the karst landscape while providing for other land uses where appropriate.

Objective: Allow for the continuation of natural karst processes. Maintain the productivity of the karst landscape while providing for other land uses where appropriate.

Background: Karst is a comprehensive term that applies to the unique topography, surface and subsurface drainage systems, and landforms that develop by the action of water on soluble rock (primarily limestone and marble (carbonates) in Southeast Alaska. The dissolution of the rock results in the development of internal drainage, producing sinking streams (streams that sink into the stream bed or karst features), closed depressions, sinkholes, collapsed channels, micro relief karst features (e.g. karren), and caves.

The geology and climate of Southeast Alaska are particularly favorable for karst development. Extensive areas of very pure carbonate (>95 percent $CaCO_3$), approximately 549,522 acres (859 square miles), are found within the boundaries of the Tongass National Forest. This includes carbonate bedrock on private, state, and federal lands. Because of fractures in the carbonates, high annual precipitation, and peatlands adjacent to the carbonate bedrock, karst has developed, to varying extent, within all carbonate blocks. The Tongass National Forest contains the largest known concentration of solution caves in Alaska.

In southeast Alaska, the karst landscape can be characterized as an ecological unit found atop carbonate bedrock in which karst features and drainage systems have developed as a result of differential solution by surface and groundwaters. These acidic waters are a direct product of abundant precipitation and passage of these waters through the organic-rich forest soil and the adjacent peatlands. Recharge areas may be on carbonate or adjacent non-carbonate substrate. A few characteristics of this ecological unit include: mature, well developed spruce and hemlock forests along valley floors and lower slopes, increased productivity for plant and animal communities, extremely productive aquatic communities, well-developed subsurface drainage, and the underlying unique cave resources (Baichtal and Swanston, 1996, Wissmar et al. 1997, Bryant et al. 1998).

These karst areas are most comparable to those of karst lands found on Vancouver Island and the Queen Charlotte Islands of British Columbia, Canada; portions of Patagonia (Chile); Tasmania; and the west coast of the South Island of New Zealand. All of these areas have very steep surface slopes and subsurface hydraulic gradients, and very high levels of rainfall. These characteristics put them among the most dynamic karst terrains on earth, evolving and changing more rapidly and abruptly than karst in more moderate settings. The Karst Panel Report (Aley et al. 1993) found the karst lands of the Tongass to be of national and international significance for a variety of reasons. The Karst Review Panel in the summer of 2002 reconfirmed these findings (Griffiths et al. 2002). Both of these panels consisted of world-renowned karst experts with a breadth of karst resource backgrounds and a wide variety of international exposure to karst areas and management considerations. Not only is the level of karst development and the karst hydrology and mineralogy globally significant, the paleontological and archaeological discoveries have, for the first time, written the prehistory of southeastern Alaska and contributed to and challenged theories of the peopling of North America. This research in conjunction with associated and ongoing palynology and glacial history research is defining the paleoecology of the region.

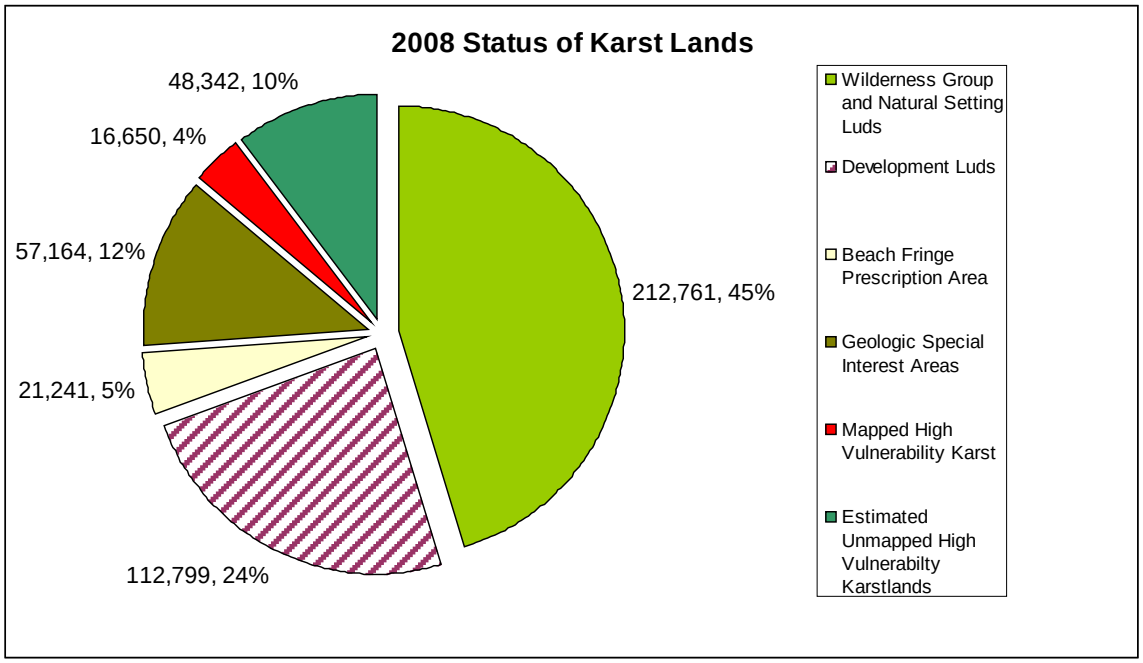
The native and local inhabitants of Southeast Alaska have long known of the presence of caves. The existence of well-developed cave systems was first formally reported in 1975 and mapping of the caves began in 1987. The existence of vast areas in which karst had developed was fully recognized in 1990. Though noted by early foresters and geologists, about this same time the interrelationship between timber production and highly productive forests atop the karst landscape became apparent. With the passing of

the Federal Cave Resources Protection Act (FCRPA) in 1988, the Forest struggled with methods to protect the many caves throughout the landscape. At first, protection focused on only the large, significant karst features and cave entrances. Subsequent measures tended to look at entire karst hydrologic systems including contributing non-carbonate catchments.

From 1993 to 1997, the Forest worked on revising the Tongass Land Management Plan, also known as Forest Plan. One of the five "emphasis areas" identified in the Forest Plan revision was karst and cave resource management. Responding to the need for a management strategy, standards and guidelines were developed which provided for other land uses while taking into account the function and biological significance of the karst and cave resources within the landscape. This strategy was developed with the recommendations of a karst and cave resource significance assessment completed by Aley et al. in 1993, and it combined the most current thinking on karst management issues. The Forest began adopting a land management strategy for the karst lands similar to "hazard area mapping" or "risk assessment." Referred to as "vulnerability mapping" or "karst vulnerability," this strategy assesses the susceptibility of the karst resources to any land use. Vulnerability mapping utilizes the fact that some parts of a karst landscape are more sensitive than others to planned land uses. The key elements of the strategy focus on the openness of the karst system and its ability to transport water, nutrients, soil and debris, and pollutants into the underlying hydrologic systems. The strategy strives to maintain the capability of the karst landscape to regenerate a forest after harvest, to maintain the quality of the waters issuing from the karst hydrologic systems, and protect the many resource values within the underlying cave systems as per the requirements of the FCRPA.

Using the 2008 Forest Plan Land Use Designations (LUDs) and the most current geologic information, some 468,957 acres (734 square miles) of carbonate underlie the lands currently administered by the Tongass National Forest. Of those acres, 269,925 acres (57 percent of the Tongass karstlands) are in the Wilderness Group and Natural Setting LUDs, 57,164 acres in Geologic Special Areas for Karst. Additionally, 21,241 acres lie within the beach fringe prescription area. The remaining 177,791 acres (38 percent of the Tongass karstlands) of carbonate are in Development LUDs. Of the karstlands in Development LUDs, 16,650 acres are mapped as high vulnerability. Of the remaining 161,141 acres of karst lands within the Development LUDs, it is estimated that through inventory and karst vulnerability assessments, that a minimum of 30 percent or 48,342 acres of additional high vulnerability karst lands would be characterized from those lands. Considering all these LUDs and projected inventory results, 356,158 acres or 76 percent of the karst lands are protected or are modeled to be. Therefore, the remaining 24 percent of the karst lands may be available for some level of management pending the results of a thorough inventory and karst vulnerability assessment. Some of these areas have already been harvested and management would be as pre-commercial and commercial thinning. Current GIS queries show a total of 95,479 acres (20 percent of the Tongass karstlands) of harvest on karst on lands managed by the Tongass National Forest.

Karst and Cave Ecosystems Figure 1. 2008 Status of Karst Lands



The above areas of carbonate and LUDs on karst were generated in February of 2006 from the updated geology layer provided to the Tongass National Forest working in cooperation with the US Geological Survey (USGS) in Anchorage. The USGS geology layer was queried to reflect rock units known to develop karst systems. The USGS geology layer was also modified to reflect recent mapping completed in conjunction with the Maden, Iyouktug, Sealevel, and Licking Creek Project Areas and mapping completed by the Forest on northwestern Etolin Islands.

The Forest Plan Standards and Guidelines for Karst Resources (2008 Forest Plan) outline a management strategy and define a process, which requires a karst landscape assessment be conducted. This four-step process first identifies and inventories the karst development and karst hydrologic systems, then evaluates karst resources as to their vulnerability or sensitivity to land uses affecting the karst systems. Consistent implementation of these guidelines across the Tongass has been a challenge. It is believed that this is partially due to unclear direction and limited experience of field personnel with this unseen resource. The flexibility in interpretation has resulted in conflicts between the Forest Service and concerned organizations, particularly the local caving community. Specifically the definitions of high, moderate, and low vulnerability karst have been interpreted differently in the field. Differences in interpretation are exacerbated by the lack of understanding of the way timber harvest impacts karst and cave resources, most notably by changes to hydrology and sediment delivery. The discussion in the 1997 Forest Plan does not make clear the difference between riparian management objectives and karst and cave management objectives. This understanding is critical for Forest Service employees tasked with implementing resource protection measures in the field. The 1997 Forest Plan did not discuss second growth management opportunities on karstlands and did not address the question of salvage of windthrown timber on karstlands.

Multiple reviews of the current and proposed karst management strategies have been conducted by two panels, independent reviewers, and internally. These include Karst and Cave Resource Significance Assessment, Ketchikan Area, Tongass National Forest, Alaska (Aley et al. 1993); Application of a Karst Management Strategy: Two Case Studies from the Tongass National Forest, Southeastern Alaska, The

Challenges of Implementation (Baichtal, 1997); Heceta Sawfly Salvage Sale, Soils, Karst, and Cave Resource Evaluation, Heceta Island, Southeastern Alaska (Baichtal and Landwehr, 1997); Karst Vulnerability Assessment Review, Heceta Island (Aley, 1997); and Karst Management Standards and Implementation Review, Final Report of the Karst Review Panel (Griffiths et al. 2002). These reviews combined with implementation and effectiveness monitoring and resource specialist input form the basis for the proposed changes discussed below. The standards discussed here have been implemented since 1991 in one form or another. Thus, the Forest has nearly 20 years of implementation experience. The effectiveness and appropriateness of these standards have been discussed and debated internally and externally, both nationally and internationally. The final report from the Karst Panel in 2002 noted that "implementation of the 1997 TLMP Karst Standards and Guidelines has ensured a high level of protection for karst resources overall. The Panel noted high standards in both the philosophy of management, and the way that specific management practices were formulated and applied. Implementation of specific policies and procedures was found to be very good and in general compliance with the stated goals and objectives of the karst program."

In 2006 the Tongass National Forest initiated a process to amend the 1997 Tongass Forest Plan. The 2008 Forest Plan Amendment includes substantial changes to the Karst and Cave Management Standards and Guidelines. These new guidelines will hopefully correct some of the ambiguity of past direction and clarify the karst and cave management strategy and process. The 2008 Forest Plan also includes additions to the Geologic Special Interest Areas to protect nearly 47,000 additional acres (57,164 acres total) karst lands that are most vulnerable to disturbance from development.

Karst and Cave Ecosystems Question: Are the biological, mineralogical, cultural, paleontological components, and recreational values of the karst and caves maintained?

Monitoring was completed on projects implemented under the direction of the Standards and Guidelines in the Forest Plan. Work completed under the Forest Plan Karst and Cave Standards and Guidelines included preliminary inventory, cave inventory and mapping, timber harvest unit and road reconnaissance, timber harvest unit layout, and road layout.

Monitoring Results

The Karst and Cave Standards and Guidelines outlined in Forest Plan were implemented to the fullest extent practicable. The Karst and Cave Standards and Guidelines outlined in Forest Plan showed through effectiveness monitoring to ensure a high level of protection for significant caves and karst resources overall.

Current ongoing projects and those with signed Records of Decision (RODs) focus on karst area protection. The Karst Resources Standards and Guidelines require that areas of high vulnerability karst within the project area be deleted from land considered for harvest. Karst lands included in project areas are typically low or moderately low vulnerability karst. The Karst Resources Standards and Guidelines were fully implemented in completed projects such as Logjam and Slake Timber sales on central Prince of Wales Island. The Karst Resources Standards and Guidelines are fully implemented in proposed and ongoing projects such as the Big Thorne Timber Sale, Kosciusko Island Timber Sale, Dargon Point Categorical Exclusion (CE), Twelve Mile Restoration Environmental Assessment (EA), Review of the Juneau Access Road Proposal, the Wrangell Timber Sale, Phase 1 and 2 of the Forest Highway 43 construction from the Coffman Cove Junction to the Whale Pass Junction, and the Sunnahae Trail construction. Karst resource inventory is planned in 2013 for completion of the Kosciusko Timber Sale. Karst resource input was provided for a number of sales associated with the Small Sales Program on

Thorne Bay and Craig Ranger Districts on Prince of Wales Island. Particular emphasis was placed on the inventory and design of the prescriptions and mitigation proposed for commercial thinning opportunities.

Efforts on the above projects included on the ground inventories by the Forest Geologist and geology staff, soil scientists, hydrologists, fisheries, and timber specialists. Features were mapped and characterized and the streams flowing to and from them identified. Resource reports for each area were developed. The findings of these efforts have been mapped and incorporated into the final reports. Also included were survey and inventory of some of the caves found within the project areas. Resource reports were provided to the planning IDTs and incorporated into the final design of the projects and the project recommendations. These findings were also incorporated into the Chapter 3 discussions in the environmental documents associated with these projects.

Effectiveness monitoring has been historically tied to post harvest monitoring and preliminary cave resource inventories. In fiscal year (FY) 2012, a minor amount of logging occurred on karst lands where mitigation had been prescribed. Monitoring of some of the small sales on the Thorne Bay Ranger District was conducted to evaluate the effectiveness of proposed mitigation. Monitoring of these sites found that prescriptions such as partial suspension and buffer windfirmness were achieved. Limited subsurface monitoring was accomplished. These included subsequent trips into known cave systems to document changes and pre-harvest inventory of karst features to establish baseline inventories. No substantial changes as a result of management activities were documented within the known cave systems.

The Kosciusko karst watershed monitoring project may continue on Kosciusko Island in 2013 with the acquisition of four new water quality sondes. In cooperation with the State of Alaska, this project was initiated to monitor water quality at two springs that provide water to the town of Edna Bay, Alaska. The project monitored water quality prior to, during, and following commercial thinning of young growth within the contributing watershed.

Monitoring of the effectiveness of the implementation of the Standards and Guidelines over the past few years has shown the need for clarification of the implementation procedures, and identified changes to the standards needed. The 2008 Forest Plan Amendment karst and cave resource guidelines reflected these changes. These changes capture the findings of past effectiveness monitoring and hopefully provide clarification of the implementation procedures.

Evaluation of Results

Karst and cave resources are accepted as a valuable resource across the Tongass. Resource specialists from various disciplines are bringing observations, concerns, and discoveries to the attention of the Forest Geologist and/or geology staff for consideration during the inventory and design phase of projects. Implementation monitoring has shown the need for continued education and training of specialists across the Tongass. Specialists requested implementation education and training. Substantial changes have been implemented in the Karst and Cave Resource Guidelines for the 2008 Amendment to the Tongass Land and Resource Management Plan, which better define the karst management strategy and vulnerability assessment process.

Programs such as the Small Sale Program on Thorne Bay Ranger District allow the karst management specialist to work closely with the presale forester, purchaser, and sale administrator to ensure consideration of karst resource values. As funding allows, the Forest needs to continue to strive for pre-harvest, immediately post-harvest, and post-harvest monitoring of areas where mitigation was recommended.

The Karst and Cave Resource Standards and Guidelines in the 2008 Forest plan have helped with implementation and clarification of standards from past guidelines. The awareness of karst and cave resources and mitigation measures are more easily integrated into project design and implementation.

Monitoring has shown that mitigation designed to protect karst resources has been more effective than in the past, especially when considering the effects of wind throw and losing streams. The current standards allow for appropriate protection measures for minor features to be designed on a case-by-case basis as field assessed by a karst management specialist. This is an important change from past standards that allow flexibility in the implementation of standards. It is believed that the current standards as written are effective in protecting the karst and cave resources on the Tongass National Forest.

Action Plan

Recommendations include continuation of current efforts, such as implementation of the karst and cave resource standards and guidelines across the Tongass in all projects where resources may occur, and work to increase awareness of potential karst and cave resources within proposed projects across the Forest. Training and involvement of karst specialists, hydrologists, soil scientists and other resource specialists is essential in implementation of the Karst Resources Standards and Guidelines.

As timber harvest occurs in areas where karst is present and mitigation has been prescribed, effectiveness monitoring will follow as funding allows. Tracer dye studies will continue to further characterize karst groundwater systems.

Citations

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