THE OREGON CAVE CONTROVERSIES AND THE NATIONAL COMMISSION ON RISK ASSESSMENT AND RISK MANAGEMENT

William R. Halliday
Founder, Cascade Grotto of the NSS
6530 Cornwall Court
Nashville, TN 37205
bnawrh@webtv.net

Abstract

Since the 2003 National Cave and Karst Management Symposium, the ferocity of controversies at Oregon Caves National Monument has diminished but deterioration of the cave under National Park Service management has begun to attract newspaper attention. The "spelunker tour" through a paleontological site has been deferred pending a new cave management plan. Several erroneous and misleading publications have been withdrawn from general distribution and from the monument's bookstore. Ludicrous misinformation persists in the Monument's "Official Map and Guide," however, and even more extensively in the guides' patter. In July 2005 at the NSS Convention I discussed the cave's geology with particular reference to the geological misinformation which has been promulgated for about 20 years.

Despite this vigorous misinformation, it is clear that Oregon Caves National Monument no longer meets expectations for continued status as a unit of the National Park System. It should be transferred to the USDA Forest Service, the Oregon State Park System, Josephine County, or to a private operator. Meanwhile, however, recommendations of the National Commission on Risk Assessment and Risk Management should be applied to the forthcoming cave management plan. These include risks both to humans and to the environment, with emphasis on such constructive concepts as avoidance of "command and control" decisions and involvement of "stakeholders" such as cavers throughout the evaluation and management process. In addition to their potential role at Oregon Caves National Monument, their application at Mount St. Helens in 1980 would have saved some 50 lives and much controversy about access for study of its caves after the eruption. Similarly in 2005, their application would have prevented the current controversy about alleged but undemonstrated carbon dioxide in caves of Kilauea Caldera, Hawaii. The National Speleological Society should support widespread use of these principles.

Introduction

In general, only examples of good cave management are presented at National Cave and Karst Management Symposiums. But to protect caves and cave resources, bad cave management practices must also be included occasionally. This paper has two purposes:

(1) To identify Oregon Cave as a site-specific example of harm resulting from bad cave management: harm to the cave, harm to Oregon Caves National Monument, and harm to the National Park Service as a whole.

(2) To introduce the cave management community to comparatively new Federal standards of risk assessment and risk management. These published standards may be useful in preventing future bad cave management. Because of its risks

to both the cave and to the public, cave management is largely risk management.

1918 National Park Service Standards and Their Application to Oregon Caves National Monument

The first clear, detailed standards for units of the National Park System were promulgated by Interior Secretary Franklin K. Lane in 1918 (Lane 1918, quoted in Unrau and Williss 1983). They are vigorously asserted today in ParkWeb, an active National Park Service Web site which includes Unrau and Williss (1983) in full. These standards include (but are not limited to):

- "The national parks must be maintained in absolutely unimpaired form for the use of future generations as well as those of our own time";
- "Every activity ... is subordinate to the duties imposed upon it to faithfully preserve the parks in posterity in their natural state";
- "In the construction of roads, trails, (and the like), particular attention must be devoted always to the harmonizing of these improvements with the landscape";
- "In studying new park projects you should seek to find 'scenery of supreme and distinctive quality or some natural feature so extraordinary or unique as to be of national interest and importance ... distinguished examples of typical forms of 'world architecture'... such as the Grand Canyon."

Unfortunately Oregon Caves National Monument was tacitly exempted from these standards from 1934 to the present.

Short History of Oregon Cave–1934

In 1918, Oregon Cave and tiny Oregon Caves National Monument had been administered by the USDA Forest Service for nine years. If anyone had considered them in the context of the standards just cited, the likely conclusion would have been that they met the standard on harmonization but none of the others. Although widely advertised regionally and promoted extensively, Oregon Cave clearly was:

- a fun show cave, and
- a notable geological feature of regional interest, not a feature of national significance.

Unquestionably it suffered from overuse and inadequate protection, but the brand-new (1916) National Park Service expressed no interest in making it a unit of the National Park System. In 1934, 16 years later, these still were true. Yet in 1934, President Franklin Delano Roosevelt used a classical "command-and-control" decision to transfer it to a flabbergasted National Park Service: a Presidential Proclamation.

Short History of Oregon Cave 1934–1985

In 1934, the National Park Service was neither prepared to administer Oregon Caves National Monument, nor to protect it (Finch 1934). In retrospect, it could have evaded this unexpected new responsibility as it did for some other lands also transferred to it by the proclamation. Had it done so, it would have avoided much demeaning controversy. But in 1934, the National Park Service was as expansionist as many another bureaus of the federal government. Despite its longstanding standards, it chose to retain the cave and to seek enlargement of the tiny Monument area around its entrance (Finch 1934). The first National Park Service cave management recommendations for Oregon Cave urged "that any changes in the operations of the Caves (*sic*) come by a process of evolution (Finch 1934). And so it was. For half a century the cave was managed much as it had been from 1909 to 1934. More and more it came to look like a worn-out show cave.

Short History of Oregon Cave 1985–present

Rather than being "absolutely unimpaired," Oregon Cave became a shattered husk. Everything breakable on or near the tourist path was broken, even well overhead. Because of the tight, narrow geometry of its passages, recurrent deposits of skin oils and dirt and lint accumulations were inevitable. The last breakable speleothem on the tour route (the beautiful little "Bird of Paradise") disappeared in 1999 — about the time that the cave first was locked securely at night (Halliday and Swofford 2003). Trails were paved, dug up, repaved, and sometimes moved a few meters without consider-

ation of environmental impacts. Despite the lack of definitive knowledge of the cave's original complex pattern of air flow, bulky, ineffective airlocks were installed to supposedly restore its original pattern of circulation. Very expensive gleaming stainless steel railings detracted even more from the cave's own landscapes. (Although seemingly ice-cold to the touch, such stainless steel constructs are a valuable protection for visitors and for troglobites in voluminous, near-virgin caves which are warm enough for visitors to grasp railings for more than a few seconds, for example, Grotta Grande del Viento, Frasassi, Italy). It is doubtful, however, that any troglobites in and around the tour route have survived its century of abuse. But any troglobite survivors surely were hardy enough to also survive use of more .

Concerning "Standards, Dignity, and Prestige"

In terms of Secretary Lane's "standards, dignity and prestige," Oregon Cave is not in the same class with the other caves which are namesakes of their National Park Service unit: Carlsbad Cavern, Mammoth Cave, Wind Cave, Jewel Cave, Timpanogos Caves, and Russell Cave. Locally, Mammoth Cave is more than a little people-worn. But its vastness and its extraordinary historical and archeological values more than compensate for that. Russell Cave is a special case. It was donated to the National Park System to preserve and interpret a nationally significant archeological sequence. Somehow that archeological sequence no longer is exhibited. But its adjacent subterranean wilderness remains virtually intact. And Carlsbad, Wind, Jewel, and Timpanogos simply are matchless.

Oregon Cave retains much of its value as a show cave but it is surpassed in many ways by such state park caves as Alabama's Cathedral Cavern and Montana's Lewis and Clark Cavern (originally Morrison Cave National Monument). Its scenic resources are surpassed by many privately operated show caves (for example, Texas' Caverns of Sonora) and by at least one cave administered by the USDA Forest Service (Blanchard Springs Cave, Arkansas). Important scientific resources (paleontological for example) exist in the small, undeveloped sections of Oregon Cave, but paleontological resources are not high on the National Park Service's list of qualifications for units of its system. When Utah's Crystal Ball Cave was rejected for national monument status (Wykert 1959), the inspection report did not even mention the numerous bones of prehistoric mammals strewn about its floor (Halliday 1965).

Present Assertions About Uniqueness and National Significance of Oregon Cave

Principal current assertions about extraordinary uniqueness and national significance of Oregon Cave seem to center about "six types of rock," supposedly an extraordinary combination in a cave. This represents a basic misunderstanding which apparently dates from the 1980s. This was the time when Congress chose the USDA Forest Service to administer Washington State's new Mount St. Helens National Volcanic Monument including Ape Cave — then the longest lava tube cave on the American continents. To the surprise of many American conservationists, including me, the USDA Forest Service promptly demonstrated that it was capable of administering national monuments quite ably.

Some conservationists, again including me, suspect that this was threatening to administrators of a nearby unit of the National Park System which could not be brought into compliance with standards of the National Park Service.

Even in the 1950s and 1960s, there was evidence of concern about this. In 1959, while serving as Assistant Park Naturalist of Crater Lake National Park (which then administered Oregon Caves National Monument), Richard Brown expressed the hope that I could find something unique and extraordinary about Oregon Cave. The most I could provide was a conclusion that Oregon Cave has all the features of a large cave system in a remarkably small area (Walsh and Halliday 1971 and 1978, Halliday 1977). This conclusion evidently was insufficient; I am unaware that it ever appeared in any National Park Service publication.

The six types of rock cited in the "Official Map and Guide" (National Park Service, 2000, 2002) and trailside exhibits are said to be:
(1) "plutonic igneous,"
(2) "contact metamorphic,"
(3) "regional metamorphic,"
(4) "volcanic igneous,"
(5) "clastic sedimentary,"
(6) "chemical sedimentary."

At the 2005 National Speleological Society Convention I presented this classification to the session on Cave Geology and Geography (Halliday in press). No one spoke to concur with it; one problem is that it conflicts with the long-standing mainstream of geological thought which recognizes only three types of rock: igneous, metamorphic and sedimentary.

Further, documentation of the existence and significance of the "six types of rock" in the cave is tenuous. For example, "volcanic igneous" rock is said to be represented by volcanic ash (a very common component of soils throughout much of the Pacific states). My tour guide in April 2005 was less than convincing about this. Stopping at the trailside patch of supposed volcanic ash (which looks like ordinary cave silt on a ledge), he explained that it had not been confirmed as volcanic ash, "But they're going to examine it soon."

Still further, the principal "plutonic igneous" rock in the cave likely is nothing of the sort. This is the supposed "quartz diorite" dike in the Ghost Room depicted in the "Official Map and Guide" and pointed out by tour guides. In the 1960s, a thin section microscopic study of a sample of this dike by former NSS President George W. Moore revealed that its contents were compatible with a sedimentary dike instead (Moore ca. 1962, cited in Halliday 1963, 1966-67, 1969). At least in the mid and late 1960s, his report was in National Park Service files, and even before this analysis, National Park Service publications referred to it as a clastic dike (for example Anon. 1958, 1959, 1960).

The only metamorphic rock in the cave is the marble in which it formed, with a very small amount of argillite and perhaps of other impurities also present in the block of marble. Neither of these occurrences is unique or extraordinary. Dozens of other caves in the Klamath Mountains and hundreds in the nearby Sierra Nevada also formed in marble with similar small quantities of impurities. In many of them, other metasedimentary, metavolcanic, and igneous rocks can be seen where dissolution of the marble block was especially efficient (Halliday in press). With rare exceptions, (for example Black Chasm, Calif), such noncarbonate rocks are not part of the caves from which they are viewed. The fact that they can be viewed from Oregon Cave is unremarkable; they can be viewed better in road cuts and in other surface exposures.

Listing of both "contact metamorphic" and "regional metamorphic" rock apparently implies that various degrees of metamorphism can be detected within the cave's marble. It is doubtful that this is the case. Any supposed "contact metamorphism" adjacent to the clastic dike would be surprising.

Finally, subdividing Oregon Cave flowstone into either "clastic sedimentary rock" or "chemical sedimentary rock" is not in accord with basic karstic mineralogy (for example Hill and Forti 1997).

During the present symposium, John Roth (oral communication) defended the systematic publication of these and other misstatements (Table 1), saying they were intended "to challenge readers," a practice he attributed to Park advocate Freeman Tilden. It is difficult to believe that Tilden or any other National Park Service spokesman would condone or urge National Park Service publication of false or misleading assertions.

The National Commission on Risk Assessment and Risk Management

It is clear that not all of the Oregon Cave problems we surfaced in 2003 (Halliday and Swofford 2003) can be resolved as long as the cave is administered as part of the National Park System. Our 2003 recommendation that Oregon Caves National Monument be returned to the USDA Forest Service remains valid. In these days of tighter Federal budgets, however, some alternatives also should be considered: transfer of the cave to the Oregon state park system, to Josephine County for a county park, and even privatization. Decisions regarding its disposition should not be hasty, nor should they be "command-and-control" decisions like President Roosevelt's Presidential Proclamation. This implies a (hopefully) short period of continued management of the cave by the National Park Service.

During this interim period, certain recommendations of the National Commission on Risk Assessment and Risk Management seem both appropriate and useful. If these recommendations had been in place at Oregon Cave since 1980, controversies would have been greatly reduced and management of the cave would have been much healthier: healthier for the cave, for its denizens, and for its visitors. This is because all cave management poses at least potential risks, and bad management poses increased risks. Such risks can be

minimzed by:

- utilizing all relevant information in decision matrices;
- involving "stakeholders" in a cooperative decision framework;
- employing alternatives to command-and-control decisions, and also employing alternatives to default decisions, to the greatest degree possible;
- utilizing meaningful peer review mechanisms which include stakeholder input, and;
- utilizing iterative management strategies after decisions are made.

All these principles are recommendations of this Commission.

Evolution and Development of the National Commission

Congress initially mandated a narrow role for this commission: to study and make recommendations on health risks from air pollution. However its role was expanded by both the first Bush administration and the Clinton administration. It eventually encompassed other health risks and risks to the environment. When it was completing its work in 1997, its members realized that they also had gone beyond the original intention: that its recommendations be directed toward federal programs. Its framework thus evolved into broad principles also applicable to "public and private entities at the state, regional, and local levels" (Presidential/Congressional Commission 1997). Its two-volume final report is readily accessible on the Web by searching for "Commission on Risk Assessment." Because of its ultimate breadth, some 60% of this report is irrelevant to cave management (risks from drugs, risks from chemicals, risks from irradiation, and so on). Cave managers will find the other 40% provocative and generally applicable in a wide variety of decision and management matrices.

The commission's report began with six broad, seemingly oversimplified principles:
(1) defining each problem and putting them into context,
(2) analyzing the risks associated with each problem,
(3) examining the options for addressing each risk,
(4) making decisions about which options to implement,
(5) taking actions to implement these decisions,
(6) evaluating the results of each action.

It immediately went on to specific new ground, however, stressing that this framework must be conducted in collaboration with "stakeholders," (persons and entities potentially affected by such decisions). Further, because decisions often must be made on the basis of incomplete information, management plans must be subject to change ("iteration") as new information becomes available. It did not use the word "stonewalling," but its criticism of this traditional practice is clear. It repeatedly condemned "default decisions," perhaps an equally traditional practice.

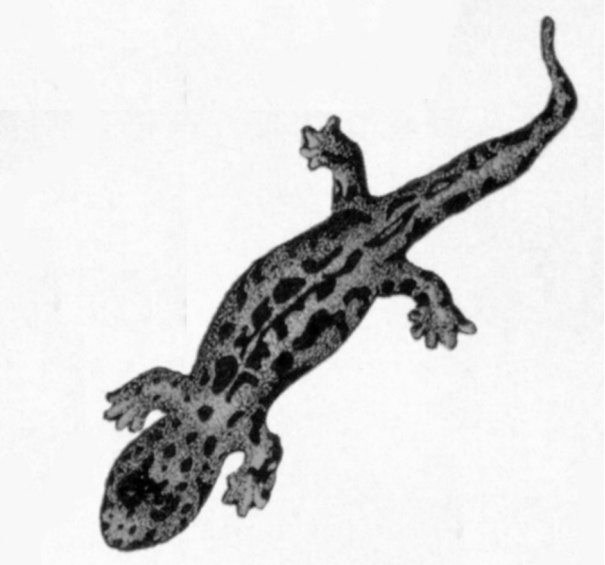
Additional new areas included its recommendation of avoidance of command-and-control decisions "whenever possible," and its recommendation of independent peer review of pending decisions, with stakeholders included on the peer review panel. Perhaps most controversial, it urged that the entire process be open to the public and the media, with "honesty and accuracy," and that the weight of evidence supporting different assumptions and conclusions be laid out for all to review.

While some of the management problems at Oregon Cave are beyond the reach of these principles (for example its geometry), even cursory consideration indicates that many current Oregon Cave controversies exist because its administrators did not comply with these recommendations. Further, it is not difficult to think of other cave management controversies in which they would have been very helpful: administration of Mammoth Cave National Park at the time of the C-3 Expedition (resolved eventually); administration of the Gifford Pinchot National Forest before, during, and after the initial eruptions of Mount St. Helens 1980–1981 (soon resolved); the secret 1990 gating of Mowich Cave, Oregon, by the Umpqua National Forest (recently resolved); 15 years of cave management controversies at Hawaii Volcanoes National Park culminating with the unjustifiable 2005 closure of its Kilauea Caldera caves cased by unsupported speculation about possible dangers from CO_2 (unresolved).

These new Federal standards are binding on no one and no agency — not even the Environmental Protection Agency which was heavily involved in their development. But they now provide cave managers an unparalleled mechanism for risk management and conflict resolution. The National Spe-

leological Society should recommend their implementation as widely as possible.

Table 1. Some other misstatements in the 2002 "Official Map and Guide" of Oregon Caves National Monument.

1. "Cavers use (cave) popcorn as a compass to find new passages or, when lost, their way out."	During this symposium, John Roth defended this statment to me, face-to-face, stating that it was based on his personal experiences. Since coralloids ("cave popcorn") are found over a vertical range of about 1,000 feet in Carlsbad Cavern, I suggested that he present his findings at the 2006 N.S.S. Convention session on cave geology and geography. He demurred.
2. The drawing of the supposed Pacific giant salamander actually is that of a common eastern spotted salamander (probably *Ensatin*a sp). 	During this symposium, John Roth defended this attribution to me, face-to-face, on the basis of species variability cited in taxonomic texts. I suggested that he present this attribution at the 2006 N.S.S. Convention session on cave biology. He demurred. 
3. The cutaway diagram portrays an imaginary scene of great scenic impact (as well as supposed examples of the "six types of rocks").	No vista in the cave has so great a scenic impact.
4. (The Pacific giant salamander is) "one of the few amphibians known to vocalize."	Anyone who has been in a tropical rain forest at night is likely to doubt this statement.
5. "A salamander warns us of changes in our environment."	This is imagination run wild.
6. "Since 1985 … crystal clear water once again cascades over white marble."	This implies that only the post-1985 NPS operations in Oregon Cave produced this result. This is outright fabrication. I observed "crystal-clear water cascading over white marble" in the cave in 1948, 1959, 1960 and other dates before 1985.

7. "Since 1985 … new lighting and trail system will reduce evaporation and unnatural foods. "	Evaporation varies naturally in different parts of the cave. This is largely imagination and speculation. And just what are "unnatural foods," anyway?
8. "Since 1985 … one can now see a renewed cave."	This is simply untrue. The tour route is cleaner than in 1985, but many of the cleaned speleothems are now mud-colored and the route still is a gutted husk, even more cluttered with air locks and stainless steel railings than before 1985. Further, there is no documentation that any biota of the tour route is "renewed."
9. The cave is "lighted with an improved trail."	In April 2005 three short sections of the tour route were in total darkness so that our party had to grope our way along the wall. One of these dramatic sections included two rock steps.
10. "Cave temperatures are around 40° F yearround."	In April 2005, the entrance passage was below freezing with icicles which were dry to the touch. I observed the same thing in 1959, 1960, and 1961.
11. "Surface trails are not maintained during snow conditions" but it is implied that it is safe to visit the cave at such times.	In April 2005, compact snow and ice on the exit trails created very dangerous conditions.
12. The leaflet notes that "several passages are narrow with low ceilings" but adds: "do not touch or lean on the cave walls or formations."	Even where well-lighted (see above), in narrow passages with low ceilings touching the walls, ceiling, and formations is unavoidable.
13. "Airlocks have restored natural cave winds by blocking air flow in artificial tunnels."	During this symposium, John Roth acknowledged to me that the airlocks had been unsuccessful in doing this.
14. "Oregon Cave...is rich in diversity". " … one of the world's most diverse realms … ," "The surface world of Oregon Caves mirrors the diversity found underground." and so on.	This is mere puffery. There is no valid reason to speculate that that the environment of Oregon Cave is any more diverse than that of numerous other caves at various elevations in the Klamath Mountains (Halliday and Collier, 2005).
15. The "Official Map and Guide" repeatedly refers to "cave ghosts."	This is not a recognized term in geology nor cave mineralogy (for example, Jackson, editor 1997; Hill and Forti 1997).

16. Moonmilk "is created by the same type of bacteria used to make today's antibiotics."	The April 2005 tour guide translated this as "Moonmilk is as good as an antibiotic ointment." which also is untrue. Most of today's antibiotics are synthetic, and bacteria used to create others are from strains which are selected and purified with extreme care, not those which make moonmilk in caves.
17. The supposed "pallid bat" depicted in the leaflet actually is a free-tailed bat, presumably *Tadarida mexicana*. Also, "healthy numbers" of pallid bats are said to be present in the cave now.	Note: It is doubtful that any pallid bat ever has been found in Oregon Cave.
18. The leaflet implies that its four photos of cave minerals were photographed in Oregon Cave.	Probably none of these photos were taken in Oregon Cave. The photo of cave pearls probably was taken in Carlsbad Caverns.
19. "A myriad of calcite formations decorate the cave."	Most of the tour route lacks speleothems.
20. "Note the keyhole-like shape of the cave formed by the roundish chamber and the notch caused by the downcutting of the stream."	This sentence is largely imagination. In only a little of the cave is its cross-section keyhole-shaped.
21. The paragraph and block diagrams on subduction are confused beyond recognition.	When I presented the block diagrams to the 2005 NSS Convention session on cave geology and geography, no one in the audience could comprehend the meanings of the diagrams. My tour guide in April 2005 gave a concise, clear explanation of subduction without referring to the leaflet.
22. The spotted owl is said to be the chief predator of flying squirrels.	Spotted owls don't even occur in some 99% of the ranges of flying squirrels in the USA .
23. Oregon Cave is "nestled within an unusually diverse array of rock types."	Oregon Cave is nestled entirely within marble. And non-carbonate rocks outside its marble block are similar to those in many other speleoliferous sections of the Klamath Mountains and Sierra Nevada (Halliday and Collier 2005).

24. "Violent geological events spanning millions of years have created (Oregon Cave)."	No violent geological events were involved in the creation of Oregon Cave — only ordinary dissolution of marble. As for "millions of years," this is spin. Steve Turgeon's studies (for example Turgeon and Lundberg, 2001) show no evidence of speleothem deposition much before 500,000 years before present. The date of conversion from a closed to an open system is uncertain and probably different in different parts of the cave. Inception of Oregon Cave passages obviously began earlier than speleothem deposition, but at present, it is unjustified speculation to assign a specific date to its dissolution processes, much less a sensational date of "millions of years."

Table 2. Some additional misstatements by my tour guide, April 2005

1. Cave popcorn (coralloids) is/are known as "compass rock."	
2. Cave popcorn (coralloids) always point(s) toward a cave's entrance.	
3. "Moonmilk is as good as an antibiotic ointment."	
4. "Calcite is white because it contains air bubbles.	Evidently he has never seen Iceland spar.
5. Caves in marble are very special.	He didn't say why they are special, or where. They are ubiquitous in the Klamath Mountains and Sierra Nevada.
6. "Grizzly bear bones more than 50,000 years old have been found in the cave."	Grizzly bears probably had not yet differentiated from *Ursus arctos* 50,000 years ago.

7. Virtually all destruction of cave features occurred before National Park Service management of Oregon Cave.	During this symposium, John Roth defended this statement to me, face-to-face. He insisted that the Monument files contain photo documentation of this. Jay Swofford is equally insistent that Friends of Oregon Caves files contain photo documentation of extensive destruction of cave features during the 70 years of National Park Service management. See Halliday and Swofford, 2003.
8. The guide used the term "stalagtite" repeatedly.	
9. The guide misled the tour group about the old trail in the cave. He pointed out its narrowness in the Wigwam without mentioning that its historic iron railing had been removed recently.	This historic iron railing evidently was removed without compliance with Federal law on historic features. Also, its removal renders unsafe any use of the old trail during emergencies or for other reasons (for example photo documentation).

References

Anon. n.d. (1958). Oregon Caves National Monument Provisional Manual of Information, 5th Edition. Oregon Caves National Monument, 27 pages.

Anon. 1959. Oregon Caves National Monument Provisional Manual of Information, 6th Edition. Oregon Caves National Monument, 33 pages.

Anon. 1960. Oregon Caves National Monument Provisional Manual of Information, 7th Edition. Oregon Caves National Monument, 33 pages.

Evans, Gregory T., reviser. 1975. Oregon Caves National Monument: a manual for cave guides, by David G. Lescalleet, Park Technician. Oregon Caves National Monument, 64 p. (includes complete reprint of Halliday, 1963).

Finch, Breynton A. 1934. A report on Oregon Caves, September 7, 1934. Typescript report to Washington office of National Park Service, in files of Friends of Oregon Caves.

Halliday, William R. 1963. Basic speleological considerations of Oregon Cave. Western Speleological Survey Bulletin 11 (W.S.S. Serial # 31).

Halliday, William R. 1965. Cave of the Crystal Balls. National Parks Magazine, January 1965, p 13.

Halliday, William R. 1966–67. Oregon Cave: an introduction. Western Cave Quarterly, vol 1, no. 3, pp 2–16.

Halliday, William R. 1969. Oregon Cave, Klamath Mountains, Oregon. National Speleological Society Bulletin vol 31, no. 2, pp 23–31.

Halliday, William R. 1977. Oregon Cave: a hundred years of discovery. Pacific Search, vol 12, no. 2, pp 6–7.

Halliday, William R. and Rich Collier. 2005. Marble caves of the Klamath Mountains, Oregon and California: a photographic overview. Abstract of poster presentation in Program, 17th National Cave and Karst Management Symposium, Albany, New York, October 31–November 4, 2005, p 26. Full text in this volume.

Halliday, William R. and Jay Swofford. 2003. Management controversies at Oregon Caves National Monument. Proceedings, 16th National Cave and Karst Management Symposium, Gainesville, Fla, pp 24–32.

Halliday, William R. and Jay Swofford. 2004. Oregon Cave should be returned to U.S. Forest Service administration. NSS News, vol 62 no. 6, June, pp 172–174.

Hill, Carol and Paolo Forti. 1997. Cave Minerals

of the World, 2nd Edition. Huntsville, Ala, National Speleological Society.

Jackson, Julia A., editor. 1997. Glossary of Geology, 4th Edition. Alexandria, Va., American Geological Institute.

National Park Service. 2000, reprinted 2002. Oregon Caves National Monument, Oregon, Official Map and Guide. Fold-out two-sided leaflet. (Washington, D.C.) National Park Service, U.S. Department of the Interior.

Presidential/Congressional Commission on Risk Assessment and Risk Management. 1997. Final Report, Volume 1: Framework for environmental health risk management. Volume 2: Risk assessment and risk management in regulatory decision-making. Washington, D. C., GPO. Also available on WWW. RiskWorld Web site.

Reynolds, Christopher. 2004. The dark days of Oregon Cave. Los Angeles Times Outdoors Section, 26 October, 2004.

Unrau, Harlan D. and G. Frank Willss. 1983. Administrative history: expansion of the National Park Service in the 1930s. Administrative report, National Park Service, Washington, D.C. In files of Friends of Oregon Caves. Also on line in ParkNet, http://www.cr.nps.gov/history/online_books/Unrau-Willss/adhi.htm

Turgeon, Steven and Joyce Lundberg. 2001. Chronology of discontinuities and petrology of speleothems as paleoclimatic indicators of the Klamath Mounains, southwest Oregon, USA. Carbonates and Evaporites, vol 16 no. 2, pp 253–167.

Walsh, Frank K. and William R. Halliday, 1971. Oregon Caves: Discovery and Exploration. Grants Pass (Ore), Te-cum-Tom Publishers.

Walsh, Frank K. and William R. Halliday. 1974. Discovery of the Oregon Caves. Pacific Wilderness Journal, vol. 2 no. 2, April-May 1974, pp 16–17.

Walsh, Frank K. and William R. Halliday. 1976. Discovery and exploration of the Oregon Caves. Coos Bay, (Ore), Te-cum-Tom Publishers.

Wykert, Paul V. 1959. National Park System Preliminary Study Report: Crystal Ball Cave. one page typescript in files of National Park Service, Washhington, D.C. and Utah Speleological Survey.