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EVOLVING KARST MANAGEMENT ON THE TONGASS: WHAT TWELVE YEARS OF IMPLEMENTATION AND DEVELOPMENT HAVE TAUGHT

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For the past 12 years the Tongass National Forest in Southeastern Alaska has worked to identify, inventory, explore, and manage the extensive karst resources found there. Fueled by the requirements of the Federal Cave Resources Protection Act of 1988 and the Tongass' interpretation of that Act, internal regulations, and recommendations of the 1993 Karst Panel, a strategy was developed intended to protect the karst resources found there.

These standards were published in the Tongass Land Management Forest Plan in 1997, however, one form or another of these guidelines have been implemented from 1991 on. The Forest gathered ideas, borrowed concepts, and sought help from karst management specialists in the U.S., Tasmania, British Columbia, and Switzerland. Effectiveness monitoring of the implementation of these karst management standards have shown their strengths and weaknesses. In 2002, the Forest once again convened a panel of karst experts to independently evaluate the effectiveness of implementation of the current karst management standards and guidelines and to analyze the appropriateness of proposed changes to those guidelines. This paper focuses on the recommendations of the most recent karst panel's findings and the proposed changes to the karst management strategy on the Tongass National Forest. The proposed changes focus on clarification of the karst vulnerability assessment definitions, on the design and effectiveness of non-harvest buffers adjacent to karst features, sinking streams, etc., addresses wind throw salvage and second growth timber management, catchment area management, qualifications of inventory and resource specialists, and establishment of long term monitoring sites.

The Southeastern Alaska Karst Landscape

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, marble, and dolomite (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, and caves.

The geology and climate of Southeast Alaska are particularly favorable for karst development. Extensive areas of very pure carbonate, approximately 2950 square kilometres (km^2) (555,770 acres, 869 mi^2), 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 dissolution caves in Alaska. Our current inventory included 636 caves and many more are known about and are yet unexplored.

In Southeast Alaska the karst landscape can be characterised 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 ground waters. 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).

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 confirmed 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 palaeontological 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.

Development of a Management Strategy

The natives and local inhabitants of Southeast Alaska have long known of the presence of caves. The existence of well-developed cave systems was first reported in 1975 and mapping of the caves began in 1987. The existence of vast areas in which karst had developed was fully recognised from 1988 to 1990 (Allred, 1988; Allred; 1989, Aley et al; 1993; Baichtal, 1993 a,b,c; Baichtal, 1994). 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. Beginning in 1990, protection focused on only the large, significant karst features and cave entrances. Subsequent measures tended to look at entire karst hydrologic systems. These measures were limited by the need to provide timber for the long-term timber sale contracts that fed the pulp mills and wood-products industry in southeastern Alaska.

From 1993 to 1997, the Forest worked on revising the Tongass Land Management Plan (TLMP). One of the five "emphasis areas" identified in the TLMP 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 had been developed during the last few years beginning with the recommendations of a karst and cave resource significance assessment completed by Aley et al in 1993 and combining the most current thinking on karst management issues. The Forest adopted 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 utilises 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 in to 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. A more detailed description of the karst and cave resources and current management strategy of the Tongass National Forest is presented in the *Karst and Caves* section of Chapter 3, pages 3-82 to 3-86, and in *Appendix I* in the 1997 Tongass Forest Plan Revision Final EIS (USDA Forest Service, 1997a). This strategy was developed locally and through communication with the cooperating karst management specialists, Ministry of Forests in British Columbia (BC), Canada and BC karst experts, the Tasmania Forest Practices Board personnel, and from review of the EPIK system for karst groundwater protection in Switzerland (Aley and Aley, 1993; Aley *et al*, 1993; BC Ministry of Forests, 2002; Doerfliger, 1996; Eberhard, 1996; I'Anson, 2002; Kiernan, 2002; Stokes and Griffiths, 2002; Tasmania Forestry Commission, 1993).

The science of karst management on the Tongass is a dynamic process. As previously mentioned, the 1997 Tongass Forest Plan Revision Final EIS included Standards and Guidelines for Cave and Karst Management. Implementation and effectiveness monitoring of these standards has brought to light discrepancies with in the standards and the need for clarification. Specifically, Section III, A. (4) of the Karst Landscape Assessment; Assess Vulnerability of the Karst Terrain to Management Activity, provided the largest challenge to implementation (Baichtal and Landwehr, 1998; Baichtal, 1997). The clarification of the definition of low, moderate, and high vulnerability karst lands, the application of appropriate mitigation, catchment area management, and conflicts with riparian management standards have surfaced as topics that need clarification. The Forest is working to update the current standards and guidelines, strengthening inventory and mitigation, and identifying where additional information needs exist (Baichtal, 2002). The Karst Review Panel convened in the summer of 2002, reviewed the current and proposed karst management strategies and inventory methods. They confirmed the appropriateness of the Tongass' karst management strategy and the proposed changes and clarifications. They proposed steps the Tongass should take to strengthen the karst management program as a

whole, bringing consistency and additional professionalism to the program. These suggestions will be considered in the development of future management strategies and program development.

Approximately 1892 km² (467,600 acres, 731 mi²) of carbonate underlie the lands currently administered by the Tongass National Forest. Of those square kilometers, 359 (88,763 acres) are in the Wilderness Group Land Use Designations (LUDs) and 643 (158,926 acres) are in Natural Setting LUDs. These total to 1002 km² (247,689 acres) or 53% of the karst lands. The remaining 890 km² (219,991 acres) of carbonate are in development LUDs. Of these, 167 km² (41,333 acres) have been mapped as high vulnerability karst lands. Of the remaining 773 km² (178,579 acres) of karst lands within the development LUDs, 440 km² (108,770 acres) are mapped as suitable lands for timber production. It is estimated that through inventory and karst vulnerability assessments, that a minimum of 30% of additional high vulnerability karst lands would be characterized from those suitable lands. Considering all these LUDs, the suitable land base, and projected inventory results, 1584 km² (391,462 acres) or 84% of the karst lands are protected or are modeled to be. Therefore, the remaining 16% of the karst lands may be available for some level of management pending the results of a thorough inventory and karst vulnerability assessment.

Current Standards and Guidelines and Implementation Challenges

The TLMP 1997 Forest Plan Standards and Guidelines for Karst Resources 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 problem. It is believed that this is partially due to unclear and conflicting direction and limited experience of field personnel with this unseen resource. 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 sediment delivery. The discussion in the 1997 TLMP does not make clear the difference between riparian management objectives and karst and cave management objectives with reference to sinking streams. Implementation and monitoring of applied mitigation has shown in some instances that buffers intended to protect karst features and losing streams have failed (USFS, 2000). The current standards and guidelines also do not discuss wind throw salvage and second-growth management. Current direction stated in the standards for catchment area management protects all lands contributing to significant caves regardless of the size of the contributing watershed. The intent of this standard was to assess the watershed conditions and design a management strategy within a contributing watershed that protects the downstream karst resource values. Clarification of catchment area management is required to map out a strategy and eliminate confusion of the intent. Karst assessments requires professional skill and judgment, as well as experience with karst environments. Current standards do not specify the skills needed to carry out these assessments. The above mentioned aspects of the standards and guidelines are but a few of the specifics discussed below. These management considerations and the proposed changes were reviewed by the 2002 Karst Panel; their comments specific to these issues are contained in their report (Griffiths, 2002)

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Issue

Background

A. FCRPA Criteria

1. Biota
2. Cultural
3. Geologic/Mineralogic/Palaeontologic
4. Hydrologic Systems
5. Recreational Opportunities
6. Educational or Scientific Opportunities

B. Key Cave/Karst Resources-Related Issues

1. Karst Landscapes in Alaska
2. Forest Productivity and Importance of Carbonates
3. Surface/Subsurface Connectivity
4. Vulnerability Mapping
5. Harvesting Impacts
    - A. SURFACE RUNOFF AND SEDIMENTATION
    - B. SOIL DISTURBANCE
    - C. AESTHETICS
    - D. CAVE RESOURCES
    - E. CONTAMINANTS
    - F. ROAD AND CONSTRUCTION IMPACTS
    - G. WINDTHROW

C. Karst-Related Discrepancies in Current Standards and Guidelines

1. Karst Landscape Assessment
    - A. VULNERABILITY DEFINITION
    - B. SYSTEM-WIDE APPROACH
    - C. PROFESSIONAL QUALIFICATIONS
    - D. DISCRETE VS DIFFUSE RECHARGE
    - E. WATERSHED ANALYSIS
    - F. TIMING AND PROJECT PLANNING
2. Windthrow Mitigation
    - A. CURRENT BUFFERS
    - B. RIPARIAN VS KARST BUFFER OBJECTIVES
    - C. BUFFERS FOR LOSING OR SINKING
    - D. SINKING STREAM BUFFERS
    - E. WINDTHROW SALVAGE
3. Second-Growth Management
4. Steep Slopes
5. Additional Research Needs

Policy Clarification

A. Karst Landscape Assessment
- Step 1. Identify Potential Karst Lands and Features
  - A. SOURCES FOR LITERATURE SEARCH
  - B. PRELIMINARY MAPPING
- Step 2. Inventory Karst Resources
  - A. OBJECTIVES OF INVENTORY
  - B. PHASES OF INVENTORY
    - Phase 1. Initial Field Assessment
    - Phase 2. Detailed Inventory
    - Phase 3. Cave Survey
- Step 3. Delineated Karst Hydrologic System and Catchment Area
  - A. KARST HYDROLOGIC FEATURES
  - B. TRACER DYE TESTS
  - C. WATERSHED ANALYSIS
  - D. ELECTRONIC DATA REQUIREMENTS
    - i. Watershed Maps
    - ii. Tracer Dye Test Data
- Step 4. Assess Vulnerability of Karst Terrain to Management Activity
  - A. LOW VULNERABILITY KARST LANDS
    - i. Classification Criteria
    - ii. Management Objectives and Appropriate Land Uses
  - B. MODERATE VULNERABILITY KARST LANDS
    - i. Classification Criteria
    - ii. Management Objectives and Appropriate Lands Uses
  - C. HIGH VULNERABILITY KARST LANDS
    - i. Classification Criteria
    - ii Management Objectives and Appropriate Lands Uses

B. Windthrow Timber Salvage
- 1. Windfirm Buffers
- 2. Windthrow Timber Salvage

C. Second Growth Management
- 1. Vulnerability Assessment Specific to Second Growth Areas
- 2. Management Activities
  - A. PRE-COMMERCIAL THINNING
  - B. COMMERCIAL THINNING
  - C. SECOND GROWTH HARVEST

D. Steep Slopes
- 1. High Vulnerability Topography
- 2. Field Confirmation

E. Additional Research Needs

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