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A GIS-based inventory of terrestrial caves in West Central Florida: Implications on sensitivity, disturbance, ownership and management priority

Grant L. Harley
University of South Florida

A GIS-Based Inventory of Terrestrial Caves in West-central Florida: Implications on Sensitivity, Disturbance, Ownership, and Management Priority

by

Grant L. Harley

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of the requirements for the degree of
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University of South Florida

Major Professor: Philip Reeder, Ph.D.
Philip van Beynen, Ph.D.
Robert Brinkmann, Ph.D.

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Dedication

To my parents for instilling in me a strong work ethic and commitment to follow my passion; my wife, Mandi, for her unconditional love and support; and fellow cavers for accepting me and offering their time and energy to help conserve and protect the underground...you know who you are. Without all of your help, this project was not possible.

Acknowledgements

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A big thank you especially to fellow cavers Tom Turner and Robert Brooks for trusting me underground and helping inventory each cave included in this project. Without your time and energy, this research would be an amalgam of blank paper. Your experience and wisdom underground are invaluable and I am grateful for both of your help.

I must also thank my *partner in crime, business, and the underground* Jason Polk, who took the time out of your own dissertation to help in the field. I think you need to switch your dissertation from paleoclimate research to cave conservation. Even though I know you would enjoy it, your advisor would lose his mind...so maybe it’s not such a good idea.

Many people have had a positive influence upon my life along this journey down into thirty-six caves in west-central Florida, and beyond. First and foremost I want to extend my heart-felt appreciation to my wife, Mandi. Without your unconditional love and support, these past two years of work would have been much harder. You've been my inspiration.

I need to thank my entire family, especially my parents, who have always been there for me. To my mother and father (Lynda and George), thanks for raising me in a loving home and teaching me to do everything in life to my best ability. Thank you to my sister, Lindsay, for always being there for me.

There are many other people I wish to thank, and for those of you who have been a part of this project, or my life, if even for only a moment, thanks for always believing in me. There will be many other days and many other caves to explore, conserve, and protect, so this project is only the beginning. I want to thank the Lord for giving me this opportunity.

Note to Reader

Note to Reader: The original manuscript of this document contains color that is necessary for understanding the data. The original thesis is on file with the USF library in Tampa, Florida, USA.

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Abstract

Active cave management, which represents any continuous action to conserve, restore, or protect a cave environment, is virtually non-existent in west-central Florida. This study focuses on developing an inventory to rank terrestrial caves in west-central Florida by management priority. A GIS-based cave inventory system, including a cave sensitivity index and cave disturbance index, were used as a tool to gain an understanding of the management priority of west-central Florida caves.

The inventory was applied to 36 terrestrial caves in west-central Florida, which demonstrated a wide range of sensitivity and disturbance. The results show that by relying solely on sensitivity and disturbance scores, management priority may not be accurately determined. Further examination revealed that ownership and management status also affect management priority.

Consequently, cave sensitivity, disturbance, ownership, or management status does not solely indicate management priority. Rather, the management priority of caves in west-central Florida depends on a number of complicated,

interwoven factors, and the goal of management must be examined holistically. Each cave must be individually examined for its sensitivity, disturbance, resources, management, and social and physical context in order to gain an understanding of management priority. Nonetheless, the cave inventory system developed for this project was used to gain a general understanding of which caves hold management priority, based on the cave manager's objectives. In order to ensure the conservation and protection of west-central Florida terrestrial caves, support from county or state government, combined with cave inventory data, is crucial in developing sound management policy.

Chapter One: Introduction

The exploration and study of caves increased steadily in popularity over the last 50 years. This newfound interest is shown by substantial growth in certain cave-oriented organizations such as the National Speleological Society and affiliated grottos across the United States. Increasing the number of active cavers places pressure on well-known caves, with the destruction of inherent sensitive resources an almost unavoidable outcome (DuChene 2006). Only recently are people acknowledging that cave conservation and protection are essential, otherwise these invaluable resources will be lost to future generations.

> "Most natural processes operate very slowly in caves. Once damaged, a cave may never recover, and scars and litter left by careless visitors will remain indefinitely. Broken cave formations look pathetically out of place when taken outside. Even the bare bedrock is a part of a cave's attraction, and it looks shabby if marked. When you visit a cave, try to cause as little disturbance as possible. Consider even your slightest impact on the cave, then multiply it by the number of people who are likely to pass through during the cave's lifespan, and the cumulative effect will be clear. Protecting, preserving, and restoring caves, as well as maintaining access to them, are essential parts of cave stewardship" (Palmer 2007, pg. 19)

The quotation is an excerpt from Art Palmer's 2007 book *Cave Geology* and describes the motivation for this study.

Some attempts have been made to formalize the protection of caves. The enactment of the Federal Cave Resource Protection Act of 1988 (FCRPA) gave caves located on Federal land the opportunity to be protected by a number of government agencies including the Bureau of Land Management (BLM), National Park Service (NPS), U.S. Fish and Wildlife Service, U.S.D.A. Forest Service, and the US Geological Survey (USGS). Caves located on other lands, public or private, are not protected by the FCRPA, which in many cases results in their demise. To manage these caves efficiently, their disturbance, sensitivity, and resources must be evaluated through means of a cave inventory. In many states, researchers and cavers have taken the initiative to conserve and protect cave systems. However, in many localized regions of certain states, such as west-central Florida, conservation ethics are deficient (Figure 1). Currently, there are no laws, regulations, or policies that require sound management of cave systems.

To complicate the lack of protection efforts at the state, or county level, each terrestrial cave in west-central Florida is unique, with varying levels sensitivity to humans and disturbance. For example, during this study, Sick Bat Cave, Citrus County, Florida was inventoried in an attempt to catalogue detailed descriptions of inherent resources, determine the cave's relative sensitivity to human degradation, and establish the cave's current level of disturbance. Sick Bat is located on public, state-owned land and remains unmanaged and easily accessible. No cave-reliant biota, connections to the Floridan Aquifer System (FAS), or pristine speleothems were found during inventory. While the sensitivity of the cave was quite low, its disturbance was found to be high, with occurrences of trash, widespread destruction of speleothems, contemporary graffiti, and human-induced surface impacts.

In contrast, Crumbling Rock Cave, Citrus County, Florida is located on private land and is actively managed by a conservation-minded landowner. The cave is not open to the public and a gate allows for controlled access. The cave contained a Florida endangered species, geological formations, and an aquifer connection that are sensitive to human degradation. The sensitivity of the cave resources was found to be high and overall disturbance of the cave was low.

Cave resources, sensitivity, disturbance, and management are terms used throughout this manuscript. Given the multiple uses of each word, they are often in need of clarification. The term “cave resource” includes any materials or substances occurring naturally within a cave including biotic, cultural, mineralogic, geologic, paleontologic, and hydrologic resources (FCRPA 1988). The phrase “cave sensitivity” is used frequently to describe the vulnerability of cave resources to human degradation. Theoretically, a cave can be sensitive to many things in the natural environment; however, this study is only concerned with determining how sensitive a cave is to anthropogenic disturbances, both surface and subsurface. “Cave disturbance” is a phrase used to describe the destruction of a cave and its inherent resources as a result of surface and subsurface anthropogenic factors.

There are many degrees of cave management, hence the need to clarify the term within the context of this thesis. “Cave management” represents any continuous action that conserves, preserves, restores, or protects the well-being of a cave environment. Caves that are not actively managed are considered unmanaged. Active cave management practices are necessary to conserve and protect the inherent resources of a cave system. Henceforth, the “management priority” of a group of caves represents which caves should be considered foremost when drafting management plans that focus on conservation and protection of these natural resources.

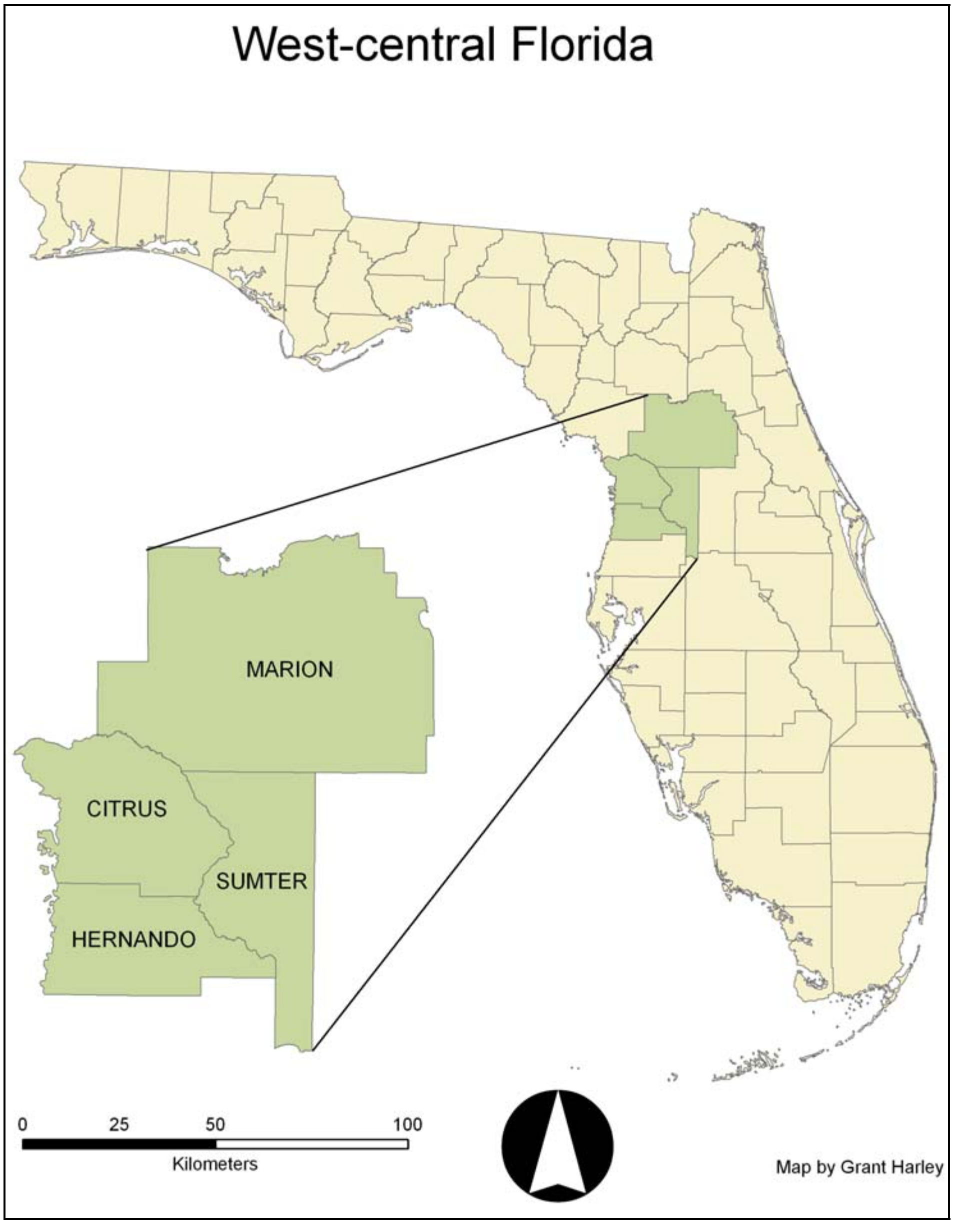

Figure 1. West-central Florida.

Human-Environmental Interaction

The human interest in the exploration and utilization of caves dates back many centuries (Gillieson 1996). Many people have benefited from the shelter, storage capacity, and spiritual haven they provide. No matter the use, humans have always been fascinated with the exploration of cave systems. The karst landscape of Florida is one of the most significant and extensive karst terrains found throughout the world (Thornbury 1960; Lane 1986). Because Florida is one of the most populated states in the United States, a growing population and persistent urban sprawl are only a few of the possible threats humans pose to the sensitive karst environment. Not only do certain human actions threaten the condition of surficial karst features in Florida such as sinkholes, springs, and disappearing streams, they also pose a danger to subsurface features like caves. Cavernous systems are dynamic natural resources that are affected by surface and subterranean environmental changes. Florida lies in a particularly fragile position because of its exponential increase in population. The lack of information regarding cave contents and the environmental sensitivity of caves to anthropogenic disturbances directly prohibits the management of cave systems in Florida.

Research Strategy

Problem Statement

Unfortunately, active cave management in west-central Florida is virtually nonexistent. A disconnect exists between researchers, landowners, and the caving community regarding the knowledge of cave contents, sensitivity, and disturbance. This project provides insight on cave contents, sensitivity, disturbance, and presents a tool for determining cave management priority in west-central Florida.

Furthermore, data were compiled and analyzed in order to evaluate the association between cave ownership, sensitivity, disturbance, and management.

Research Purpose

This project was initiated through a collaborative effort between the Withlacoochee State Forest (WSF) and the Department of Geography at the University of South Florida. The overall purpose of this study was to create a GIS-based inventory with the ability to determine the management priority of caves. Terrestrial caves were visited in order to assemble a detailed record of resources and determine the approximate sensitivity and disturbance of each cave through means of a GIS-based inventory. Given the widespread lack of cave management in west-central Florida, the intention of the inventory is to serve as a guide for determining which caves hold management priority.

Research Questions

The research questions involved in this study included:

1. Can current cave inventory methods be adapted to make data collection more efficient?
2. Can cave sensitivity and disturbance be used to determine management priority?
3. How do ownership and current management status affect the overall management priority of a cave?

Research Objectives

To address these questions, several objectives were needed:

1. Analyze, develop, and refine current cave inventory data collection methods;
2. Formulate indices to measure cave sensitivity and disturbance;
3. Discuss the implications cave sensitivity and disturbance have on management priority ; and
4. Discuss the association between cave sensitivity, disturbance, management, and ownership.

The intended objective of this thesis was to develop an inventory to rank terrestrial caves in west-central Florida by management immediacy, based on relative sensitivity and disturbance. The measures developed in this research, which include the GIS-based cave inventory, cave sensitivity index, and cave disturbance index, are intended to be used as a tool to gain an understanding of the management priority of west-central Florida caves. The geodatabase containing the inventory data collected during this study serves as a link between researchers, land owners, and the members of the west-central Florida caving community.

Background Information

Just as Gillieson (1996) and White (1988) attest, the definition of “cave” is inherently dependent on the definer. Caves naturally form in a myriad of host rocks, depending on composition, and are classified by their size and shape of passages, length, and general layout of openings. Those which are classified as solution caves form from the chemical solution of carbonate rock such as limestone or dolomite (White 1988; Gillieson 1996).

However, Palmer (2002) explains that speleogenesis requires one necessity: the groundwater must dissolve the carbonate bedrock quick enough to form caves before the rock is eliminated by surface erosion. Caves also form from the dissolution of evaporate rock such as gypsum and halite. Additionally, caves may form from the silicate solution of sandstone and basalt. All of the previous methods of cave formation are considered to be a part of the evolution of karst terrains (Gillieson 1996). Limestone caves form along groundwater paths that are characterized by high discharge and turbidity. Solution caves found in Florida are formed when there is sufficient subsurface water flow to dissolve bedrock and keep allogenic water in contact with the soluble cave walls, fissures, or cracks (Palmer 1991).

Conceptually, a cave is only considered a cave if it is large enough to allow the human body to enter (White 1988). Perhaps it depends on the size and shape of the explorer that ultimately defines a cave. More scientifically, a cave is “a natural cavity in a rock which acts as a conduit for water flow between input points, such as streamsinks, and output points, such as springs or seeps" (White 1984, quoted in White 1988). Rather, a more non-scientific definition clarifies caves as "a natural cavity in a rock which is enterable by people" (Gillieson 1996).

Although the definition of cave differs in the literature, many states in the United States have their own parameters which are used to define a cavern. According to the Florida Cave Survey, a cave is defined as a natural cavity which equals are exceeds one of the following dimensions: horizontal length of 30 feet, total vertical extent of 30 feet, or vertical drop (pit) of 30 feet. This study uses the Florida Cave Survey definition of "cave" (Florida Cave Survey Constitution 2005).

The term "terrestrial cave" represents any cave that has air-filled passage. It also includes caves with direct connections to the FAS. Terrestrial caves should not be confused with "aquatic caves", which include caves without air-filled passage. Aquatic caves are commonly found in Florida at spring discharge locations. Only terrestrial caves are included in this study.

Karst Landscape

Terrestrial caves are one of the many features found in the karstified Florida landscape. The word "karst" has its roots as an orographic, proper name (for more on the etymology of *karst* see Jakucs, 1977). It was not until years after the first usage of the term that it morphed into a general term of physical geography.

The concept of karst terrains was made prevalent by E. Dudich in 1932:

> "Karst is a geographic concept subsequently altered into a geomorphologic technical term. Today, those regions are called karst that exhibit the same features as the Karst in the geographic sense. These features tend to manifest themselves on rocks that are comparatively readily soluble, with little or no residue. These rocks include rock salt, gypsum and limestone. The first two rarely appear in substantial masses on the surface, but limestone abounds. Hence, all the true karsts of some magnitude are in limestone regions" (Dudich 1932 quoted in Jakucs 1977, pg. 32).

Although there is an abundance of limestone underlying Earth's surface, approximately 10-20%, karstified areas are more atypical (Thornbury 1960). According to Thornbury (1960), the following are considered significant karstic areas around the world: the Causse region of southern France, Spanish Andalusia, Greece, northern Yucatan, Jamaica, northern Puerto Rico, western Cuba, the coastal plain fringing the Great Australian Bight, central Florida, the Great Valley of Virginia and Tennessee, southern Indiana, west-central Kentucky, and north-central Tennessee.

A karst landscape is created by the chemical dissolution of limestone. As a result, certain landforms become apparent in karst environments. Closed depressions, disrupted surface drainage, caves, and underground drainage systems or conduits are all examples of landforms abundant in a karst landscape (White 1988).

The degree of karst landform development depends on a number of factors, which influence the dissolution of limestone, such as precipitation (Trudgill 1985), permeability and porosity of the limestone (White 1988), amount of calcium carbonate contained in the limestone (Trudgill 1985), and turbidity of groundwater flow in the limestone (Lane 1986).

Karst Geomorphology

Limestone is a rock containing carbonate (CO_3) as part of its chemical make-up. Limestone is also classified as a sedimentary rock composed mostly of calcite ($CaCO_3$). Limestone is either formed through the actions of organisms or as a result of inorganic processes. The vast majority of limestones are biochemical limestones formed of pieces of algae, coral, and shell fragments (McGeary et al. 2004).

The geomorphology of limestone is characterized by dissolution and erosion processes through joints and fissures in bedrock (Trudgill 1995). Limestone is dissolved when a certain acid interacts with calcite. This acid is called carbonic acid (H_2CO_3). Carbonic acid is produced when water mixes with carbon dioxide ($H_20 + C0_2 \rightarrow H_2CO_3$). Even though carbon dioxide is found in the atmosphere (0.03 percent), most of the carbon dioxide responsible for combining with water to dissolve limestone is found within the soil and is produced by the decay of soil humus (Moore and Nicholas 1964).

Limestone is the most abundant sedimentary rock and it is not uncommon for limestone to contain 99% calcium carbonate, which is the reason for its high susceptibility to dissolution (Trudgill 1985).

A major control on the dissolution rate of limestone is precipitation (Trudgill 1985). Precipitation has a direct correlation to the moisture content in soils. Combined with slope, the moisture content of the soil influences run-off rates, which controls the amount of water interacting with the rock. Soil acts as a domicile for carbon dioxide and percolating rainwater discharge (Jakucs 1977; Trudgill 1985). In order to understand the physical context of this study, the general geomorphologic characteristics of Florida must be identified.

Karst Geomorphology of Florida

Literature regarding the geomorphology of Florida is limited and of rather broad nature. One of the only complete works concerning Florida's geomorphology was penned by William White in 1970. Even though his work titled *The Geomorphology of the Florida Peninsular* was a complete representation of the entire physiographic regions of Florida, the manuscript lacked detailed regionalism.

According to White (1970), Florida can be categorized into three separate physiographic regions: the Distal zone, the central zone, and the proximal zone. The southern or distal zone is characterized by lowlands. This zone is unique because it is the only place in the United States where the Atlantic-Gulf of Mexico coastal land extends all the way to the outer edge of the Continental Shelf. The central zone is distinguished by parallel ridges in line with the coastline of Florida). The northern or proximal zone of the Florida peninsula is characterized by dry highlands and hills as a result of declining sea level. Generally, the highlands of the proximal zone are above the piezometric surface (White 1970). Each terrestrial cave included in this study is located on one of the following physiographic regions defined by White (1970): Brooksville Ridge, Cotton Plant Ridge, Sumter Uplands, or Ocala Hills.

Chapter Two: Physical and Social Context

Defining the Study Area: West-Central Florida

This study was conducted in west-central Florida, which includes Marion, Citrus, Sumter, and Hernando counties (Figure 1). West-central Florida is a karst landscape conducive for researching cave sensitivity and disturbance for several reasons. First, the study area contains hundreds of terrestrial caves spatially dispersed throughout the landscape. This study includes caves located on both public and private lands. Every cave with public ownership is located in the Withlacoochee State Forest, which is state-owned land. Each private cave is located on a privately-owned parcel of land. Second, access to many of these caves is possible due to the convenient location of the study area to three of Florida’s caving organizations, or grottos: Tampa Bay Area Grotto, Central Florida Cavers Grotto, and Florida Speleological Society (Figure 2). These grottos are affiliated with the National Speleological Society (NSS). Members of these three grottos were helpful in suggesting and locating caves used in this study. Finally, the caves of west-central Florida vary in extent, contents, sensitivity, and disturbance, making the study area a prime location for conducting the cave inventory and determining cave management immediacy.

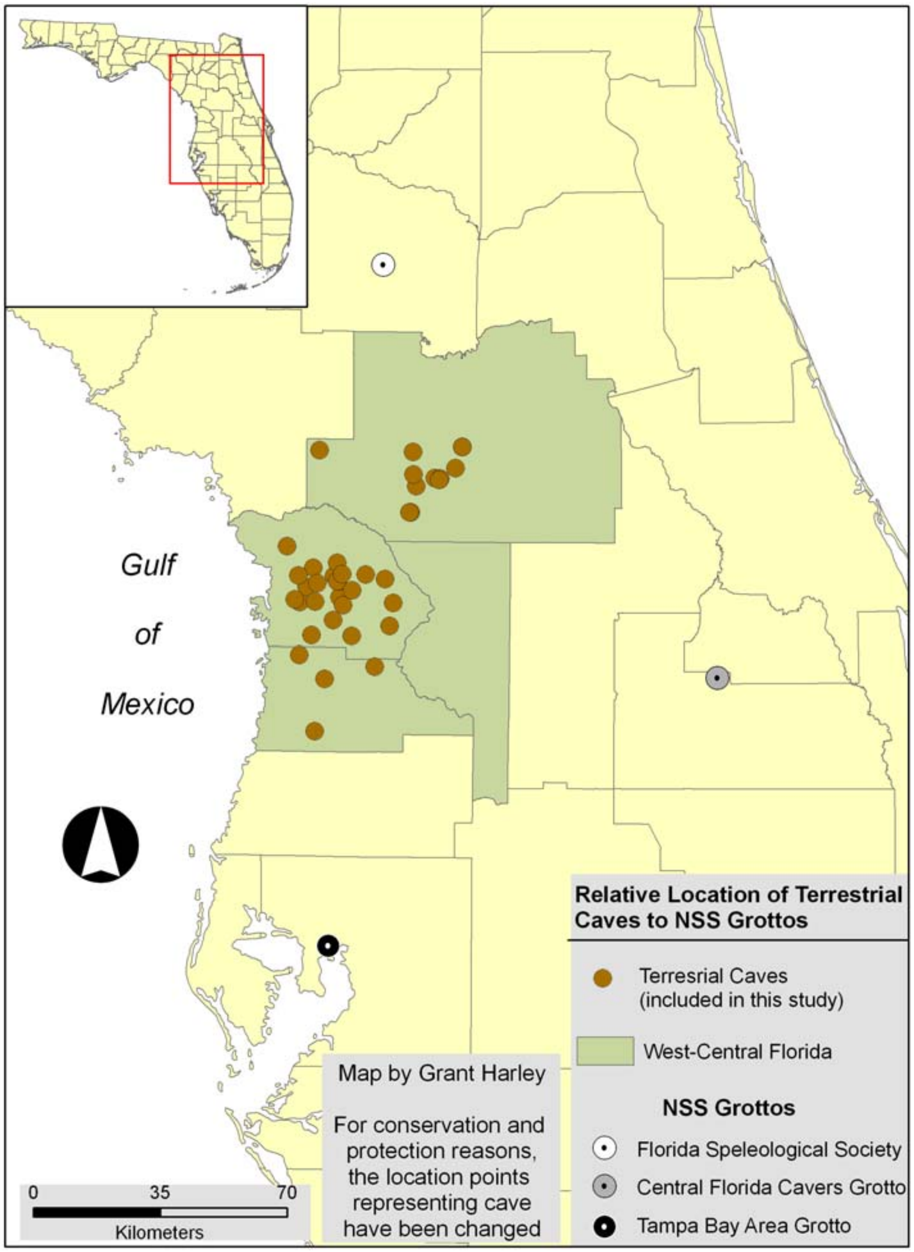

Figure 2. Relative location of terrestrial caves (included in this study) to grottos affiliated with the National Speleological Society (NSS).

West-central Florida Caves and Geologic Framework

In Florida, most caves are currently underwater and located in the coastal lowlands where the water table is located close to the surface (Florea 2006). Thick, Quaternary sediments overlie karst features in lowland areas of the state, which suppresses their surface expression (Tihansky 1999). Conversely, in upland areas, such as the Brooksville Ridge and Ocala Uplift, terrestrial caves are known to exist because the location of the water table is far below the surface. Terrestrial caves in west-central Florida have been known for decades. For instance, Maynard's Cave in Lecanto, Citrus County (Darling 1961; 1962) and the Dames Cave complex, Citrus County (Brinkmann and Reeder 1993, 1994; Brinkmann 2003) have established records of visitation since the early 1900s. Other than these studies, little scientific documentation exists regarding air-filled caves in west-central Florida.

Florea (2006) presents the most comprehensive account of cave geomorphology in west-central Florida. Cave passages in west-central Florida are dominantly tabular and laterally extensive (Florea 2006). Passage directionality is controlled by a system of NE-SW and SW-NE fractures throughout the host rock. The cave passages end in tabular and fissure-type structure that are too tight for a human body to fit (Florea 2006). Cave passages do not act as discrete conduits in the aquifer, nor do they connect together into a dendritic-style drainage system (Florea 2006).

Underlying most of Florida is the FAS, composed of Tertiary carbonates and estimated to contain over 19,000 km3 of water (Miller 1986). Even though more than 90% of 17-million Florida residents rely on the FAS for drinking, industry, and irrigation waters (Scott et al. 2004), little is known about the connectivity of cave systems that comprise west-central Florida's karst (Florea

2006). The known cave systems included in this study all developed within one of the following rocks: Avon Park Formation, Ocala Limestone, Suwannee Limestone, and Tampa Member (formerly Tampa Limestone) (Florida Geological Survey 2006)

The Avon Park Formation, a cream to light-brown or tan, Middle Eocene, fossiliferous, marine limestone, ranges from 15-91 meters thick (Stewart 1968) (Figure 3). In a few areas of west-central Florida, molds of evaporites may be present in the dolostone, which is interbedded in the formation (Bishop and Lane 1987) The Avon Park Formation occurs throughout Florida and comprises the oldest rock outcroppings in Florida. These sediments are locally exposed in sinks and quarries near the crest of the Ocala Platform in Citrus and Levy Counties (Lane 1986; Bishop and Lane 1987). Some of the fossils embedded in the Avon Park Formation include forams, mollusks, echinoids, algae, and carbonized plant remains (Bishop and Lane 1987).

The Ocala Limestone overlies the Avon Park Formation, is approximately 122 meters thick, and is composed of white to cream, Upper Eocene, marine limestones and occasional dolostones (Stewart 1986; Bishop and Lane 1987) (Figure 3). The texture of the limestone is usually soft and porous, but some parts have been converted into a hard, dense rock due to the cementation of particles by the deposition of calcite. Ocala Limestone is composed of almost pure calcium carbonate, which facilitates its solution in the landscape. Ocala Limestone underlies most of Florida, but is exposed at the surface in only a small portion of the state. In many quarries in Hernando and Citrus Counties, the rock is mined for its use as cement. Some of the fossils that are found in the Ocala Limestone include forams, echinoids, bryozoans, mollusks, and rare vertebrates (Bishop and Lane 1987).

Overlying the Ocala Limestone is the Suwannee Limestone, a white to cream, fossiliferous, Lower Oligocene marine limestone. Its thickness ranges from 15-30 meters (Stewart 1968) and contains nearly 10% silica impurity (Cooke 1945) (Figure 3). Irregular chert lenses are commonly seen at contacts between the Ocala Limestone and the overlying Suwannee Limestone (Florea 2006). Mollusks, foraminifers, corals, and echinoids include many fossils that are imbedded in the limestone.

Overlying the Suwannee Limestone in the study area is the Tampa Member of the Arcadia Formation (Figure 3). It ranges from 15-30 meters thick and is a yellow-colored, fossiliferous, Upper Oligocene to Lower Miocene, marine limestone containing variable amounts of dolostone, sand, clay, and phosphate (Stewart 1986; Bishop and Lane 1987). Generally, the Tampa Member is a hard, massive crystalline rock. Some fossils found in the rock include forams, mollusks, and algae. The Tampa Member is also well-known for containing Florida’s State Stone, the silicified fossil agatized coral (Bishop and Lane 1987). Some outcrops occur to the south of the study area near Tampa, Hillsborough County; however most of the Tampa is overlain by the Miocene Hawthorn Group and undifferentiated sand and clay deposits (Tihansky and Knochenmus 2001).

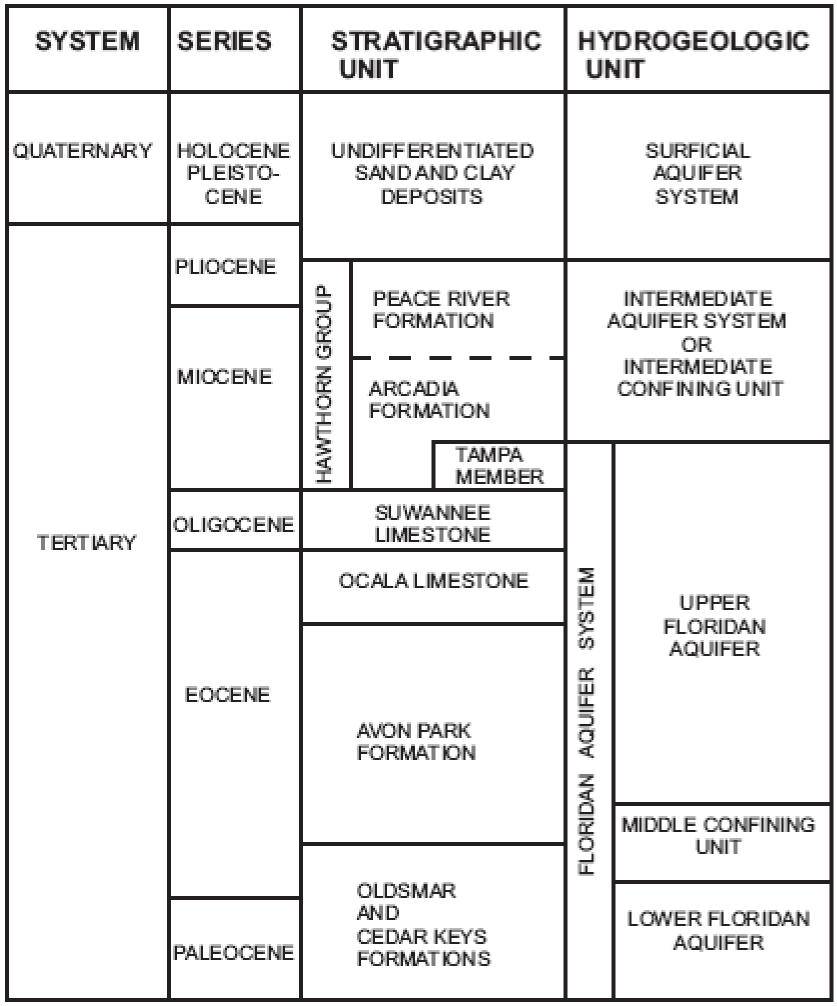

Figure 3.Tertiary and Quaternary geologic formations in Florida (taken from Tikansky and Knochenmous 2001).

Physical Geography of the Study Area

Marion, Sumter, Citrus, and Hernando counties comprise the geographical area of west-central Florida. These four counties have a combined area of approximately 8,269 km^2 and total population of nearly 689,000 (U.S. Census Bureau 2006). The highest natural point in the study area occurs in Citrus County at 94 meters above sea level (m.a.s.l.) and the lowest point is 0 m.a.s.l. at the Gulf of Mexico. Annual climate in west-central Florida is characterized by a summer wet season and a winter dry season. Average annual rainfall in the area is 137 centimeters with the majority falling from June to September. The average summer temperature in the area is 35 °C, while the average winter temperature is 14 °C (FloridaSmart 2005). Terrestrial caves are found within four physiographic divisions in the west-central Florida area: Brooksville Ridge, Cotton Plant Ridge (CPR), Ocala Hills, and Sumter Upland (White 1970). A map of terrestrial cave locations included in this study as they relate to physiographic division is seen in Figure 4.

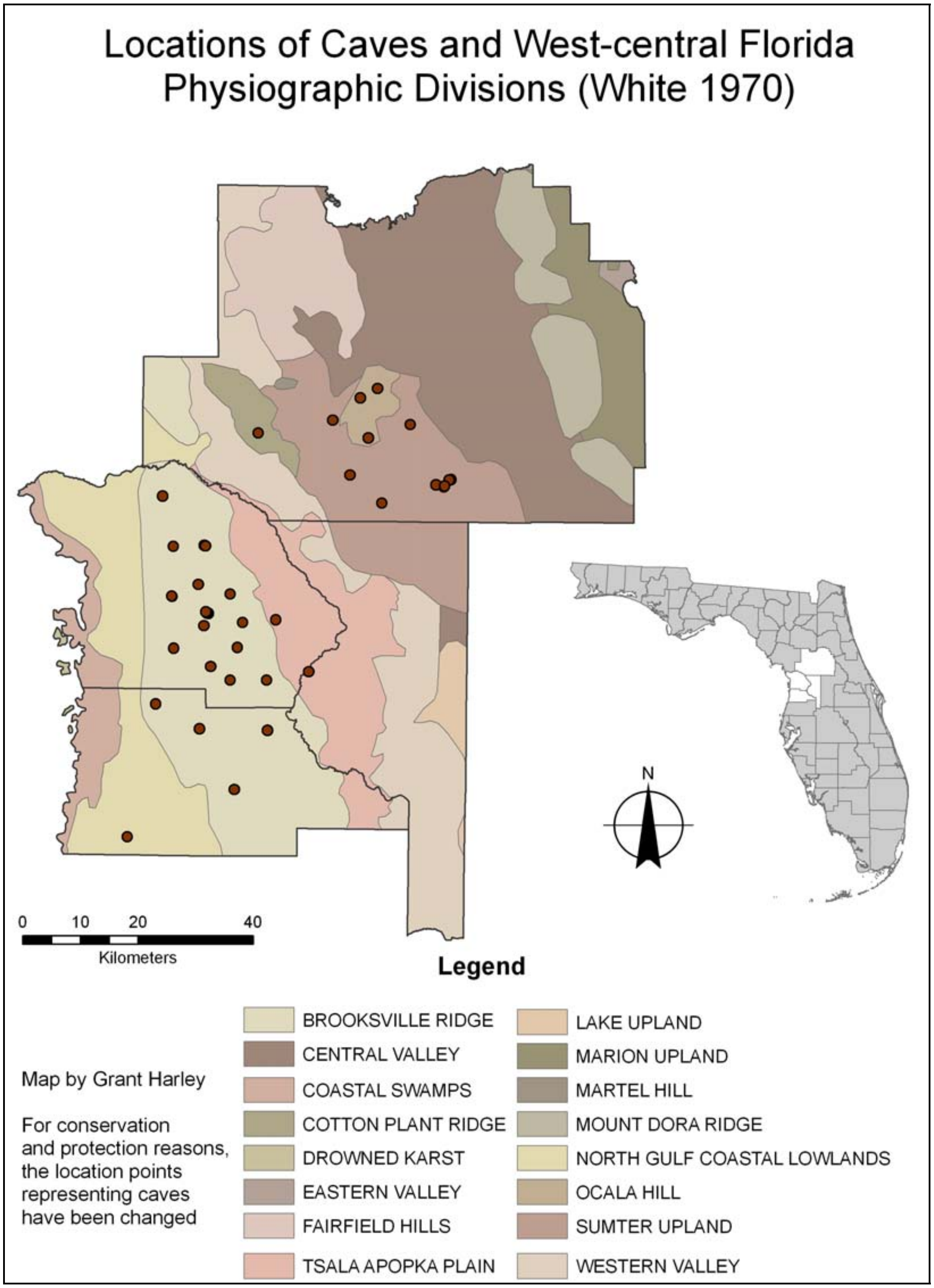

Figure 4. Locations of caves included in this study and west-central Florida physiographic divisions as defined by White (1970).

The Brooksville Ridge

The majority of caves included in this study are located on the Brooksville Ridge, which includes all inventoried caves in Citrus, Sumter, and Hernando Counties (Figure 4). The Brooksville Ridge is the largest of the ridges located in the Central Upland of the Florida Peninsula. Its length is approximately 177 km, but it is the width of the Brooksville Ridge area that makes it the largest of all other ridges in Florida (White 1970). The larger, southern part of the ridge is around 95 km long and 16 to 24 km wide, while the smaller, northern part of the ridge is about 80 km long and 6 to 9 km wide. Elevations vary throughout the length of the Brooksville Ridge from 21 to 60 m above sea level. Higher portions of the ridge are located in the southern end, which are up to 22 m higher than portions in the northern end (White 1970).

It should also be noted that the Brooksville Ridge runs parallel with the other Florida ridges and shoreline. The higher elevations of the Brooksville Ridge are located in a zone which runs along the western side of the southern part of the ridge (White 1970). At the southern end of the Brooksville Ridge lies the lowland dubbed “Western Valley.” Flanking the Brooksville Ridge to the east is the Cotton Plant Ridge. The western edge of the Brooksville Ridge is suggested to be a marine terrace scarp. White (1970) based this hypothesis on the fact that certain parts of the scarp at the western edge of the Brooksville Ridge have been shores at more than one sea level (White 1970).

Figure 5. Gentle, rolling topography near Brooksville, Florida. In the background is an upland mesic-hardwood hammock adjacent to a sinkhole lowland in the foreground.

The topography of the Brooksville Ridge is rolling with internal drainage. Upland mesic-hardwood hammocks separate sinkhole lowlands that are mostly occupied by wetlands or lakes (Florea 2006) (Figure 5). Even though all inventoried caves of Citrus, Sumter, and Hernando Counties are located along the Brooksville Ridge, this does not account for all caves included in this research. Inventoried caves in Marion County are located on either the Cotton Plant Ridge (CPR), Ocala Hills, or Sumter Upland regions.

Cotton Plant Ridge, Ocala Hills, and Sumter Upland

The CPR borders the Brooksville Ridge to the east (Figure 4). It is oriented differently than the Brooksville Ridge in a northwest-southeast direction. Land elevations on the CPR rarely exceed 30 m.a.s.l. Its length and width are somewhat smaller than its neighbor to the west at 25 km long and at the most 8 km wide. According to White (1970), there is little surface drainage on the CPR and it appears that the ridge is composed mostly of wind-blown sand dunes.

The Ocala Hills trend southwest from the city of Ocala for about nine miles. They span about 8 km at their widest part. Elevations along the Ocala Hills reach some 45 to 60 m.a.s.l. (White 1970). The Ocala Hills have a northeast-southwest orientation, differing from other central Florida upland surface features in the area.

Located just east of the Brooksville Ridge and CPR is the Sumter Upland physiographic division. This upland surface feature runs parallel with the Brooksville Ridge and is about 56 km long and 24 km wide (White 1970). Topographically, elevations are a bit higher in the southern end of the upland and slowly decline towards the northern end. According to White (1970), this difference in elevation is due to subsidence resulting from the dissolution of the underlying limestone. Southern end elevations range from 25-30 m and from 25-33 m in the northern end.

Withlacoochee State Forest (WSF)

Of the 33 state-owned forests in Florida, the WSF is presently the third largest and is divided into eight tracts of land (Figures 6 and 7). This vast stretch of land covers approximately 157,500 acres and spans four counties in west-central Florida (Citrus, Pasco, Hernando, and Sumter).

Between 1936 and 1939, under terms of the U.S. Land Resettlement Administration, the Federal government purchased the tracts of land that are included in WSF. Land management of the forest was the responsibility of the U.S. Forest Service until 1958, when a lease-purchase agreement transferred the property to the Florida Board of Forestry. The relative location of the WSF in west-central Florida is depicted in Figure 6. The karst features found within the WSF boundaries include: springs, sinkholes, and terrestrial caves. Each public cave included in this study is located on the Citrus Tract of the WSF, which is located on the border of Citrus and Hernando Counties. The land within the boundaries of the WSF is protected by the state, which makes it an excellent natural laboratory for karst research.

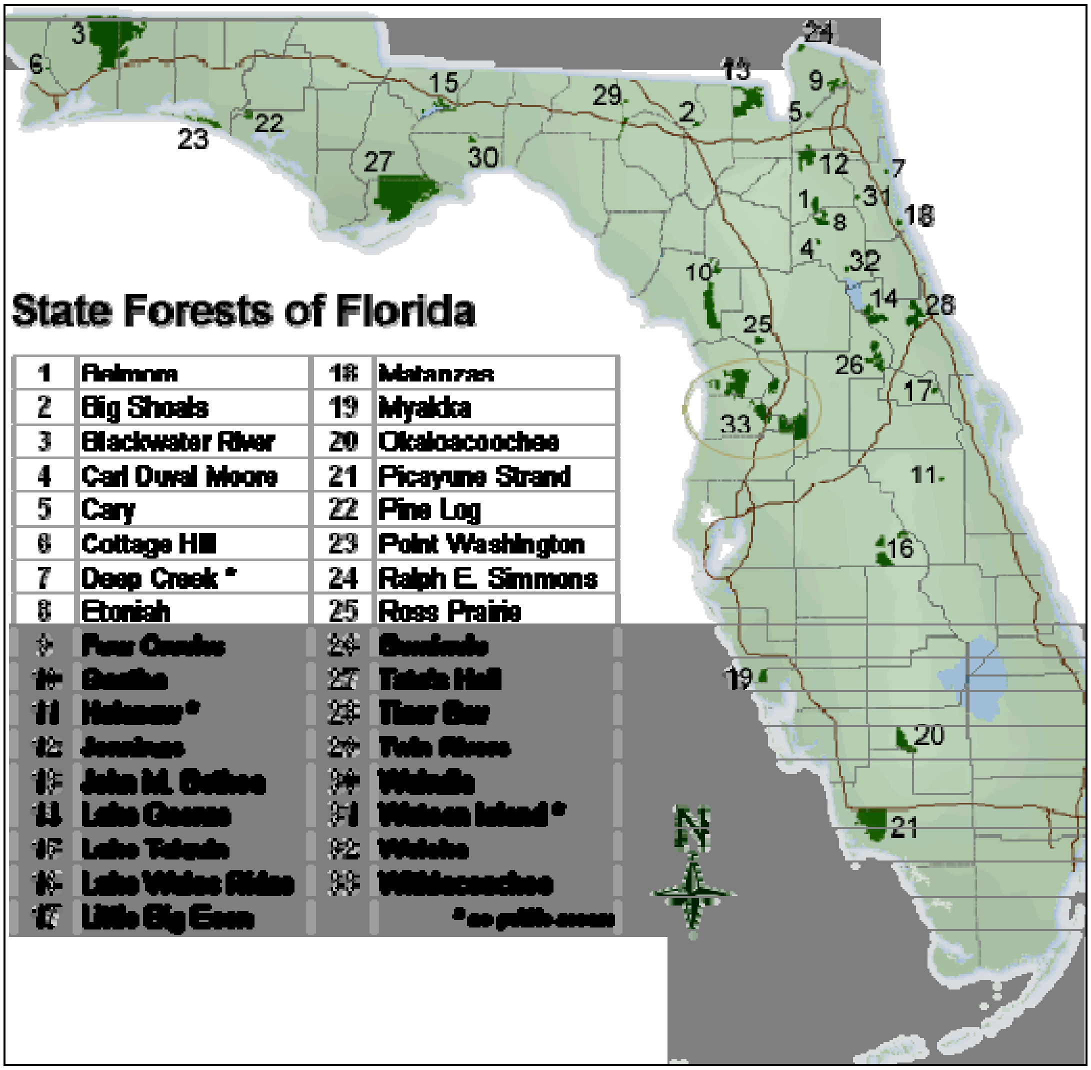

Figure 6. Map showing state forests of Florida. (http://www.fl-dof.com/state _forests /index.html)

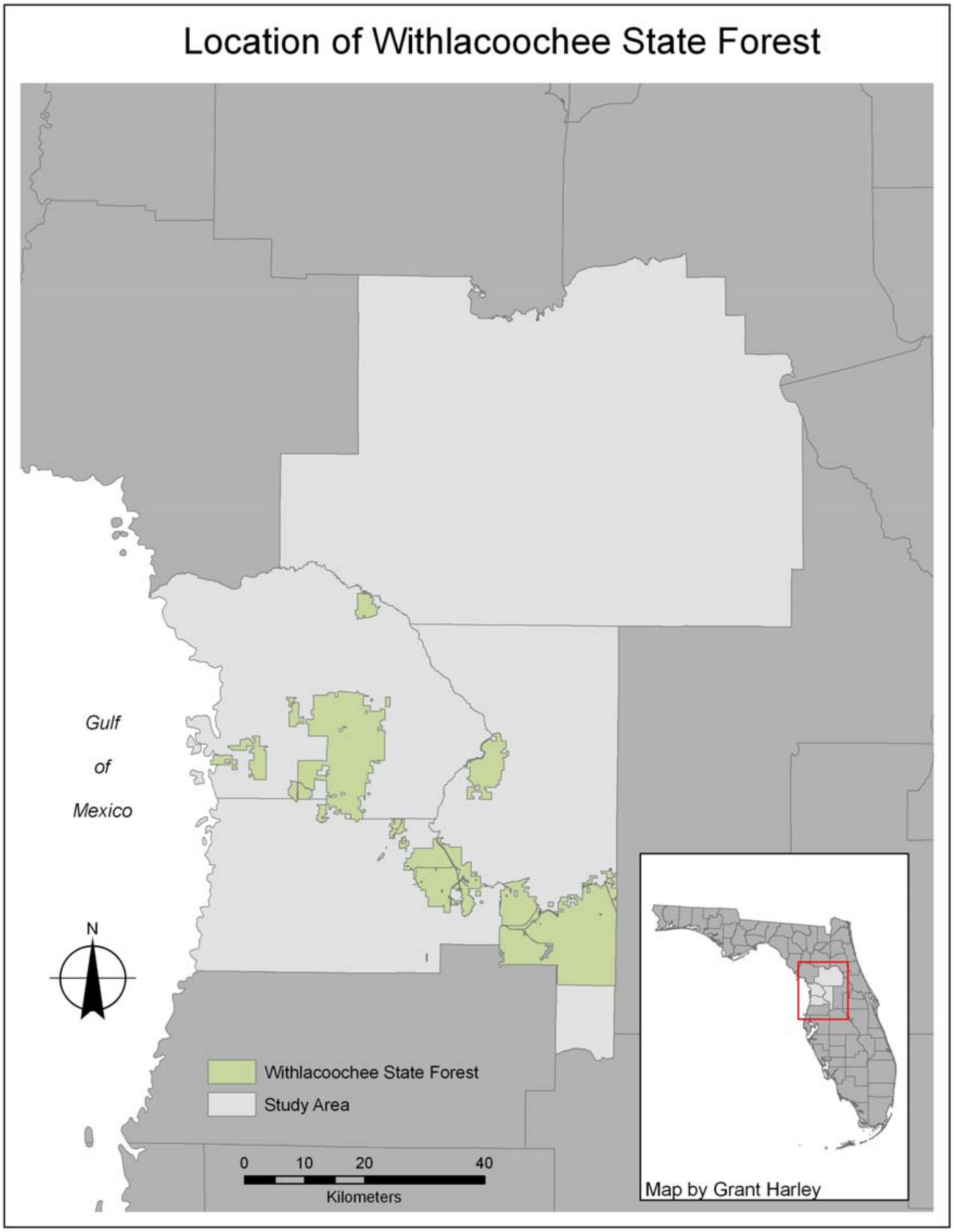

Figure 7. Location of the WSF as related to the extent of the study area.

Social Context

There are hundreds of terrestrial caves located in west-central Florida. As mentioned earlier, the public caves included in this study were all located in the Citrus Tract of the WSF, which is public land owned by the state of Florida. This study also includes caves located on private land. Private caves are located on parcels of land owned by an individual, group of individuals, or an organization. Access to public and private caves is discussed in the *Sources of Information and Data Collection Overview* section in Chapter Three.

The lack of cave management is a serious problem in west-central Florida. Florida is one of the fastest growing states in the nation, with a population growth of 1.78% between December 2005 and December 2006 (Christie 2006). Land developers are continually discovering caves, therefore continuing the need for cave conservation and protection. Yet, few caves are currently being managed in west-central Florida.

Information regarding the contents of public and private caves is deficient. This study is a result of the needs expressed by the WSF. The forest is currently in need of a guided approach to manage their caves. As a result, WSF staff approached the Department of Geography at the University of South Florida (USF) for help in the issue, which is how this project was conceived. One of the strategies of USF is to establish the university as a national model for an institution fully engaged with its local, national, and global communities, and this project fits into that strategy.

Initially, the WSF sought help as a result of a 1999 incident involving two boys on a recreational caving trip to the state forest acted as a wake-up call for WSF personnel (Zimmer et al. 1999; Zimmer 1999). Two boys from San Antonio's Boys Village were visiting Peace Sign Cave in the Citrus Tract of the WSF when they became stuck in a tight passage. It took rescuers from six different agencies over two hours to pull the two boys out of danger and airlift them to the nearest hospital, where they were treated for hypothermia (Zimmer et al. 1999; Zimmer 1999).

This incident made it clear to the state forest that it needed to revise strategies of cave management so as to needed to address the liability their caves present. Prior to the 1999 incident, no permits were required for entry into Dames Caves. However, the forest now requires a special-use permit for any group of people wishing to legally enter WSF caves. Cave discoveries continue to be brought to the attention of WSF personnel, but they still remain unaware of their sensitivity and disturbance, and few caves are managed in the WSF.

Management of caves continues to be deficient in both public and private land. However, before caves can be managed, land owners must understand their contents, sensitivity, and disturbance. The exploratory GIS-based cave inventory presented in this thesis serves as a tool for understanding the inherent contents of caves, their sensitivity, and disturbance.

Cave Management

The first step of cave management is to understand caves as systems that develop through natural processes in the landscape. The term *best management practice* is used commonly in place of *management*. This phrase demonstrates the realization that conservation strategies are continually evolving and improving. With the progression of science and research, the methods of cave management used today may be obsolete tomorrow. Thus, "*current best practice* in cave conservation and management is not an end product, but rather a conscious process of defining and enhancing standards" (Hildreth-Werker 2006, pg. 18).

Not every cave is managed by the same method, or for the same reason (Gillieson 1996). When considering the environmental impact of humans on cave systems, it is important to include both the subsurface and surface (Gillieson 1996; Hildreth-Werker and Werker 2006; Watson et al 1997). "Protection of karst features has all too often focused upon caves, and not given adequate consideration to the need for protection and proper management of the total karst area as a land unit" (Watson et al 1997, pg. 15).

Tourist caves are the most widely known to the public because they are openly accessible to anyone and broadly advertised. For this reason, tourist caves have many problems such as destruction of speleothems (Villar et al 1986), speleothem desiccation (Gillieson 1996), dust collecting on speleothems (Jablonksy 1992), and lint clinging to walls and formations (Gillieson 1996). With these known problems, tourist caves accept the tradeoff between disturbance and education.

Non-show caves, or wild caves, also experience disturbance. Stitt (1977) describes a range of human impacts, both surface and subsurface, on caves, while Everson et al. (1987) is a more specific account of the recreational impacts in Missouri caves. Gamble (1981) considered only four types of disturbance to a cave, its overlying surface, and catchment area; however, karst management should be holistic in its approach (Watson et al 1997). Each time a cave is visited, it is impacted. A dug or quarried entrance can be blocked, but the cave atmosphere is forever influenced (Gillieson 1996). However, cave conservation ethics can mitigate human disturbance and preserve resource sensitivity.

Developing a cave management strategy should adhere to the process of environmental policy, as described in Vaughn (2007). First, a problem is identified. In this stage, an inventory is conducted to better understand and document the current condition of a cave system. Next, a management plan is drafted. After considering all aspects of cave conservation and restoration, a management strategy is outlined by a group of cave specialists. After the management plan is drafted, it must be adopted by the landowner and cave manager. The next stage is implementation, where the management plan is actively enforced. Finally, an evaluation of the management strategy must be made. Since cave management is also known as *best management practice*, it is clear that cave conservation and restoration methods are continually evolving, and new methods of management are always on the horizon (Hildreth-Werker 2006).

The History of Cave Inventory

Projects involving the inventory of caves rarely appear in the literature. The few inventories found in publication were conducted at various resolutions, temporal scales, and with different purposes. Therefore, the definition of cave inventory depends on the project for which it is being conducted. The most recent and complete definition of "cave inventory" appears in DuChene (2006):

> "Cave inventory is the systematic observation and recording of significant features found within a cave. An inventory may include many types of data on the archaeology, biology, chemistry, hydrology, geology, history, mineralogy, paleontology, speleogenesis, and impacts of modern human use. The amount and type of information collected depends on several factors: the purpose of the project; the nature and complexity of the cave; and technical financial, personnel, and temporal limitation" (DuChene 2006, pg. 19).

The modern framework of the cave inventory, which involves cataloging significant features, began after the adoption of the FCRPA of 1988. Prior to the late 1980s, cave inventories usually involved cataloguing biota, archaeological sites, and fossil deposits, which date back to the 1700s (DuChene 2006). Over time, cave mapping changed along with inventory framework.

Since the 1700s, cave maps are used in conjunction with cave inventory as a systematic method for collecting data from caves (DuChene 2006). Early cave maps were simple drafts of a cave's perimeter, excluding internal detail

(Figure 8). However, cave survey and mapping evolved along with inventory methods. Today, cave cartographers attempt to include as much inventory information as possible on cave maps, since inventory personnel use them to attach a mathematical location to internal resources (Figure 9).

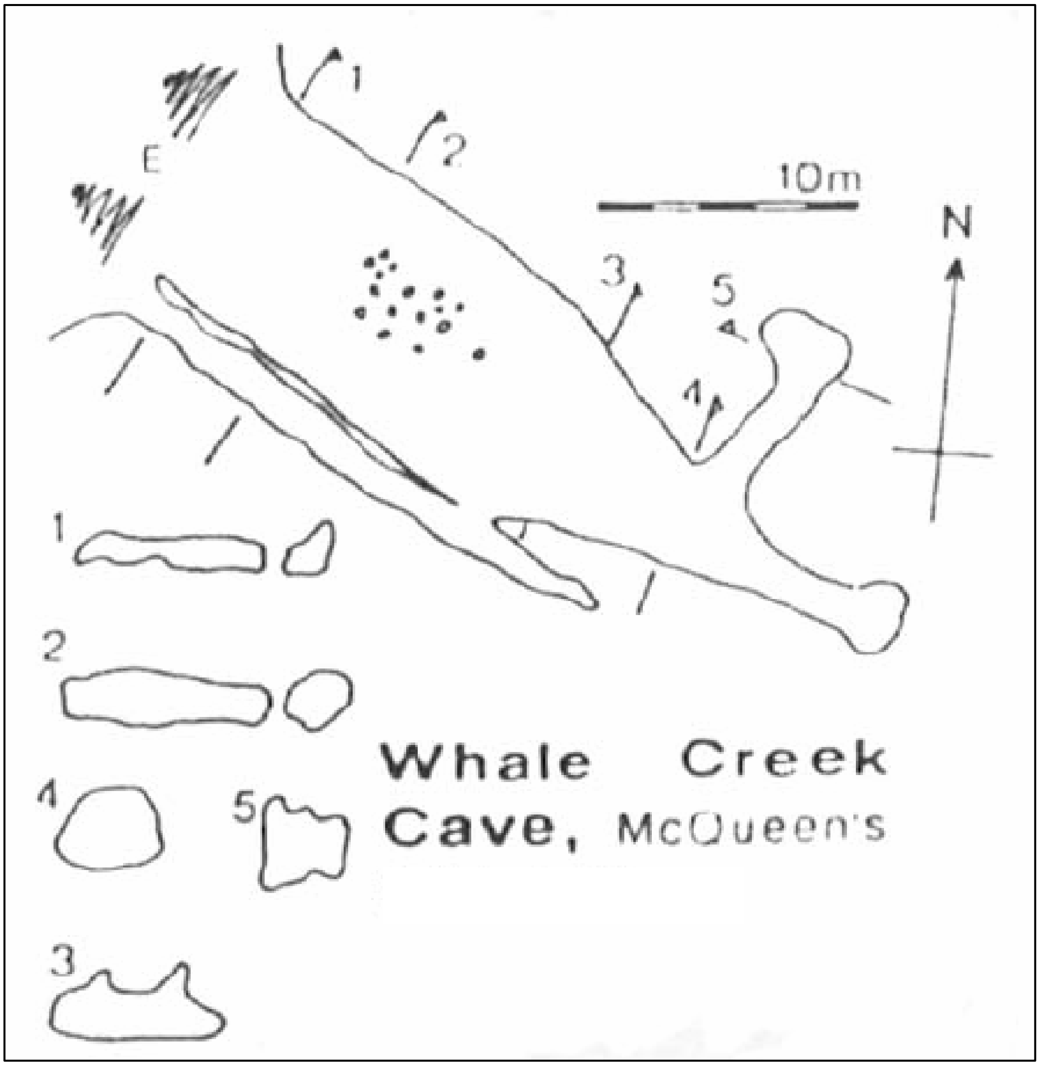

Figure 8. Cave map (1982) of Whale Creek Cave,McQueen's, Cat Island, Bahamas (Palmer, R.J. 1982).

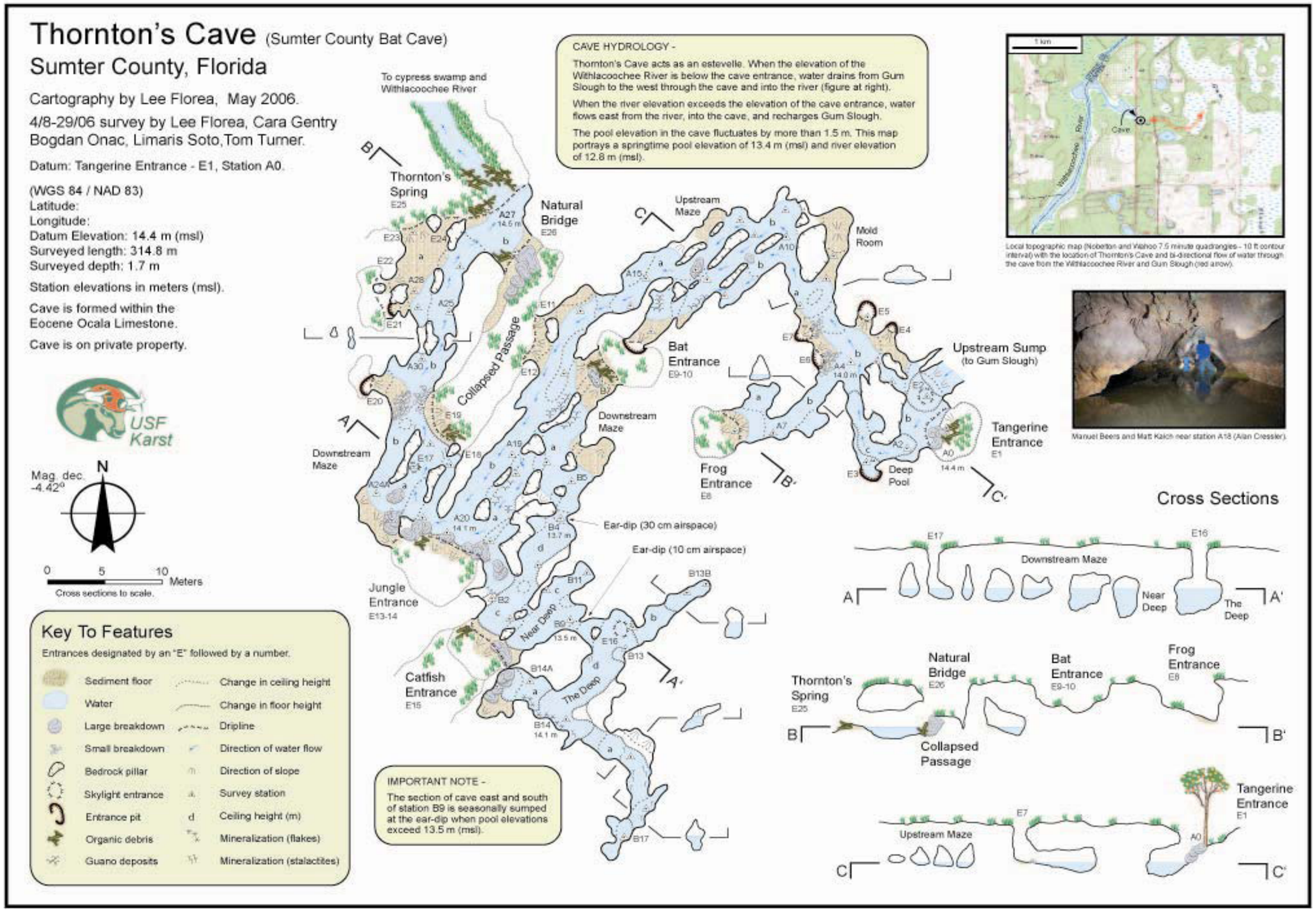

Figure 9. Cave map (2006) of Thornton's Cave. Sumter County, Florida (Florea 2006).

Figures 8 and 9 possess many differences. Figure 8 is an example of a twenty-two year old map that shows little internal detail of Whale Creek Cave, Bahamas. In contrast, Figure 9 shows a recent map of Thornton’s Cave, Sumter County, Florida. The map shows a great amount of internal detail and resource information that would be included during a cave inventory, such as bat roosts and guano, speleothems, mineralization formations, and hydrology. It even includes information on how the cave interacts with the surrounding environment.

Even though cave inventory methods evolved over time, the purpose remained the same; cave inventories provide information, which is the key to appreciating and understanding caves and their contents. Additionally, understanding caves as natural systems and resources is the key to their management and protection (DuChene 2006). A basic cave inventory is useful to scientists and other researchers when locating potential study areas. Inventories provide the information required to make educated decisions about the management of caves and their inherent resources. When making decisions about cave access, managers use inventory information to locate areas potentially sensitive to human disturbance, or areas of scientific research within a cave. Managers then use this information to direct a travel route to bypass these areas, or close an area of the cave altogether.

Types of Inventory

Stokes and Griffiths (2000) and DuChene (2006) define three types of cave inventory, which vary in detail and structure depending on the objectives of the project. These include: 1) reconnaissance inventories, which usually include a simple collection of features without specific mention of abundance, condition, or distribution (Figure 10); 2) general-purpose inventories, the most common in the United States, include a collection of the abundance, distribution, and identity of all significant resources within a cave; 3) project-specific inventories focus on a particular resource or feature found within a cave, such as an archaeological finding, or cave biota. Figure 11 illustrates the type of detail and focus attained during this type of inventory. Project-specific inventories usually support a larger project, such as specific resource restoration or an archaeological excavation. Each of these inventories are qualitative, quantitative, or both, depending on the purpose of the study (DuChene 2006).

Imaginary Cave
Date:

Team: ____________________

Speleothems:
- Calcite
  - Columns
  - Draperies
  - Flowstone
  - Helictites
  - Soda straws
  - Stalactites
  - Stalagmites

Cave Fill:
- Breakdown
- Gravel
- Guano
- Mud
- Sand
- Silt

Fossils:
- Bones
- Skull

Archaeology:
- Torch fragments

Biota:
- Bats
- Beetles
- Isopods
- Fish
- Crayfish
- Spiders

Figure 10. An example of a qualitative form used for a reconnaissance inventory (DuChene 2006).

Potential Items for Cave Inventory Lists

Speleothems:

Aragonite
- Anthodites
- Bushes
- Frostwork

Calcite
- Bell canopies
- Coatings
- Crusts
- Crystals
  - Nailhead spar
  - Dogtooth spar
- Draperies
- Drip pit linings
- Flowstone
- Helictites
- Mammillaries
- Rafts
- Rims
- Rimstone dams
- Shelfstone
- Shields
- Soda straws
- Splash rings
- Stalactites
- Stalagmites
- Trays

Sulfate
- **Barite**
  - Crystals
  - Massive
  - Stalactites
- **Celestite**
  - Coating
  - Crystals
- **Gypsum**
  - Crust
  - Crystals
  - Needles
- **Flowers**

Moonmilk:
- Balloons
- Coatings

Minerals:
- Aragonite
- Barite
- Calcite
- Gypsum
- Nitrates
- Quartz

Fill Material:
- Clay
- Gravel
- Guano
- Ice
- Mud
- Sand
- Loess
- Topsoil

Bedrock Features:
- Bedding planes
- Breccia
- Limestone beds
- Sandstone beds
- Shale beds
- Strike and dip of beds
- Faults
- Joints

Paleontological Features:

Bedrock Fossils
- Algal deposits
- Brachiopods
- Bryozoans
- Cephalopods
- Coral
- Crinoids
- Echinoids
- Gastropods
- Pelecypods
- Scaphopods
- Sponges

Secondary Fossil Deposits
- Pleistocene bones
- Trace fossils
- Footprints
- Scratch marks
- Scat
- Nests
- Dens

Speleogenetic Features:
- Boxwork
- Drip pits
- Karren
  - Pothole karren
  - Rillenkarren
  - Spitzkarren
- Scallops
- Stream slots
- Water lines

Biota:

Vertebrates
- Amphibians
- Bats
- Birds
- Fish
- Mammals
- Reptiles

Invertebrates
- Amphipods
- Isopods
- Beetles
- Centipedes
- Crayfish
- Earthworms
- Flies
- Leeches
- Millipedes
- Moths
- Psuedoscorpions
- Scorpions
- Snails
- Spiders

Microbiota
- Coatings
- Filaments

Water:
- Dripping water
- Pools
- Seeps
- Streams
  - Pools
  - Raceways
  - Riffles
  - Springs
  - Swallets
- Wet surfaces

Archaeological Features:

Cultural Artifacts
- Carbon blackened
  - Walls
  - Ceilings
- Ceremonial items
- Chips and flakes
- Hearths
- Pottery
- Pottery sherds
- Projectile points
- Petroglyphs
- Pictographs
- Sandals
- Tools
- Torch fragments

Human Remains
- Bones
- Burials
- Coprolites
- Scat

Historical Features:
- Habitation
- Historical signatures
- Mining equipment
- Nitrate leaching tools
- Stills

Damage:

(Restoration Targets)
- Batteries
- Broken formations
- Carbide dumps
- Chalk marks
- Contemporary graffiti
- Flagging material
- Human waste
- Mold blooms
- Mud tracks
- Off-trail footprints
- Trail markers needed
- Soiled formations
- Trails
- Contemporary trash

Figure 11. Potential Items for cave inventory lists (DuChene 2006).

Prior Cave Inventory Research

As mentioned earlier in this chapter, research involving cave inventory is rarely found in the literature. A few cave inventory projects involve the mechanical tabulation of cave resources on paper (Mylroie 1978, 1979, 1981; Smith 1981; Brown and Kirk 1999; Douglas 1999; Stokes and Griffiths 2000; Roth 2004). However, since the advent of GIS, researchers realized the potential of combining cave inventory and GIS. Hence, GIS is given the credit for propelling cave inventory methods into well-known literature. Today, finding published studies that incorporate a mixed-methods approach to cave inventory is becoming more common.

Project-Specific Inventories

In 1999, a project-specific, biological inventory of caves within the George Washington and Jefferson National Forests in Virginia was conducted (Brown and Kirk 1999). Forest personnel applied the inventory in two phases. The first phase of the project involved documenting and identifying all stygobitic fauna associated with the environments of the 90 caves on their inventory list. Of the 90 caves, 25 were found as acceptable habitats for stygobites. The inventory team only considered stygobitic fauna, or cave-obligatory, aquatic invertebrates. The second phase of the study included a detailed inventory of aquatic stygobites and the hydrologic condition in which they live. In addition, the team also provided general information on a variety of other cave fauna, including pack rats, raccoons, bobcats, cave crickets, millipedes, collembola, harvestmen, mites, spiders, salamanders, crayfish, and bats (Brown and Kirk 1999) The inventory information gathered by the team was analyzed to address management challenges to caves in the forest. However, the inventory only considered biologic and hydrologic resources, and was not a holistic approach at cataloging all cave resources.

Caves are inventoried for both their biological and cultural resources. On September 13, 1997, the Hubbard's Cave History Project began in Hubbard's Cave, Tennessee (Douglas 1999). The goal of the project was to acquire cultural resource information to aid in future protection, management, and restoration projects for the cave. Hubbard's Cave contained a myriad of cultural resources from the Civil War era including ladders, steps, bridges, saltpeter vat remains, and various wall-markings. A detailed account of these cultural resources was acquired by the inventory team, as well as information on bats that roosted in a western passage of the cave. With this information, the inventory team was able to coax the Nature Conservancy into installing a bat-friendly gate at the entrance to protect both its cultural and biological resources (Douglas 1999). Like Brown and Kirk (1999), Douglas (1999) only mentioned the inventory of a few cave resources.

In 2004, Monica Roth completed a thesis that involved the study of flank-margin caves in the Bahamas and San Salvador. A project-specific, geological inventory was conducted by surveying caves and analyzing their geometric properties. Although the inventory described by Roth (2004) did not include information on cave resources, it did include data on the diverse geometries of 66 flank-margin caves. The objectives of the project were to inventory flank-margin caves and examine their development through geometric analysis. Geometric data was collected in the field and analyzed with both AutoCAD and Microsoft Excel. Because the objective was to analyze geometric data, a basic inventory met the needs of the study. Even though Roth (2004) described a method of manually collecting inventory data on paper and a computer-based analysis of the data, GIS was not implemented.

General-Purpose Inventories

General purpose inventories are currently the most common type used in the United States (DuChene 2006). A review of the literature revealed several general purpose inventories that implemented GIS to analyze results. However, GIS was used as a post-inventory tool, not in field data collection. One such example was Hurricane Crawl Cave in Sequoia National Park, California. Despain and Fryer (2002) explain how GIS and a general-purpose inventory were used to manage the cave. The project first focused on the inventory of rare, fragile, and significant cave resources. Once collected on paper *in situ*, the inventory data was loaded into a GIS and used to provide statistical analysis on the relationship between certain significant and sensitive resources and travel routes within the cave.

Using analysis of buffer zones around key features in a GIS, management restrictions were made in certain sensitive areas where travel routes were unable to avoid these features. Since there were over 1,200 key features in the inventory database, a GIS was the only option for analyzing such a large database of features. This method of using cave inventory data and GIS was successful in aiding management concerns for the park. Despain and Fryer (2002) planned to use the same methodology to address cave management challenges in other national parks in California.

In another national park, Horrocks and Szulkalski (2002) conducted a study using GIS to map the potential extent for Wind Cave, South Dakota. Wind Cave is one of the largest cave systems in the United States with a total passage length of 166 km as of 2002. Initially, a general-purpose inventory and GIS were used to make management easier, but researchers noticed further uses for the GIS-stored inventory database. By using geological data acquired from the inventory and various GIS layers including slope, aspect, orthophotoquads, land ownership maps, the park boundary maps, and a map of the current extent of the cave, they determined the current cave boundaries cover only 1/10 of the total potential or maximum likely extent of the cave. Such research would be impossible without the combination of inventory data and GIS.

Similar to Horrocks and Szulkalski (2002), Ohms and Reece (2002) conducted a study utilizing GIS to aid the management of Wind and Jewel Caves, South Dakota. Cave managers of both caves were presented with daily challenges given the sheer length and complexity of the two separate cave systems. The primary goal of the study was to determine the relationship of specific cave resources with overlying surface features, which was accomplished by using GIS. A GIS was also used in both Wind and Jewel Caves to display general-purpose inventory data tied to each survey station. The storage and display of inventory data within a GIS enables the managers of each cave to make management-related decisions in a swift and accurate manner. For instance, at Jewel Cave, GIS was used to aid management decisions regarding the use of herbicides above the cave and to more accurately distinguish where the cave crosses surficial political boundaries (Ohms and Reece 2002).

By using GIS, cave specialists at Timpanogos Cave National Monument (TICA) addressed the strains over 70,000 visitors place on the cave system and its resources each year (McNeil et al. 2002). Because of the functionality of GIS, management of the cave, inherent resources, and land above the cave was possible. After conducting a general-purpose inventory of the significant and sensitive features within TICA, the data was loaded into Cave and Karst GIS software developed by the Environmental and Science Research Institute (ESRI). This special software along with inventory information enabled interpretive mapping, 3-D visualization, and cave resource management of TICA (McNeil et al. 2002).

In order to manage and analyze an archaeological cave site, Moyes (2002) used GIS and cultural inventory information. In the past, archaeologists used GIS only as a tool for studying large regions; however, Moyes (2002) applied the tool to study a cave site: Actun Tunichil Muknal (ATM). ATM is a Terminal Classic Maya ceremonial cave in Upper Belize Valley, Cayo District, Belize. This study demonstrated the effectiveness of GIS as a means for data storage, display, visualization, analyzation, and generation. Terminal Classic Maya artifacts were clustered by combining GIS technology and a K-means clustering analysis. Basic GIS functions, such as buffers and overlays, were used to evaluate the distances between artifact clusters and morphological features in the cave. These clusters of artifacts were also used to analyze and distinguish areas of the cave used by the Maya. New insights into ancient Maya ritual cave use were accomplished by the use of GIS, which are implausible by standard methods of mapping and analysis (Moyes 2002).

McNeil et al. (2002), Moyes (2002), Horrocks and Szulkalski (2002), Ohms and Reece (2002), and Despain and Fryer (2002) considered cave sensitivity in each of their inventories, but not cave disturbance. Moreover, each of the aforementioned studies used GIS as a tool for post-processing data, but not for inventory data collection.

Cave and Karst Disturbance

This study is concerned with combining GIS with cave inventory, sensitivity, disturbance, management, and ownership. In order to measure the disturbance of karst environments at the county level, Van Beynen and

Townsend (2005) created a hierarchal and standardized index. Rather than focusing on one aspect of the environment, the Karst Disturbance Index (KDI) is a holistic approach at measuring human impact on karst environments, which includes cave systems. Disturbance indicators used to measure the approximate degree of human-induced degradation of cave environments include the amount of cave flooding due to surface alterations, vandalism, sediment removal, condensation corrosion, desiccation, removal of cultural artifacts, removal of minerals, and floor sediment compaction. The KDI is an appropriate tool for understanding the disturbance of a karst environment at the county level, but not on a smaller scale, such as a single cave system.

Similar to the KDI described by van Beynen and Townsend (2005), visitor impact mapping is another method of determining the amount of human-induced cave disturbance. During the 1995 National Cave and Karst Management Symposium, Hans Bodenhamer first presented his concept of a tool that enabled the mapping of visitor impact levels in caves (Bodenhamer 1995; 2006). Each area of the cave was classified and color-coded according to the severity of visitor impact. Five different classes of visitor impact were defined: pristine, no observable impacts, light impacts, heavy impacts, and severe impacts. No foot traffic was found on floor surfaces classified as pristine. Areas of no observable impact had floor surfaces on which visitor impacts were not noticed, even under close inspection by the research team.

Finally, areas classified as lightly, heavily, or severely impacted were defined according to their relative amount of disturbance (Bodenhamer 2006).

Bodenhamer drew point maps to locate and describe damaged resources, as well as drafted area maps to show the extent of floor disturbance. Each time the cave was visited by the research team, they re-mapped the same areas and measured visitor impact. This enabled them to compare impact maps within a single cave, or between multiple caves to determine where each area of the cave had changed over time due to continued impact from visitors. Bodenhamer (1995, 2006) focused mainly on mapping floor disturbances from visitation, and did not include human impacts on geologic formations, biota, or hydrology.

Cave Studies in West-Central Florida

Literature containing information on Florida caves is of limited nature and predominately focuses on biological, botanical, geomorphological, and geological topics. Past research conducted in west-central Florida is biologic, hydrologic, and speleogenetic in nature. No studies regarding cave inventory were conducted in Florida. Therefore, a regional cave inventory and study of cave sensitivity and human disturbance in west-central Florida is necessary to determine management priority.

Biospeleological Research

Several caves included in this study were mentioned for their biological resources. George H. Hubbard (1901) published the first paper on Florida cave biology titled “Insect Life in Florida Caves”. Since Hubbard’s publication, a number of troglogibitic arthropods were discovered in Florida, mostly aquatic crustaceans. However, the most recent description of Florida cave fauna is Peck (1970), and only includes records of three trogloxenes, 13 troglophiles, and two troglobites.

Although Peck (1970) mentions fauna in many Florida caves, the following is a description of fauna collected and described in caves included in this study. *Nesticus pallidzis* is a common cave spider that is found in caves throughout the United States. Peck (1970) describes collecting this spider in Blowing Hole Cave and the Dames Caves, Citrus County. A cave cricket (*Ceuthopilus latibuli*) with a range from Florida to Georgia was documented in Blowing Hole, the Dames Caves, Belleview Cave, Waldo Cave, and Jenning’s Cave (Peck 1970).

The Florida Department of Environmental Protection (FDEP) (2005) described cave flora and fauna found within the Withlacoochee Basin (WB). Terrestrial caves within the WB are only found in the Citrus Tract of the WSF, Citrus County. FDEP (2005) is a water quality status report of the WB compiled a collaborative effort between the WSF and FDEP. This report briefly mentions the fauna and flora of terrestrial caves within the WSF.

Several fern species were described in the entrances of caves: two species of maidenhair fern *(Adiantum tenerum* and *A. capillus-veneris),* two species of brake fern *(Pteris vittata* and *P. cretica),* a number of species of spleenwort *(Asplenium heterochroum, A. resiliens, A. cristatum, A. pumilum, A. verecundum, A. auritum,* and *A. subtile),* and the southern lip fern (*Cheilanthes microphylla)* (FDEP, 2005).

Numerous species of fauna were also found: deer mice *(Peromyscus* spp.), eastern woodrats *(Neotoma floridana),* and rat snakes *(Elaphe* spp.). The southeastern bat *(Myotis austroriparius),* with colonies numbering in the thousands, were found in a few caves during summer maternity months. The eastern pipistrelle (*Pipistrellus subflavus*), Florida's smallest bat species, was also identified in the report.

Several cave invertebrates were also described. Invertebrate species included two spiders *(Gaucelmus augustinus* and *Nesticus pallidus),* two springtails *(Isotoma notabilis* and *Tomocerus dubius),* cave crickets *(Ceuthopilus latibuli)*, mites *(Acarina)*, and harvestmen *(Phalangida)*. Aquatic invertebrates were not mentioned in the report, even though they are known to exist in several WSF caves (Werner, personal communication 2007).

Speleological Research

Other studies involving west-central Florida caves are more speleogenetic and geomorphological in nature. Brinkmann and Reeder (1994) conducted a study of speleogenesis in a section of the WSF, Citrus County, Florida. The caves studied were Vandal Cave, Peace Sign Cave, and Danger Cave located within the karst terrain of the Brooksville Ridge region of west-central Florida. They found that the uplift of the Ocala Arch during the Miocene created joints in the Suwannee Limestone. The dissolution of this limestone formed cave passages. Not only did the uplift create joints, but it also placed the study area in a mixing zone of fresh water from the aquifer and saline waters from the Gulf of Mexico, which expedited the dissolution process of limestone. As uplift continued, the caves were lifted above the mixing zone and separated into six different passages by surface erosion (Brinkmann and Reeder 1994).

Vandal, Peace Sign, and Danger Caves are examples of vadose caves without direct aquifer connection. Florea et al. (2003) conducted a study of a water table cave. Briar Cave is located in Marion County, Florida and formed within the Eocene Ocala Limestone. They found that Briar Cave consisted of a bimodal distribution of conduit elevations. Upper and lower conduit levels are horizontal and developed at 19 and 13 m.a.s.l. More importantly, the study results and historical evidence of the land above the cave indicate water levels in the Upper Floridan Aquifer decreased due to anthropogenic disturbances (Florea et al. 2003).

Florea (2006) surveyed seven air-filled caves in the Brooksville Ridge area of west-central Florida. Caves are laterally extensive and tiered with principle cavernous zones located at +3, +5, +12, +20, and +22 m.a.s.l. Primarily, cave passages are oriented NE-SW and NW-SE. The cave passages included in Florea (2006) were not found to represent an integrated system of conduits between aquifer inputs and outputs.

The studies conducted by Brinkmann and Reeder (1994), Florea et al. (2003), and Florea (2006) all similarly focus on the geomorphology, geology, or hydrology of caves in west-central Florida. While studies involving project-specific inventory, measuring cave sensitivity, determining cave and karst disturbance, and using GIS as a tool for post-processing inventory data exist; however, no study uses a completely GIS-based inventory to provide a detailed account of cave resources, measuring cave sensitivity, and determining cave disturbance in an attempt to rank cave systems by their management priority.

Chapter Three: Methodology

This chapter summarizes the sources of information, data organization, and methods used to conduct this study. Discussed in this chapter are: 1) how to develop and refine cave inventory and data collection methods in the most efficient manner; and 2) how to best formulate indices to measure cave sensitivity and cave disturbance.

Sources of Information

“Cavers are, in every way, an underground society. Far fewer people explore caves than, for example, hike or ride mountain bikes. Some carry a national directory of NSS members so that, wherever they travel, they can find a comrade” (Dewitt 2003). However, by following the proper procedures, access to both public and private caves is possible. The first step of conducting an inventory in a cave is acquiring access. This study included both public caves, located in the WSF, and private caves, located on privately-owned parcels of land. Access to caves on public land was given by WSF personnel, which required a special-use permit in order to drive on closed roads and enter any terrestrial cave.

The first step in gaining access to private caves was to become a member of the National Speleological Society (NSS) and one of its local, affiliated grottos. After becoming a member of the Tampa Bay Area Grotto (TBAG), trips to private caves were made available by several fellow members. These members had previous knowledge of cave locations and a good relationship with each landowner. Before each private cave was inventoried, permission was given by the landowner to ensure continuation of positive researcher-landowner relationships.

Site Selection

A convenience sampling technique was used to select caves in west-central Florida (Johnson and Wichern 1998). A random sample was not practical given the lack of comprehensive cave knowledge. A collective database of terrestrial cave locations would make a random sample possible, but no such tool exists. West-central Florida was selected as a study area for this project because of the abundance of caves, previous research was conducted in several caves, and lack of cave management. In no other area of Florida is there a more suitable spatial distribution of public and private caves, making the area the most logical location in which to conduct this research.

Analysis, Development, and Refinement of Cave Inventory Methodology

One of the tasks associated with this thesis was to analyze and refine current cave inventory methods. As mentioned earlier, cave inventories are currently conducted throughout the United States by a number of groups with varying objectives. No matter the inventory type, a paper inventory form is the most widely accepted tool for recording inventory data (Vukelich 1995; O'Dowd and Broeker 1996; Vesley and Stock 1998; Stokes and Griffiths, 2000; Walz and Spoelman, 2005; DuChene, 2006). However, this research required a change in data collection methods for two reasons: 1) paper forms were destroyed by water; and 2) the amount of information required to assess to ability to rank caves by management priority was not conducive for data collection on paper inventory form.

Certain caves in west-central Florida contain a direct connection to the FAS; therefore, conducting the inventory while swimming or wading in water was not uncommon. Printing the inventory on water-proof paper is an option, but this can be expensive given the cost of the paper and length of the inventory form (9 pages). Nonetheless, destruction of the paper inventory form by water during field data collection was a problem in the beginning stages of this research. An example of the damaged paper inventory form used in the beginning stages of this study is seen in Figure 13.

Furthermore, in order to determine cave management priority, the inventory required gathering more information and data than usually found in general-purpose inventories. The inventory I applied to caves in west-central Florida was a combination of three parts: 1) detailed account of cave features, including digital photographs; 2) cave sensitivity index; and 3) cave disturbance index (Figure 12). This amount of information would require a lengthy paper inventory form. Therefore, a more efficient tool for data collection was needed.

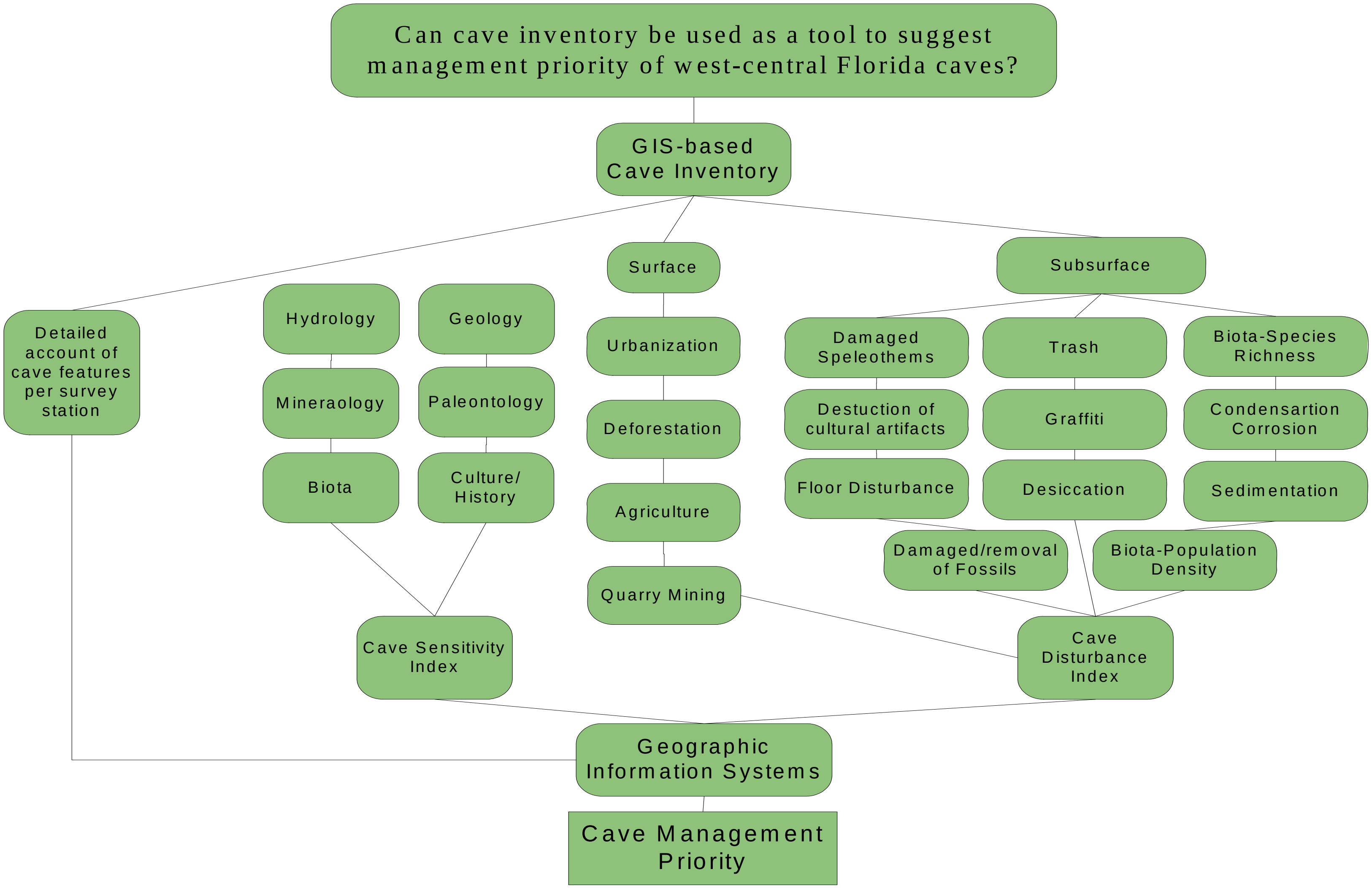

Figure 12. Methodological flow chart for determining management priority.

Figure 13. Paper form destroyed after conducting inventory in water.

Integrating cave inventory and GIS provided a non-paper method and solved the problem of destruction-prone inventory forms. In the recent past, cave specialists in several National Parks began using GIS as a tool for cave inventory and management (Knutson 1997; Despain and Fryer 2002; Ohms and Reece

2002; Horrocks and Szukalski 2002; Pfaff et al. 2000; Walz and Spoelman 2005). However, the aforementioned sources use a geodatabase to store inventory information acquired in the field by paper form, not the collection of inventory data in the cave using GIS.

Conducting the Cave Inventory

After realizing the need for GIS and inventory integration during data collection, caves were evaluated with electronic cave inventory during the summer of 2007. The cave inventory framework is based on a paper inventory model described by O'Dowd and Broeker (1996) (Appendix F). This model was used to inventory caves located within the Umpqua National Forest, Oregon and was developed as a collaborative effort between the National Speleological Society and the United States Department of Agriculture Division of Forestry. Other cave inventory models described by Brown and Kirk (1999), Douglas (1999), Walz and Spoelman (2005), Vesley and Stock (1998), and Nepstad (1991) were considered, but the O'Dowd and Broeker (1996) model was the most comprehensive and proved to be easily adaptable to suit the objectives of this project. The inventory model was adjusted to comprehensively fit in a GIS geodatabase. One of the purposes of my inventory was to provide a more detailed account of cave contents than the inventory used by O'Dowd and Broeker (1996).

After adapting the form used by O'Dowd and Broeker (1996), minor adjustments and additions were made in order for the form to be more specific to west-central Florida caves.

Devices Used for Cave Inventory

During the switch from a manual paper inventory to a completely electronic inventory, it was determined that mobile GIS software was necessary. ArcPad 7.1 is GIS software for mobile devices and provides the ability to collect field data in a reliable and efficient manner. Furthermore, it allowed inventory data to be collected and stored directly into a geodatabase, making the process of transcribing data from paper form into a geodatabase obsolete. For example, after an inventory is completed on a paper form, someone must transfer the written data into a database. Collecting and storing inventory data in the same step is a more efficient method that saves time and work, and eliminates human error during data transcription.

In order to facilitate data collection, ArcPad 7.1 was loaded onto a Dell Axim X51 personal digital assistant (PDA) (Figure 14). An Aqua Quest water-proof case was used to ensure the protection of the PDA device while conducting the inventory in aquatic cave environments (Figure 15). Certain GIS data layers were loaded into ArcPad 7.1 for use in the field. These layers included: a polygon-shapefile of Florida counties, a point-shapefile of west-central Florida caves, and a polygon-shapefile of the WSF.

Both polygon-shapefiles were acquired from the Florida Geographic Data Library and served as a spatial reference for the point-shapefile of west-central Florida caves, which was created and updated during this study.

Figure 14. The tools used for inventory data collection in the field included ArcPad 7.1 GIS software, Dell Axim PDA, and a mobile GPS device. ArcPad 7.1 was loaded onto a Dell Axim PDA. A PDA and a mobile Global Positioning System (GPS) unit, which plugged directly into the PDA, were used for inventory data collection in the field.

Figure 15. The PDA was protected with an Aqua Quest, water-proof cover.

Locating Terrestrial Caves for Inventory

A Global Positioning System (GPS) device was linked with ArcPad 7.1, which allowed for cave location acquisition in the field and storage directly into the geodatabase (Figure 16). A mobile Haicom HI-303III GPS unit was used to locate cave entrances with known waypoints. However, caves with unknown waypoints were marked in the field using the mobile GPS unit. Because of the link between GPS and GIS, these caves were immediately added to ArcPad 7.1 and made available for inventory data input directly in the geodatabase.

Figure 16 shows how the mobile GPS unit was linked directly to the PDA, and used in the field to collect and locate caves.

Figure 16. Mobile GPS unit linked with PDA device for acquisition of cave locations (photo by Jason Polk).

Inventory Framework and Contents

Several caves were previously surveyed and maps were acquired from the cartographers. However, the majority of caves were surveyed while the inventory was conducted, which is a widely accepted method (Ohms and Reece 2002; Horrocks and Szukalski 2002; DuChene 2006). As previously mentioned, a cave map containing survey stations is necessary to give cave resources a reference point when conducting an inventory. For each cave without a previous map, a survey was conducted using a compass and tape. At and between each survey station, a detailed account of specific cave contents were inventoried (Table 1). A map of each cave included in this study is seen in Appendix B. Additional information pertaining to each cave was noted and stored in the geodatabase, which is seen in Table 2.

entrance characteristics	passage characteristics	surveyed length	surveyed depth	geologic strata
biological resources	hydrological resources	geological resources	paleontological resources	mineralogical resources
cultural resources	roots	roost stains	floor characteristics	fossils
mold	bones			

Table 1. Inventory data with reference points.

latitude	longitude	inventory date	inventory ID	inventory personnel
cave ownership	equipment needed	entrance elevation	cave map status	cave management notes
cave sensitivity notes	cave disturbance notes	biologic notes	geologic notes	entry status
cultural notes	hydrologic notes	sediment notes	disturbance index scores	sensitivity index scores

Table 2. Other inventory data pertaining to cave.

Cave inventory data was stored in a GIS geodatabase. The cave inventory geodatabase was created in ArcCatalog and maintained in ArcMap 9.1, both of which are applications included in the ArcView 9.1 ArcGIS software package.

ArcPad 7.1 and ArcView 9.1 are completely interchangeable GIS applications, making data transfer from the PDA to the geodatabase straightforward. When data were ready to be transferred to the geodatabase after applying the inventory, the PDA was synced to a personal computer via Microsoft ActiveSync version 4.1.0. Once synchronized, the data were copied from the PDA directly to the geodatabase in ArcMap 9.1.

Additionally, each cave was documented with photographs using a digital camera. Documenting cave features with photographs produces a visual representation of those features during the time of inventory and is useful when comparing cave conditions through time (DuChene 2006). Sample photographs for each cave included in this study are seen in Appendix H.

Cave Sensitivity Variables

No cave inventory was found that included the measurement of cave sensitivity and cave disturbance for the use in management strategies. In order to rank caves by their management priority, cave sensitivity and disturbance were measured during inventory. Sensitivity and disturbance were determined for each cave by applying two standardized indices, which resulted in a sensitivity score and disturbance score for each cave.

Every cave is sensitive to human disturbance. The measurement of cave sensitivity can include many aspects of a cave environment, including direct aquifer connection, fragile speleothems, or the presence of endangered, cave-reliant biota. Therefore, it was crucial to define the purpose and scale of measuring cave sensitivity. In order to standardize the cave sensitivity index, certain variables were considered.

The cave sensitivity index variables were based on the cave resource inventory described by O'Dowd and Broeker (1996). The cave sensitivity index included variables of biology, hydrology, geology, mineralogy, paleontology, and culture. These variables represent cave resources that were noted during inventory and found to be potentially sensitive to both surface and subsurface human-induced degradation. Each variable was standardized into four evaluation criteria, which correlated into a score. Each sensitivity scale ranged from "0", indicating not sensitive, to "3," indicating high sensitivity (Table 3). For example, if drips, seeps, or pools and an aquifer connection were present in a cave during inventory, that cave received a score of "3" on the hydrology scale.

Variable	3	2	1	0
Biota	widespread individuals of single species; or multiple individuals of multiple species; or listed as Florida endangered species; or possible new species found	multiple individuals of single species	single individual or single species	no biota
Hydrology	drips, seeps, pools widespread; or direct aquifer connection; or intermittent stream	drips, seeps, pools, multiple areas	drips, seeps, pools sparse, localized	no features
Speleothems	widespread	multiple areas	localized area	no features
Mineralogy	widespread; or possible new mineral found	multiple areas	sparse; localized	no features
Paleontology	widespread	multiple areas	sparse; localized	no features
Cultural/Historical	cave listed as protected site on Florida Master Site File	multiple areas	sparse; localized	no features

Table 3. Cave sensitivity index.

Biology

The biology variable was intended to assess the approximate sensitivity of cave biota to human disturbance. This scale was based on the number of species and individuals found during inventory. Project-specific studies of cave biota, which are intended to understand all cave-dwelling biota, are complex and tedious. Estimating and measuring species richness and population densities of cave biota are projects within themselves (Gillieson 1996; Li 2000; Schneider and Culver 2004). The intention of the scale was to assess the approximate number of cave biota found during inventory, which correlates to the final sensitivity score of a cave on the biology scale. Currently, the richness and density of cave biota in west-central Florida is not well understood. This data is needed in order to accurately assess the actual sensitivity of cave biota, but these studies take years to complete. The scope of this project only required a general understanding of the sensitivity of biota found inside a cave at the time of inventory.

Hydrology

The hydrologic influence of a cave can make it vulnerable to contaminant inputs from surface disturbance. Cave hydrology can be modified by many human activities including well pumping, construction of paved areas within the general vicinity of the cave, and clear-cutting of trees near the cave (van Beynen and Townsend 2005). The hydrologic sensitivity scale included the spatial distribution and condition of drips, seeps, pools, aquifer connections, and intermittent streams that were noted during cave inventory.

Geology, Mineralogy, and Paleontology

Geological, mineralogical, and paleontological cave resources are considered separate variables, but are discussed together because of their similarities. Note that g*eologic resources* and *speleothems* are synonymous and used interchangeably. The protection of fragile and rare geologic, mineralogic, and paleontologic resources constitutes an important concern in the management of a cave (Despain and Fryer 2002). A speleothem is any secondary mineral deposit in a cave (Hill and Forti 1997). Certain sensitive speleothems, specifically stalagmites, are used by researchers for paleoclimate reconstruction (Dorale et al. 1992, 1998, 2002; Webster 2000; Richards and Dorale 2003; van Beynen et al. 2004; Polk et al. 2006; Webster et al. 2007). Geologic resources included soda straws, stalactites, stalagmites, drapery, helictites, columns, flowstone, or any other potentially sensitive speleothem found in a cave during inventory. The geology scale was based on distribution and quantity of undisturbed speleothems.

Cave minerals and fossils are also included as variables sensitive to disturbance. A cave mineral is a secondary mineral derived by a physio-chemical reaction from a primary mineral in bedrock. A cave mineral is not the same as a speleothem, even though speleothems are composed of minerals (Hill and Forti

1997). The classification of cave minerals is a tedious and complicated process that requires an expert. However, the objective of the mineralogic sensitivity variable is to gain an understanding of the abundance of cave minerals within a cave. Mineralogic features included any mineral resource, other than calcite, that was present during inventory.

Fossils are often found in cave systems. Such fossils are important because they serve as sources of primary information on past organisms and ecosystems (Toomey 2006). The Ocala, Suwannee, Avon Park, and Tampa Limestone are fossiliferous, shallow marine limestones found in the study area. Each of the caves included in this study developed within at least one of these host rocks. Caves developed within these rocks can have an abundance of clear, well-defined fossils embedded in the walls and ceiling, as well as other fossilized remnants of animals (Brodkorb 1956; Holman 1958) Paleontologic features included any form of fossilized resource noted in the cave during inventory. Both the mineralogic and paleontologic scales are based on distribution and quantity of undisturbed resources.

Culture

"Cultural resources should be protected and preserved, not only because there are laws saying so, but also because they are the basis of history" (Bilbo and Bilbo 2006, page 113). The culture sensitivity variable was included to recognize objects significant to American or Floridan history, architecture, archaeology, and culture that were potentially vulnerable to human degradation. The inclusion of cultural items in any inventory is crucial, for these objects may posses national, state, or local importance (Bilbo and Bilbo 2006).

The sensitivity scale for cultural resources was based on quantity of objects and inclusion of the cave as a protected cultural site on the Florida Master Site File (FMSF). The expert on cultural resources in Florida is considered to be the State Historic Preservation Office (SHPO) in Tallahassee, Florida. The SHPO maintains an archived computer database of cultural/historical resources in Florida called the FMSF. The FMSF organizes cultural resource sites alphabetically by county, which are assigned numbers sequentially as they are recorded. Records are searchable by county or township-range-section number. Any artifacts or items found during inventory of questionable cultural significance were noted, photographed, and sent to a specialist at the SHPO for further study.

Sensitivity Index Scoring System

Every cave is sensitive to human disturbance. However, depending on the occurrence of certain sensitive, inherent resources, some caves may be more sensitive to human disturbance than others. Scores from each sensitivity variable were summed to produce an aggregate number. The sum was then divided by the total possible score, which resulted in a final number between 0.0 and 1.0. This final number represents the relative sensitivity of a cave to human degradation. The closer the score is to one, the greater the overall sensitivity of the cave. If a cave receives a score of 0.00 on the sensitivity index, this does not indicate the cave is not sensitive to human disturbance. A score of 0.00 on the sensitivity index represents the cave contained no sensitive, inherent resources included on the index during inventory. Producing a final score for each cave enabled them to be ranked by their relative sensitivity.

Cave Disturbance Variables

All cave systems are modified by factors operating below and on the karst land surface. As precipitation inundates karst, vegetation controls the course of water as it intercepts organic matter and soil, which facilitates the production of carbonic acid in the root zone (Watson et al. 1997). Therefore, changing the overlying surface by clear-cutting, mining, or agricultural practices can radically alter the flow and quality of water in a cave system. “Water is the primary mechanism by which surface actions become subsurface impacts” (Watson et al. 1997).

Measuring cave disturbance can comprise many aspects of a cave, including the amount of trash, damaged speleothems, or deforestation around the cave. Therefore, in order to measure human disturbance to a cave, a standardized cave disturbance index was created, which included certain variables. The disturbance variables included in the index were modified from the Karst Disturbance Index (KDI) described by van Beynen and Townsend (2005).

The KDI serves as a holistic approach to determine the disturbance of any karst environment and included specific cave disturbance indicators, many of which were integrated into this study.

As mentioned earlier in this manuscript, the interest and exploration of terrestrial caves increased exponentially over the last 50 years. An increase in cavers results in problems of increased human disturbance from weekend recreationists, enthusiastic students, or even novice, flashlight-cavers who are unaware of the caving code of ethics and guidelines (Hildreth-Werker and Werker 2006). The code of ethics is a list of best practice guidelines to minimize effects of cavers on the cave environment. A complete explanation of the code of ethics is found in Hildreth-Werker and Werker (2006).

Since every cave is unique, human disturbance varies among public and private caves in the study area. Creating an index to provide an objective measurement of the amount of cave disturbance required the inclusion of both surface and subsurface human-induced degradation. The cave disturbance index included disturbance variables that represented the general amount of holistic human-induced disturbance to a cave (Table 4). Similar to the cave sensitivity index, each variable in the disturbance index is standardized into four evaluation criteria, which correlates to a score. Each disturbance scale ranged from “0”, indicating no disturbance, to “3,” indicating a high level of disturbance. For example, if widespread damage to speleothems was noted in a cave, the cave received a score of “3” on the speleothem damage scale.

Category	Variable	3	2	1	0
Subsurface	Trash	widespread	multiple areas	localized area	none
	Speleothems (% damaged/broken)	widespread destruction	~50% damaged	localized damage	none
	Graffiti	widespread	multiple areas	localized area	none
	Floor Disturbances	severe impacts	moderate impacts	light impacts	pristine
	Destruction of cultural artifacts (% destroyed)	>50	20-49	1-19	0
	Condensation Corrosion	widespread	multiple areas	localized area	pristine
	Desiccation	widespread	multiple areas	localized area	pristine
	Sedimentation	widespread sedimentation; or cave completely infilled	multiple areas	localized at entrance	none, rock surface in cave
	Biota-population density (% decline)	>50	20-49	1-19	0
	Biota-species richness (% decline)	>50	20-49	1-19	0
	Destruction of Fossils	widespread destruction	multiple areas	localized area	none
Surface	Deforestation (% within 1km buffer)	>50	20-49	1-19	none
	Agriculture (% within 1km buffer)	>50	20-49	1-19	none
	Urbanization (% within 1km buffer)	>50	20-49	1-19	none
	Quarry Mining	cave located in active quarry	past quarrying affected cave in multiple locations	past quarrying opened small entrance	none

Table 4. Cave disturbance index.

Trash

The occurrence of material disposed by humans is one of the most obvious forms of disturbance in a cave (Veni 2006). Any occurrence of trash negatively impacts the aesthetics of a cave environment, but it also affects the well-being of microbial life. Native bacteria, which are adapted to low nutrient cave conditions, are harmfully impacted by the introduction of trash, household waste, and human waste (Boston et al. 2006). The trash disturbance variable is based on the distribution of trash in the cave at time of observation. Trash included any type of disposed material, such as cans, bottle, paper, etc. Trash was observed at four different scale distributions: none, localized trash, trash in multiple areas, or widespread occurrence of trash.

Speleothem Damage

A speleothem is a secondary mineral deposited in a cave by the action of water. There are dozens of types of speleothem forms, but calcite and gypsum speleothems are the most common. These fragile formations are sensitive to both subsurface and surface disturbances. Increased visitation in caves generally results in increased speleothem breakage (Hildreth-Werker and Werker 2006). Speleothems are also sensitive to any change in chemistry of water percolating from the surface to the bedrock (Veni 2006). During the application of the disturbance index, damaged speleothems included any stalactite, stalagmite, soda straw, drapery, flowstone, helictite, rimstone, column, or any other type of speleothem found broken or damaged during time of inventory. The approximate amount of broken speleothems was included in the scale at four levels: pristine, localized damage/removal, ~50% removed/damaged, and widespread destruction (van Beynen and Townsend 2005). Even though these amount levels are somewhat subjective to anyone applying the index, giving the scale a low number of categories from which to choose reduces subjectivity (van Beynen and Townsend 2005).

Graffiti

The purpose of the graffiti disturbance variable was to determine the actual disturbance from graffiti in a cave, which included both contemporary and historical graffiti. Even though historical graffiti were considered as part of the culture sensitivity variable, it represents human-induced cave disturbance. As mentioned previously, any possible historical or cultural resource including rock art or graffiti was photographed and sent to cultural resource experts at the SHPO.

Graffiti is any occurrence of a letter, word, phrase, or symbol etched, spray-painted, or written anywhere inside a cave. All types of graffiti have a negative impact on a cave environment. Like trash, spray-paint introduces foreign chemicals into a cave environment potentially harmful to biota and microbial habitat (Boston et al. 2006).

The graffiti disturbance scale was based on the distribution and quantity of graffiti inside a cave, which was organized into four categories: none, localized area, multiple areas, or widespread.

Floor Disturbances

The floor disturbance variable included floor disturbances like sediment compaction and general foot traffic. The variable is based on the severity of floor disturbances inside a cave. Disturbances to the cave floor were classified as either none/pristine, light impacts, moderate impacts, or severe impacts. This scoring method was adapted from Bodenhamer (1995, 2006), which were discussed in Chapter Two. General foot traffic and sediment compaction include the damage a cave floor induces from each visitor. In some cases, a narrow foot path is marked to minimize the damage to passage floors and sediment compaction (Hildreth-Werker and Werker 2006). For example, even though Lechuguilla Cave has been explored since 1986, floor disturbances have been kept to a minimum because of strict adherence to a narrow, marked trail throughout the cave. However, in an unmanaged cave with a high amount of foot traffic, floor disturbances are often severe (Hildreth-Werker and Werker 2006).

Destruction of Cultural Artifacts

The destruction of cultural artifacts is a type of cave disturbance. Over the years, the destruction or removal of cultural artifacts occurred in many caves.

Examples include the controversy surrounding the removal of 83 artifacts from Big Island Cave, Hawaii in 1905 (Dingeman 2003), and the destruction of cave paintings and subsequent closing of the Altamira tourist cave in Spain. After further analysis, destruction of the paintings was found to be caused by higher concentrations of heat and CO_2 from over-visitation (Villar et al. 1984, 1986; Cigna 1993). In the cave disturbance index, the scoring system for this variable was based on the percentage of destroyed artifacts in the cave (van Beynen and Townsend 2005).

Condensation Corrosion

Condensation corrosion can occur naturally in caves, or be human-induced (Villar et al. 1984, 1986; Sarbu and Lascu 1997; Tarhule-Lips and Ford 1998; Dreybrodt et al. 2005). Carbonic acid is formed when carbon dioxide from a person's breath combines with water inside a cave. As many speleothems are often coated with a thick film of water, the respired carbon dioxide in a cave can cause the corrosion of speleothems (Pulido-Bosch et al. 1997). The exact amount of condensation corrosion is a tedious and complex undertaking requiring time and equipment (Dreybodt et al. 2005). However, in order to get an estimation of condensation corrosion, walls, ceiling, and formations were observed for isolated areas, multiple areas, or widespread areas of corrosion throughout the cave.

Desiccation

When the relative humidity of a cave drops too low, evaporation can increase and cause speleothems to lose their surface moisture and dry out (van Beynen and Townsend 2005). Desiccation can occur when cave entrances are widened or modified, which is common in caves in lime-rock quarries or tourist caves (Pulido-Bosch et al. 1997). Another problem in tourist caves is the increase in body heat from large amounts of visitors, which increases evaporation inside the cave, causing speleothem desiccation (Villar et al. 1986). Just like condensation corrosion, desiccation was determined by examining speleothems for disturbance in isolated areas, multiple areas, or widespread areas throughout the cave.

Destruction of Fossils

"Caves often serve as natural archival vaults and can protect valuable scientific information through the ages. Fossils are important because they are the primary sources of information on biodiversity and ecosystems of the past (Toomey 2006, pg. 83). The caves within the study area are all developed within at least one of the following fossiliferous, marine limestones: Avon Park Formation, Ocala Limestone, Suwannee Limestone, or Tampa Member (of the Arcadia Formation). Caves developed within these rocks can have an over-abundance of clear, well-defined fossils embedded in the walls and ceiling. Certain fossils in the following formations are found:

1) Avon Park Formation: mollusks, foraminifera, and algae.

2) Ocala Limestone: abundant large and smaller foraminifers, echinoids, bryozoans, mollusks and rare vertebrates.

3) Suwannee Limestone: mollusks, foraminifers, corals and echinoids.

4) Tampa Member: mollusks, foraminifera, and algae (Bishop and Lane 1987)

These fossils have the potential of being disturbed by heavy visitor traffic, human induced condensation corrosion, or fossil-hunters. The destruction or removal of fossils was noticed as occurring in a localized area, multiple areas, or widespread throughout the cave.

Cave Sedimentation

Cave sedimentation can either be autogenic or allogenic (Brinkmann and Reeder 1993). In a karst landscape, as the dissolution of limestone occurs, the process of allogenic deposition allows the transportation of sediment from the surface to the floor of a cave. Cave sedimentation can also be derived from the weathering of a cave’s parent material. This process is called autogenic deposition and produces clay within the cave environment (Brinkmann and Reeder 1993).

The process of cave sedimentation can be caused by anthropogenic or natural processes. The amount of allogenic sedimentation depends on a multitude of factors: topographic position of the entrance on the landscape, the size of the entrance, the type and quantity of surface soils above a cave, and the porosity and permeability of the rock in which the cave developed. Without conducting a variety of different analyses of the sediment, it is impossible to know exactly how much sedimentation has occurred and where it came from. However, this project was only concerned with the spatial distribution of human-induced sedimentation in a cave during inventory. Therefore, the cave sedimentation variable was based on four criteria: none (mostly rock surface in cave), localized at entrance, multiple areas, and widespread sedimentation (or cave is completely infilled).

Deforestation

Deforestation has a negative effect on karst systems (van Beynen and Townsend 2005; Milanovic, 2006). Deforestation removes roots and vegetation, which hold soil in place and mitigate erosion. When trees and vegetation are removed, soil erosion increases and can cause increased sedimentation rates in a cave. Calculating deforestation was accomplished by determining the extent of vegetation removal within a 1 km buffer ring applied in ArcGIS. Deforestation data was acquired from the Florida Geographic Data Library for each county in the study area and uploaded into the ArcGIS project. A 1 km buffer ring was applied around each cave and the percentage of deforestation inside each ring was calculated using the Xtools Pro extension for ArcGIS desktop. The more deforestation within a buffer, the higher the score was for each cave. The longest cave in the dataset is around 1 km; therefore a buffer ring of 1 km was used to ensure the inclusion of all cave passage. An example of this process is seen in Figure 17.

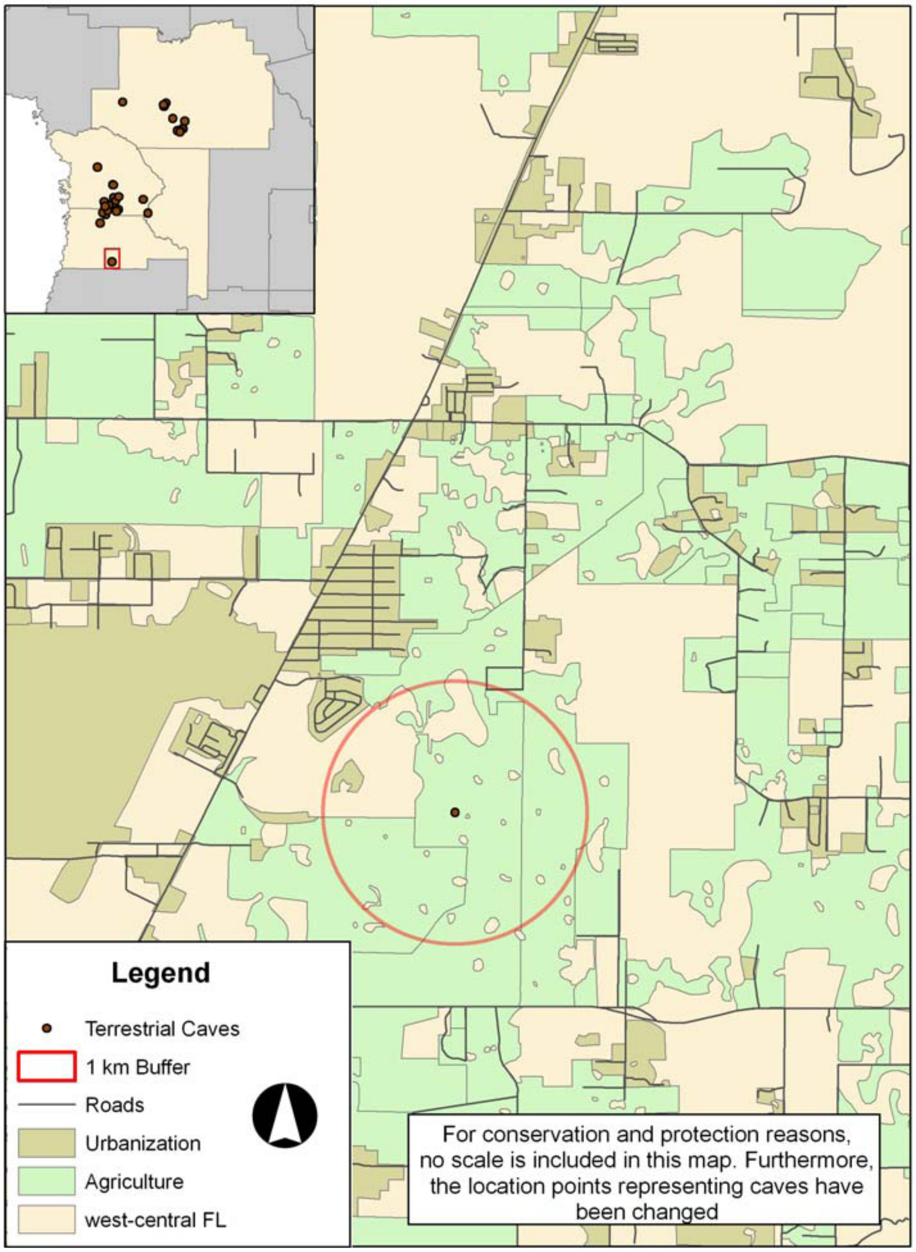

Figure 17. Example of buffer ring analysis in GIS.

Agriculture

Agricultural practices can have a negative affect on a karst environment (van Beynen and Townsend 2005). In Bohol, Philippines, Urich (1989) described the stresses that wet-rice/carabao agriculture has on the water quantity of a karst region. In an area like west-central Florida, agricultural practices include vast farms of citrus, row crops, and pastureland for grazing cattle. The use of pesticides and herbicides by farms and the nitrates found in cattle waste are only a few of the potential hazards agriculture has on a cave system. Since a general understanding of the affect agriculture has on each cave in the study area, the amount of agricultural disturbance to a cave was calculated by the same method described for the deforestation variable.

Urbanization

Building over or near karst features has a negative impact on karst environments (van Beynen and Townsend 2005). Depending on the position of a cave entrance within the landscape, certain caves have ephemeral sinking streams that act as direct transports for water from the surface to the aquifer during rain events. A cave can be negatively impacted by urbanization in many ways, including stormwater runoff pollution and increased visitation. Calculating the affects of urbanization on each cave was accomplished by determining the percentage of urbanized land within a 1 km buffer around each cave.

A 1 km buffer ring was applied around each cave in ArcMap and the percentage of urbanized land inside the buffer ring was calculated.

Quarry Mining

The most destructive practice to surface karst is quarrying (van Beynen and Townsend 2005). Over the past decades, large opencast mining in Great Britain has increased. In the United Kingdom, humans have removed more rock in the past century than nature removed in the last 10,000 years (Gunn and bailey 1993). Quarrying has many negative impacts to karst features, especially caves. Quarrying can cause drawdown of the water table, resulting in the formation of sinkhole, and destroy caves (van Beynen and Townsend 2005). Many caverns are destroyed, along with certain sensitive resources, each year in west-central Florida by mining practices (Figure 18, 19). The quarry mining sensitivity variable was based on the general affect quarrying had, or has on a cave system. During inventory, if a cave was found to be located in an active quarry, it received the highest score on the index. However, if past quarry practices affected a cave in multiple locations, like opening a large entrance, it received a score of two. A score of one was given to caves where past quarry practices opened a small entrance.

Figure 18. A cave system was likely destroyed from limestone quarry practices as speleothems were found scattered on the floor of this abandoned quarry. Tom Turner stands on a boulder for scale, which is the same boulder mentioned in Figure 18 (photo by Dan Straley).

Figure 19. These calcite crystal formations were exposed on the surface of a boulder on the floor of an abandoned quarry. Note the sunglasses for scale (photo by Tom Turner).

Disturbance Index Scoring System

The scoring system for the cave disturbance index was adapted from van Beynen and Townsend (2005). Scores from each disturbance variable were summed to produce an aggregate number. The sum was then divided by the total possible score, which resulted in a final number between 0.0 and 1.0. This final number represented the relative human disturbance to a cave. The closer the disturbance score was to one, the greater the overall disturbance.

Producing a final score for each cave enables them to be ranked by amount of overall disturbance.

When data for a disturbance variable was not able to be determined, but was still applicable to the cave, that variable was noted with a Lack of Data (LD) score. In order to determine the level of confidence of the final cave disturbance score, the total number of LDs was summed and divided by the total number of variables, which resulted in a score from 0.0-1.0. A higher LD score resulted in a lower degree of confidence, which suggested more research is needed in that area. If a variable was not applicable to a cave, it was not included in the scoring system (van Beynen and Townsend 2005).

Summary Statistics

In order to gain an understanding of the sensitivity and disturbance of public and private caves within the dataset, summary statistics were conducted. These statistics included a calculation of the mean, maximum, minimum, and standard deviation of both public and private caves using SPSS 15.0 for Windows software. These data calculations are used to analyze and compare cave sensitivity and disturbance values between public and private caves included in this study.

Chapter Four: Results

Cave Inventory Results

During this study, 36 terrestrial caves were inventoried (Figure 20). Of the 36 caves, 17 are located on private land and 19 are located on public land (Figures 21 and 22). The overall objective of the cave inventory is to prioritize caves by management priority through measuring cave sensitivity and disturbance. As previously mentioned, the cave inventory included three categories of data: 1) detailed descriptions of cave contents, resources, and features; 2) cave sensitivity index scores; and 3) cave disturbance index scores.

Detailed Descriptions of Cave Contents

Data acquired during the inventory were stored and maintained in a geodatabase in a GIS. The geodatabase includes 36 records and 86 fields (Appendix E). However, not all fields from the geodatabase are included in Appendix E. Certain descriptive data pertaining to the location of each cave, such as latitude, longitude, township, range, and section, were not published in this thesis because of an agreement with the landowners not to disclose exact or approximate locations of their caves.

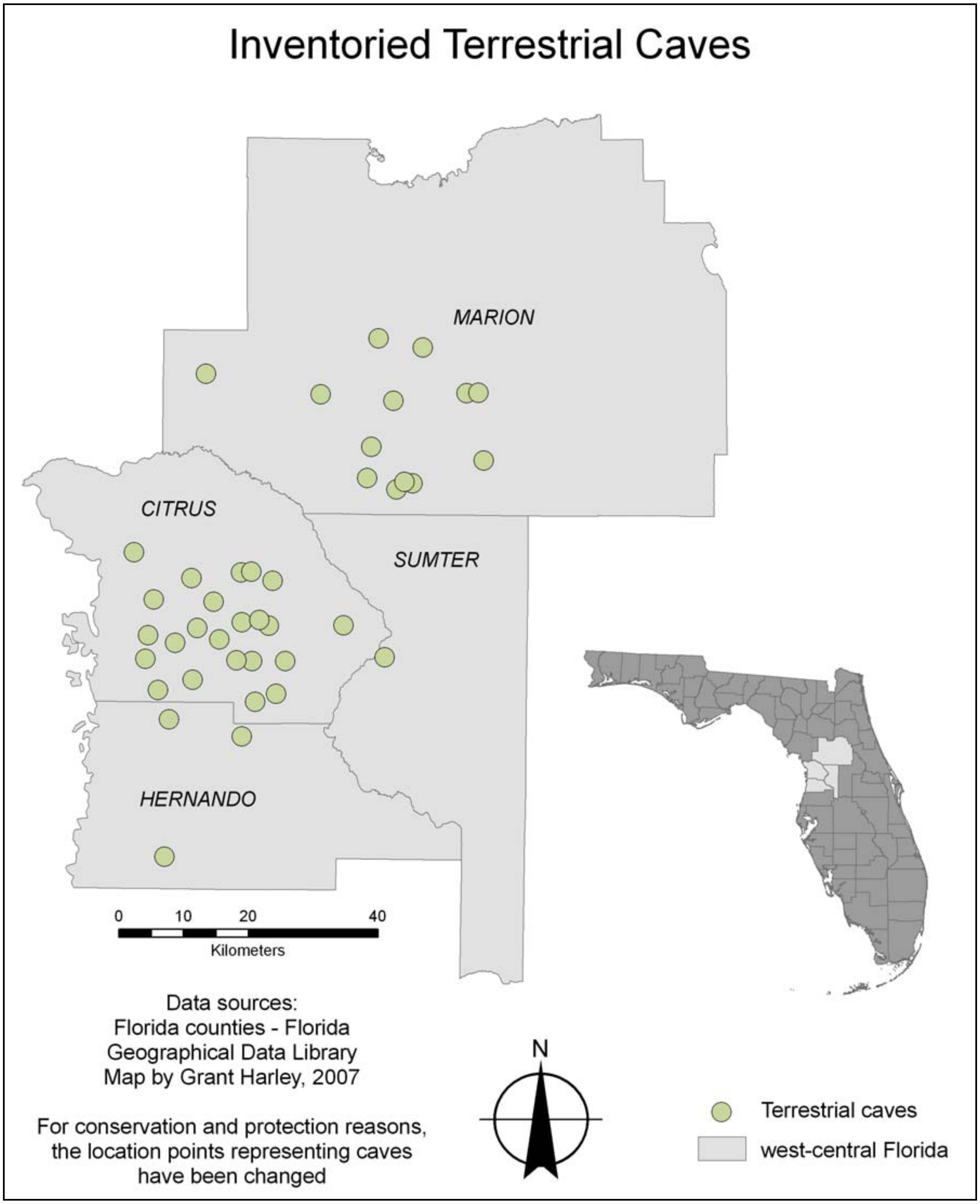

Figure 20. Locations of terrestrial caves inventoried during this project.

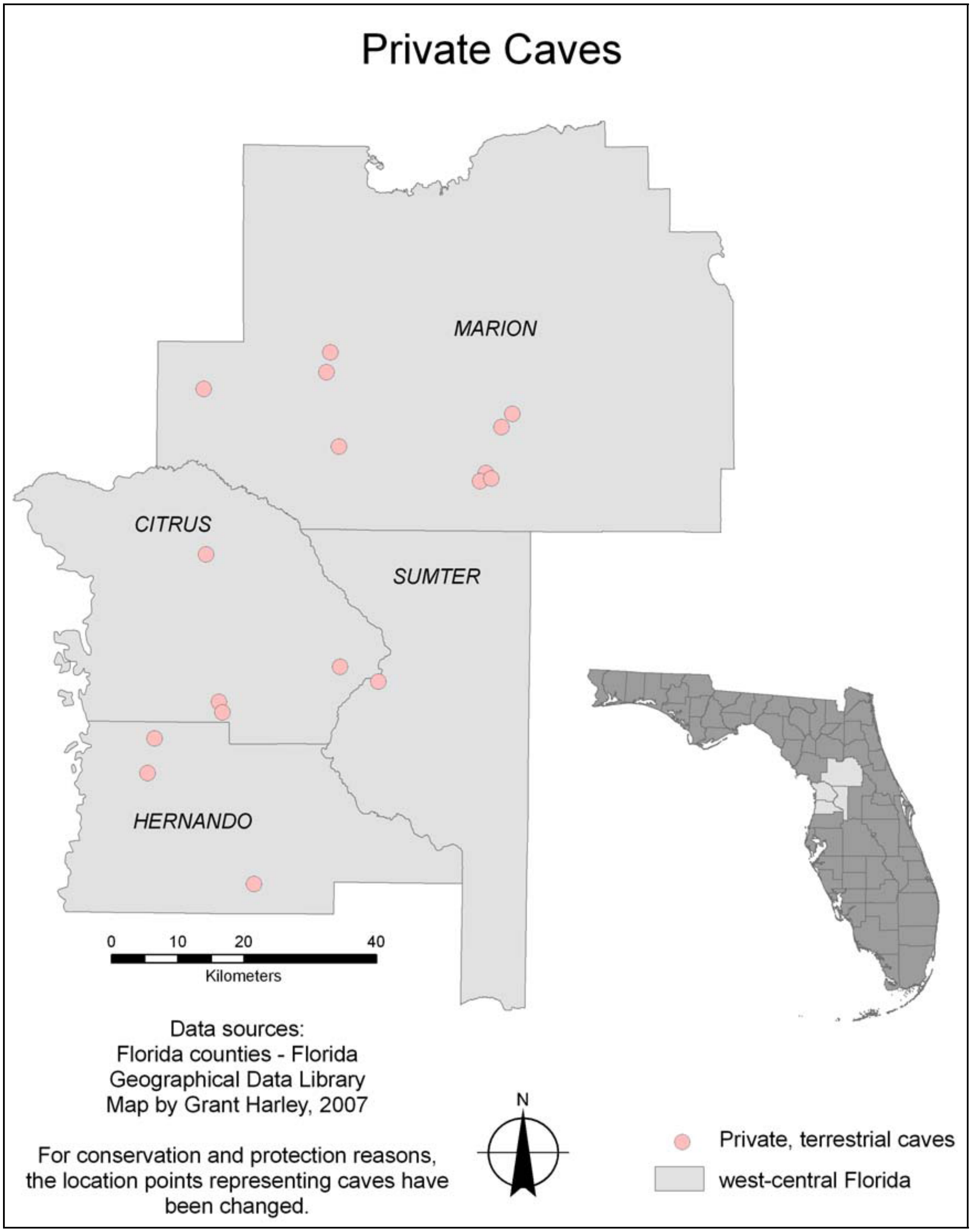

Figure 21. Locations of private caves inventoried during this project. Of the 36 total caves, 17 were private.

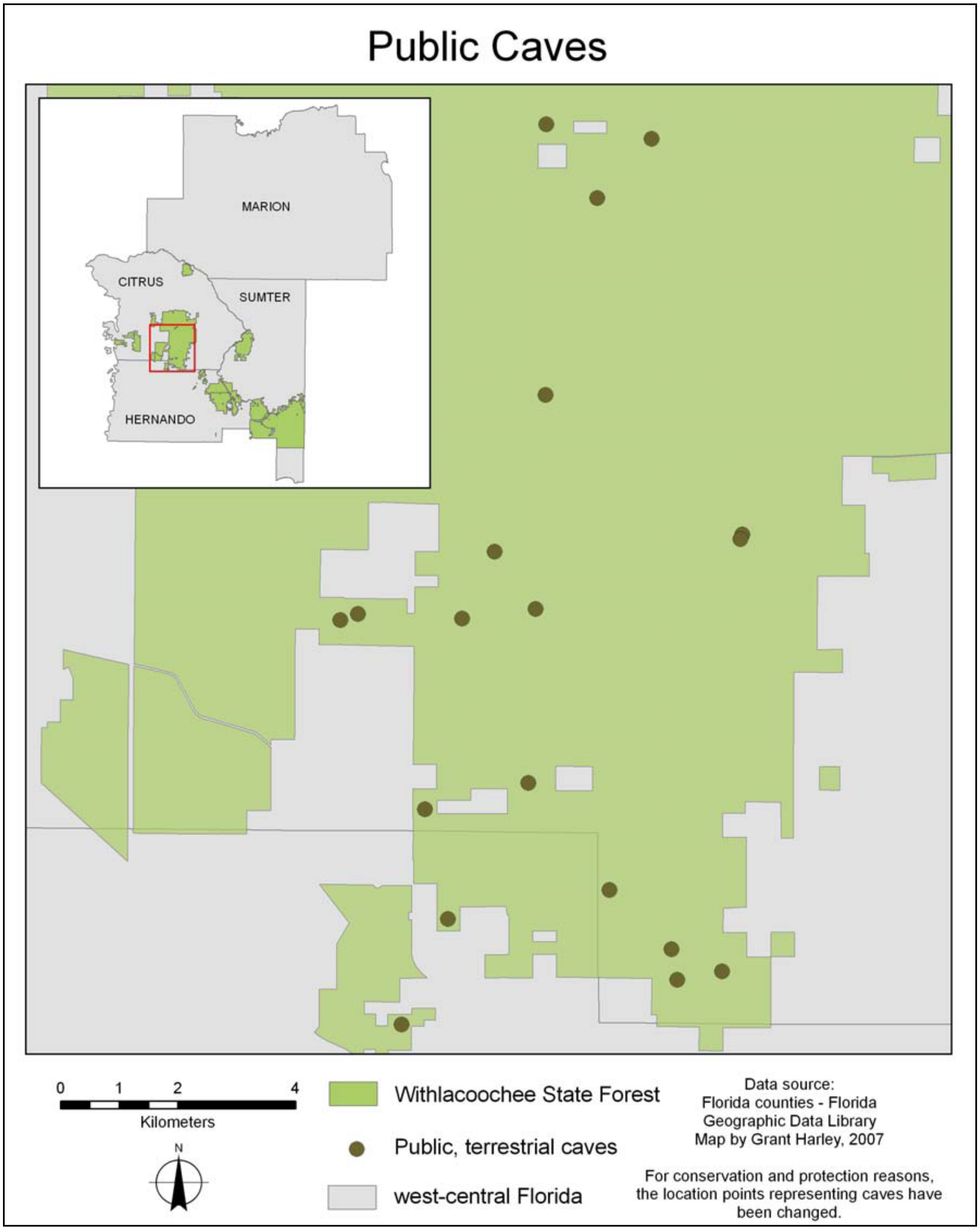

Figure 22. Locations of public caves inventoried during this project. Of the 36 caves, 19 were located on the public, state-owned land of the Withlacoochee State Forest, west-central, Florida.

In order to completely understand each inventory field, a data dictionary was included as a supplement to the geodatabase (Appendix A). The data dictionary includes an explanation of each geodatabase field with a list of possible values/codes. For example, the field of “Geologic_Strata” in the geodatabase is used to record the geologic unit(s) a cave developed within, and is collected in the field during inventory. The data dictionary explains the purpose of the field and possible values: Geologic unit in which cave developed. Codes = Ocala Limestone (Eocene), Suwannee Limestone (Oligocene), Avon Park Formation (Middle Eocene), Tampa Member (Arcadia Formation) (Upper Oligocene-Lower Miocene). Terrestrial caves in the dataset are only found within four geologic units in the study area and these served as possible values, or codes (Appendix A).

Cave Sensitivity Index Scores

The cave sensitivity index scores are presented in Table 5. The cave sensitivity index variables are based on the cave resource significance inventory described by O’Dowd and Broeker (1996). In this study, the cave sensitivity index variables include biology, hydrology, geology, mineralogy, paleontology, and culture. Each scale was standardized into four evaluation criteria, which correlates into a score. Each sensitivity scale ranged from “0”, indicating no sensitive resources, to “3,” indicating a high amount of sensitive resources.

The goal of the sensitivity index was to gain a general understanding of cave sensitivity based on the condition of a cave’s inherent resources.

Name	Ownership	Biota	Hydrology	Speleothems	Mineralogy	Paleontology	Cultural	Score
BRC	Private	3	3	3	3	3	0	0.83
Briar	Private	3	3	3	3	3	0	0.83
Crumbling Rock	Private	3	3	3	3	2	0	0.78
Turpentine	Private	3	3	1	2	3	1	0.72
Belleview Formation	Private	2	3	3	3	1	0	0.66
Goat Mummy	Private	3	2	3	2	1	0	0.61
Thornton's	Private	3	3	1	2	2	0	0.61
Werner	Public	3	3	0	2	3	0	0.61
Bottle Cap	Public	2	3	3	1	2	0	0.61
Legend	Public	2	3	3	1	2	0	0.61
Blowing Hole	Public	2	2	3	2	1	0	0.56
Jackpot	Public	3	3	0	1	3	0	0.56
Football	Private	2	3	2	2	1	0	0.55
Jenning's	Private	3	3	0	1	2	0	0.50
Finch's	Private	2	3	1	1	1	0	0.44
Sneak	Private	3	3	0	0	2	0	0.44
Maynard's	Private	1	3	2	1	1	0	0.44
Trail 10	Public	3	1	1	1	0	0	0.33

Table 5. Cave sensitivity index scores.

Name	Ownership	Biota	Hydrology	Speleothems	Mineralogy	Paleontology	Cultural	Score
Big Mouth	Public	3	3	0	0	0	0	0.33
Ocala Caverns East	Private	3	3	0	0	0	0	0.33
Girl Scout	Public	1	1	0	0	0	3	0.28
Sick Bat	Public	1	1	0	0	0	3	0.28
Vandal	Public	1	1	0	0	0	3	0.28
Dog Drop	Public	2	1	1	0	0	0	0.22
Floating Rock	Public	0	3	0	0	1	0	0.22
Peace Sign	Public	0	1	0	0	0	3	0.22
Hitchhiker	Private	1	1	1	0	0	0	0.17
Holy Oak	Public	1	1	0	1	0	0	0.17
Ocala Caverns West	Private	0	3	0	0	0	0	0.16
Rattlesnake	Public	0	3	0	0	0	0	0.16
Quarter	Public	0	2	0	0	0	0	0.11
Fallen Oak	Public	1	0	0	0	0	0	0.06
Indigo	Public	1	0	0	0	0	0	0.06
Reuff’s	Private	1	0	0	0	0	0	0.06
Jeep	Public	0	0	0	0	0	1	0.05
Heroine	Private	0	0	0	0	0	0	0.00

Table 5. (continued)

Two caves (BRC and Briar) received the highest sensitivity score in the index with scores of 0.83, and one cave (Heroine) received the lowest possible score, 0.00 (Table 5). BRC and Briar Caves received the highest scores because of the abundance of sensitive features found in the caves. During inventory, BRC contained widespread, fragile speleothems, widespread drips, seeps, and pools, widespread mineral deposits, and widespread echinoids, mollusks, and other pristine fossils embedded in the walls and ceiling. Briar Cave also contained widespread speleothems and drips, an aquifer connection, widespread mineral coatings, and widespread echinoids and mollusks that were undisturbed. In contrast, no sensitivity variables were noted in Heroine Cave, which resulted in the lowest possible score in the index.

	N	Min.	Max.	Mean	Std. Dev.
Cave Sensitivity	36	0	0.83	0.38	0.26

Table 6. Descriptive statistics for cave sensitivity index.

The mean sensitivity of all 36 caves in the dataset was 0.36 (Table 6). More specifically, the mean sensitivity for public caves was 0.30 and the mean sensitivity for private caves was 0.48. As a whole, there are more sensitive caves located on private land than on public land (Figure 23). Since the sensitivity scores were determined by *in situ* observations during inventory, no cave received a LD score for any variable.

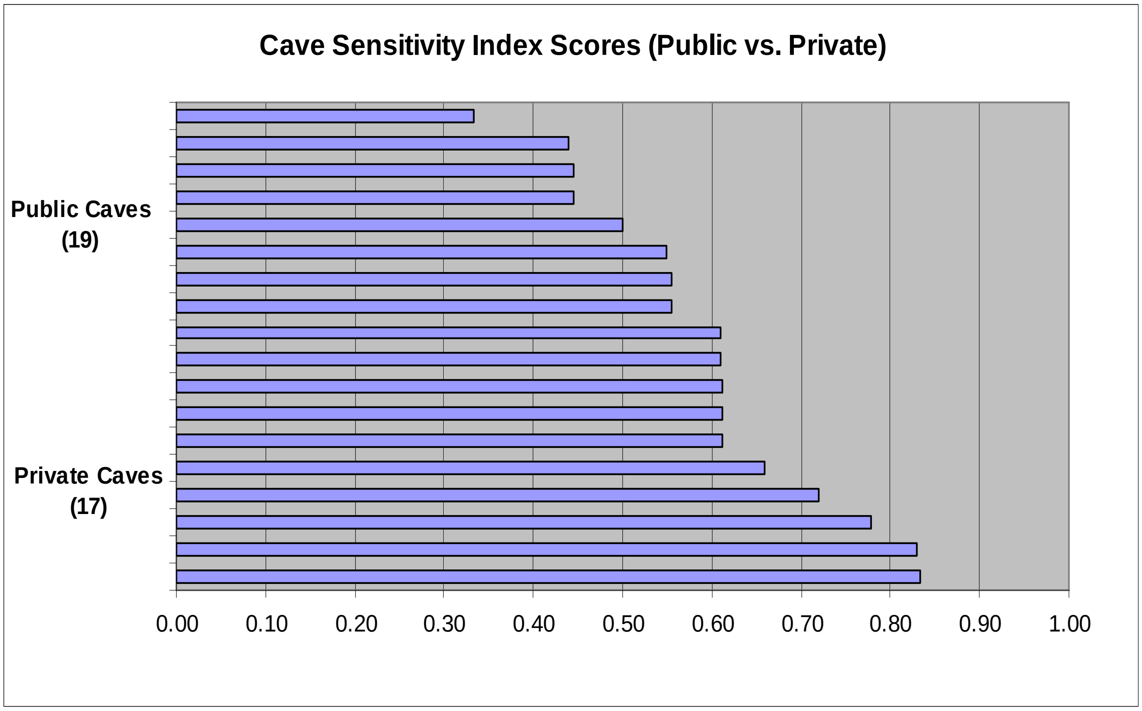

Figure 23. Cave sensitivity index scores of public and private caves.

Cave Disturbance Index Scores

In order to gain an understanding of the amount of human disturbance to a cave, a cave disturbance index was created and applied. Several variables included in the index were modified and adapted from the KDI explained by van Beynen and Townsend (2005). The cave disturbance index included the following variables: trash, speleothem damage, contemporary graffiti, floor disturbances, removal of cultural artifacts, condensation corrosion, desiccation, removal of fossils, urbanization, and deforestation. The results from the cave disturbance index are displayed in Tables 7 and 8.

Name	Ownership	Speleothems	Graffiti	Trash	Floor Disturbances	Cultural	CC	Desiccation	Sedimentation
Jackpot	Public	NA	0	0	1	NA	0	NA	NA
Turpentine	Private	0	0	0	1	1	0	0	NA
Briar	Private	1	1	0	1	NA	0	0	NA
Crumbling Rock	Private	1	0	0	1	NA	0	0	2
Finch's	Private	NA	0	1	1	NA	0	NA	NA
Thornton's	Private	NA	0	1	1	NA	1	NA	NA
BRC	Private	2	0	0	2	NA	0	0	1
Sneak	Private	NA	0	0	1	NA	0	NA	1
Trial 10	Public	2	0	1	2	NA	0	0	3
Dog Drop	Public	NA	2	1	3	NA	0	NA	NA
Indigo	Public	NA	0	1	3	NA	0	NA	NA
Bottle Cap	Public	1	1	1	3	NA	0	0	1
Big Mouth	Public	NA	0	1	2	NA	0	NA	1
Quarter	Public	NA	0	0	3	NA	0	NA	1
Reuff's	Private	NA	0	0	1	NA	0	NA	1
Werner	Public	NA	0	1	2	NA	0	NA	3
Fallen Oak	Public	NA	1	2	3	NA	0	NA	NA
Jeep	Public	NA	2	1	3	1	0	NA	2

Table 7. Cave disturbance index scores (Jackpot – Jeep).

Name	Biota Pop Den	Biota Spec Rich	Fossils	Deforestation	Urbanization	Agriculture	Quarry Mining	Score
Jackpot	LD	LD	0	0	1	1	0	0.11
Turpentine	LD	LD	0	0	1	3	0	0.17
Briar	LD	LD	0	0	1	2	0	0.18
Crumbling Rock	LD	LD	0	1	1	2	1	0.25
Finch's	LD	LD	1	1	1	2	0	0.26
Thornton's	LD	LD	0	0	1	3	0	0.26
BRC	LD	LD	1	0	1	2	1	0.28
Sneak	LD	LD	0	1	1	2	3	0.30
Trial 10	LD	LD	2	0	1	0	0	0.31
Dog Drop	LD	LD	2	0	1	0	0	0.33
Indigo	LD	LD	3	0	1	1	0	0.33
Bottle Cap	LD	LD	1	0	1	3	1	0.36
Big Mouth	LD	LD	2	1	1	1	2	0.37
Quarter	LD	LD	3	0	1	2	1	0.37
Reuff's	LD	LD	0	3	1	2	3	0.37
Werner	LD	LD	1	1	1	0	2	0.37
Fallen Oak	LD	LD	3	0	1	0	0	0.37
Jeep	LD	LD	3	0	1	0	0	0.39

Table 7. (continued)

Name	Ownership	Speleothems	Graffiti	Trash	Floor Disturbances	Cultural	CC	Desiccation	Sedimentation
Belleview Formation	Private	2	1	0	2	NA	0	0	3
Maynard's	Private	1	1	1	2	NA	0	0	3
Floating Rock	Public	NA	0	0	2	NA	0	NA	3
Holy Oak	Public	NA	3	2	3	NA	0	NA	NA
Legend	Public	1	2	2	2	NA	0	0	2
Blowing Hole	Public	2	3	2	3	NA	0	1	NA
Football	Private	2	3	1	3	NA	0	1	NA
Goat Mummy	Private	2	1	1	2	NA	2	1	1
Jenning's	Private	NA	3	2	3	NA	0	NA	3
Rattlesnake	Public	NA	1	2	3	NA	0	NA	3
Peace Sign	Public	3	3	3	3	NA	0	0	3
Sick Bat	Public	3	3	3	3	NA	0	0	3
Vandal	Public	3	3	3	3	NA	0	0	3
Girl Scout	Public	NA	3	3	3	NA	0	NA	3
Heroine	Private	NA	3	3	3	NA	0	NA	NA
Ocala Caverns East	Private	NA	1	3	3	NA	1	NA	3
Hitchhiker	Private	3	3	3	3	NA	0	0	3
Ocala Caverns West	Private	NA	3	3	3	NA	1	NA	3

Table 8. Cave disturbance index scores (Belleview Formation – Ocala Caverns West).

Name	Biota Pop Den	Biota Spec Rich	Fossils	Deforestation	Urbanization	Agriculture	Quarry Mining	Score
Belleview Formation	LD	LD	1	3	2	1	0	0.42
Maynard's	LD	LD	2	1	1	3	0	0.42
Floating Rock	LD	LD	1	1	1	2	2	0.44
Holy Oak	LD	LD	2	0	1	1	0	0.44
Legend	LD	LD	2	0	1	3	1	0.44
Blowing Hole	LD	LD	2	0	1	1	0	0.45
Football	LD	LD	1	1	1	3	0	0.48
Goat Mummy	LD	LD	2	0	1	3	2	0.50
Jenning's	LD	LD	2	0	2	1	0	0.53
Rattlesnake	LD	LD	3	1	1	0	2	0.53
Peace Sign	LD	LD	3	0	1	1	0	0.56
Sick Bat	LD	LD	3	0	1	1	0	0.56
Vandal	LD	LD	3	0	1	1	0	0.56
Girl Scout	LD	LD	3	0	1	1	0	0.63
Heroine	LD	LD	3	0	3	2	0	0.63
Ocala Caverns East	LD	LD	3	0	3	1	1	0.63
Hitchhiker	LD	LD	3	0	3	2	0	0.64
Ocala Caverns West	LD	LD	3	0	3	1	1	0.70

Table 8. (continued)

	N	Min.	Max.	Mean	Std. Dev.
Cave Disturbance	36	0.11	0.70	0.42	0.14

Table 9. Descriptive statistics for cave disturbance index.

Jackpot Cave received the lowest disturbance score, 0.11 (Table 7), and Ocala Caverns West received the highest disturbance score, 0.70 (Table 8). Jackpot Cave is a public cave located in the WSF and Hitchhiker Cave is a private cave in Marion County, Florida. Jackpot Cave had no trash, contemporary graffiti, no destruction of fossils, and light floor disturbance. Jackpot Cave is an example of a relatively pristine cave environment, while Ocala Caverns West is an example of a highly disturbed cave environment. The mean disturbance of all caves is 0.41 (Table 9), while the mean disturbance of private caves is 0.41 and public caves 0.42. In general, cave disturbance in public and private caves is virtually the same (Figure 24).

Data were unavailable to determine the population density and species richness of biota variables in the disturbance index. Therefore, all caves received a LD score for both variables, which resulted in an aggregate LD score of 0.14 for each cave. This low number signifies a relatively high degree of confidence for the final disturbance scores. However, the lack of biospeleologic data represents the need for research in this area.

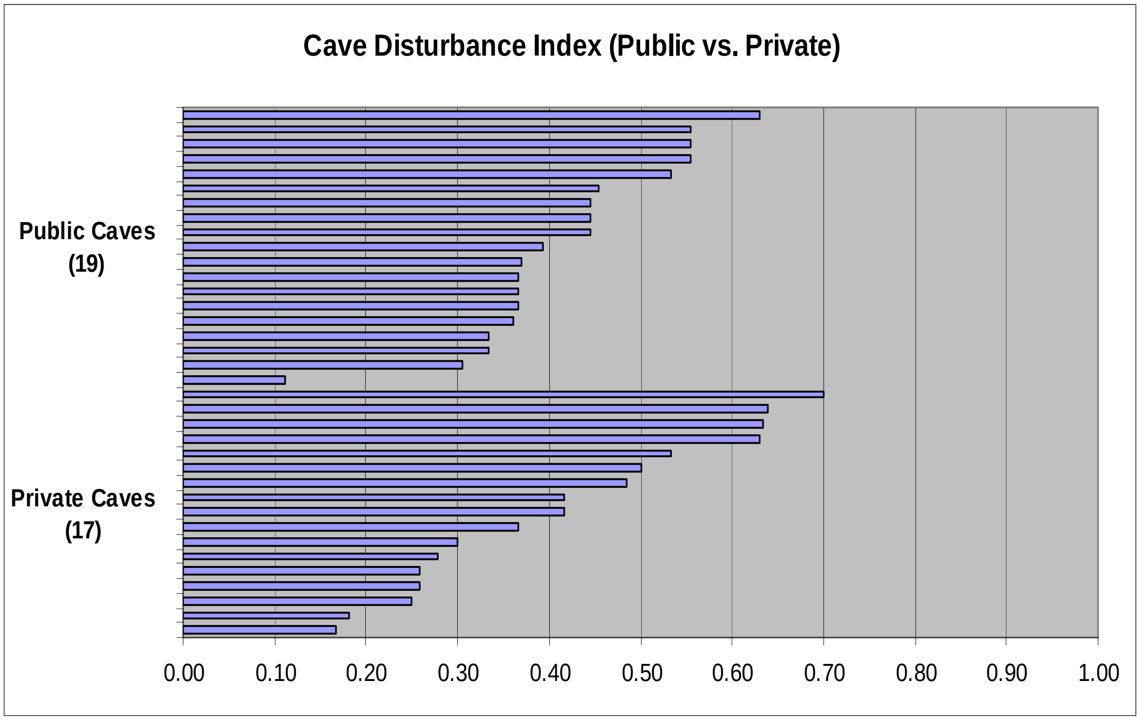

Figure 24. Cave disturbance index scores (public vs. private).

Chapter Five: Discussion

Beyond an inventory of cave resources, this thesis provides a method for using inventory data to rank cave management priority by assessing sensitivity and disturbance in conjunction with ownership and management status. Furthermore, the cave sensitivity and disturbance scores from this study do not definitively explain management immediacy. Consequently, the management immediacy of caves in west-central Florida depends on a number of complicated factors that cannot be simply explained without examining sensitivity, disturbance, management status, and ownership of each cave.

Development and Refinement of Cave Inventory Methods

As previously mentioned, the vast majority of cave inventories are currently being conducted on paper and data is transcribed into a post-inventory geodatabase (Vukelich 1995; O'Dowd and Broeker 1996; Vesley and Stock 1998; Stokes and Griffiths 2000; Walz and Spoelman 2005; DuChene 2006). This transcription of inventory data requires extra time and money, and increases human error. During this study, a progression of methodology occurred. By conducting a completely electronic inventory, data were immediately stored into a geodatabase, circumventing data transcription.

By conducting the inventory using this method, I was able to collect a wide variety of data, allowing for the ability to determine cave sensitivity and disturbance.

Cave Sensitivity

Little is known about the sensitivity of west-central Florida caves. A cave system can contain numerous features that make it sensitive to anthropogenic disturbance. A cave containing a direct aquifer connection, pristine speleothems, and endangered biota is more sensitive to human degradation than a completely dry cave containing merely breakdown. Certain cave resources demand conservation attention because of their fragile nature.

From the sample of 36 caves, a relatively wide range in cave resource sensitivity was demonstrated, as seen in Figure 23. The study includes a sample of caves from Citrus, Marion, Hernando, and Sumter counties, all of which have caves ranked high on the sensitivity index. Therefore, cave resource sensitivity is spatially well-distributed in the study area. Both public and private caves are represented throughout the ranking. However, the mean sensitivity for public caves is 0.30, while the mean sensitivity for private caves is 0.48. The difference in sensitivity between public and private caves demonstrates the need to examine other variables, as cave sensitivity itself does not indicate management immediacy without knowing the threat of human disturbance, ownership, or current management practices.

When a cave manager begins drafting a management plan for a cave, one of the foundations for the management framework is resource sensitivity. Resource sensitivity can determine passage access limitations, whether or not to gate a cave, and what kind of gate to construct. Given the limited knowledge derived from cave sensitivity scores distributed throughout the study area, other parameters must be considered.

Cave Disturbance

From the sample of 36 caves, a wide range in disturbance scores is demonstrated. In terms of ownership and spatiality, cave disturbance is well represented. The mean disturbance for public caves (0.42) and private caves (0.41) is relatively the same. Yet, there are both public and private caves that contained vast amounts of graffiti, damaged speleothems, and sedimentation. In contrast, there were also private and public caves that were virtually pristine, with localized damage to speleothems, no graffiti, and no urbanization above the cave within several kilometers.

Combining cave sensitivity and disturbance scores provides a more holistic understanding of a cave environment's current condition and management immediacy. However, as seen from the results wherein the mean disturbance for public and private caves are similar, ownership must be more closely examined in conjunction with current management status.

Ownership alone, even when combined with cave sensitivity and disturbance, does not necessarily indicate management immediacy.

There are many ways in which human activity results in the disturbance of a cave. When considering these activities, it is crucial to include both surface and subsurface disturbances. Various agricultural practices cause cave disturbance, as well as urbanization and deforestation (van Beynen and Townsend 2005). A cave is disturbed each time it is visited by a person, whether it be left-behind lint, increased carbon dioxide levels, touching walls and speleothems, or body heat (Hildreth-Werker and Werker 2006)

This project defines cave disturbance as any human-induced activity, whether surface or subsurface, that contributes to the deterioration of any feature within a cave. It is crucial to understand, the amount of cave disturbance when deciding restoration plans. It can determine whether or not to restore graphitized flowstone or walls, broken stalagmites, or damaged drapery.

Cave Sensitivity and Disturbance Indices

There are several issues that must be addressed regarding the cave sensitivity and disturbance indices. Not enough information was found regarding the population density and species richness of biota in west-central Florida caves. This resulted in a LD score for each cave of 0.14. This LD score represents a high level of confidence for each cave in terms of disturbance. However, the lack of biospeleologic data represented the need for research in this area. Without understanding the condition of cave biota, any cave inventory requires further analysis.

Both the sensitivity index and disturbance index assumed equal weight to each variable. Various researchers (Lowry et al. 1995; Montz and Evans 2001; Kedrowski 2006) argue for the use of weights in vulnerability indexing. In contrast, other researchers (Cutter et al. 2000; Chakraborty et al. 2005) argue that ranking variables by their importance is seldom agreed upon, and is therefore inappropriate. For this reason, van Beynen and Townsend (2005) reject weighting the KDI. When the cave sensitivity and disturbance indices were applied, it was impossible to imply which variables are more important, therefore, weighting was not used.

It is important to note that final scores from the cave sensitivity index and cave disturbance index should not be compared, because they are two separate and different indices that measure two separate and different aspects of a cave. Rather, cave sensitivity and disturbance scores should be considered along with ownership and current management status to better determine management priority for each cave.

Case Studies: Cave Ownership, Management, Sensitivity, and Disturbance

The complex interrelationship between cave sensitivity, disturbance, management, and ownership is best illustrated using several case studies of inventoried caves in west-central Florida. These case studies demonstrate how combining the results of sensitivity and disturbance data with ownership and management status provide a more holistic approach in determining management immediacy.

Briar Cave

Briar Cave, Marion County, Florida is privately owned and developed within the Ocala Limestone (Eocene). Pliocene and Miocene Hawthorn Group sediments and younger undifferentiated sediments overlie the Ocala Limestone in the area (Florea et al. 2003). Briar received a sensitivity index score of 0.83, which represents the wide range of sensitive resources found within the cave. After conducting the inventory, Briar contained widespread connections to the FAS; widespread, pristine speleothems including soda straws, flowstone, helictites, stalagmite, stalactites, drapery, and columns; widespread, pristine echinoids and other fossils; and cave crayfish. Several sensitive resources inventoried in Briar Cave are seen in Figures 25-27.

Figure 25. Echinoid in the Pool Room, lower level, Briar Cave.

Figure 26. Speleothems in the Endless Room, upper level, Briar Cave.


Figure 27. Lake Room in lower level (photo by Sean Roberts).

Briar also contained little human-induced disturbance, with a disturbance index score of 0.18. Few occurrences of graffiti, damaged speleothems, and damaged or removed fossils were found. Also, floor disturbances were concentrated to a single trail that is used for foot traffic throughout the cave. Furthermore, little urbanization and deforestation were present in the 1 km buffer around the cave.

Briar Cave is managed by the FSS, which is one the Florida grottos affiliated with the NSS. Due to Briar’s sensitive nature, the landowner requested that FSS manage the cave. Part of the requirement to enter the cave is to complete a waiver, so the landowner is not held liable for any accidents occurring in the cave during visitation. (Appendix C).

This site illustrates how a positive landowner-caver relationship can work toward the conservation and preservation of a cave.

Figure 28. Briar Cave gate installed by the FSS.

Of the 36 caves inventoried during this project, Briar Cave is the best example of how to manage a cave with the best intensions of protecting inherent sensitive resources. There is a secured, locked, gate at the entrance and access is restricted to one trip per month, which must be led by a member of the FSS to ensure visitors follow the management guidelines and show respect to the cave and its resources (Figure 28). Additionally, the FSS placed flagging tape around fragile speleothems that are in close proximity to the foot traffic trail and spray bottles of water near several speleothem clusters in order to rinse mud off of the formations (Figure 29). Once a month, members from the FSS make a trip to the cave in order to perform various maintenance duties, which includes: checking the water table level in the cave, rinsing mud from speleothems, replacing broken flagging tape, and ensuring the trail is clearly marked.

Figure 29. Management in Briar Cave: flagging tape and spray jug near speleothems.

These actions of cave conservation and restoration are an excellent example of how a cave should be managed. In this case, the overall management strategies have a direct association with the high sensitivity and low disturbance found during inventory. If Briar Cave was not closely monitored and access restricted, there would likely be an increase in disturbance because of the increase in visitation. Briar Cave is privately owned and contains highly sensitive resources with a management plan, resulting in a low level of disturbance. However, this is not the case for all privately owned, highly sensitive caves as shown by the next case study.

BRC Cave

BRC Cave, Hernando County, Florida is privately owned and developed within the Suwannee and Ocala Limestones. BRC Cave is perhaps the most decorated cave in Florida (Turner 2003).

> "BRC Cave, discovered in November of 2002, is like many air-filled caves of Florida in that the cave lacked a natural entrance (Turner 2003). Nothing could prepare the cavers for what lie beyond their dug entrance. Underground, BRC Cave is a wonderland of speleothems. Translucent helictites of calcite, observed only at a few sites in Florida, sprout from the wall in bushes and acquire a multitude of bizarre shapes. Snow-white stalactites and stalagmites, like giant crystal carrots, loom above shallow pools of sparkling calcite spar. Recent isotope data from two of these stalagmites has revealed a wealth of information about the climate in west-central Florida during the Holocene (Soto 2005). With more than a kilometer of mapped passages, BRC Cave is currently the 5th longest dry cave in Florida" (Florea 2006, pg. 5) (Figures 30-33).

This quotation, from Florea (2006), is a vivid description of the uniqueness of BRC Cave and is an accurate account of the inventory data. The inventory also shows the cave contained widespread drips, seeps, pools, fossils, and biota. Since its discovery in 2002, the cave has been tied up in a whirl-wind of controversy. The landowner is unconcerned with the conservation and protection of the cave on their land because of liability and plans for future development around the cave. However, to the caving community and researchers, the cave is an excellent natural laboratory, as demonstrated by Soto (2005).

Figure 30. Robert Brooks approaches a cluster of calcite helictites, BRC (photo by Bruce Brewer).

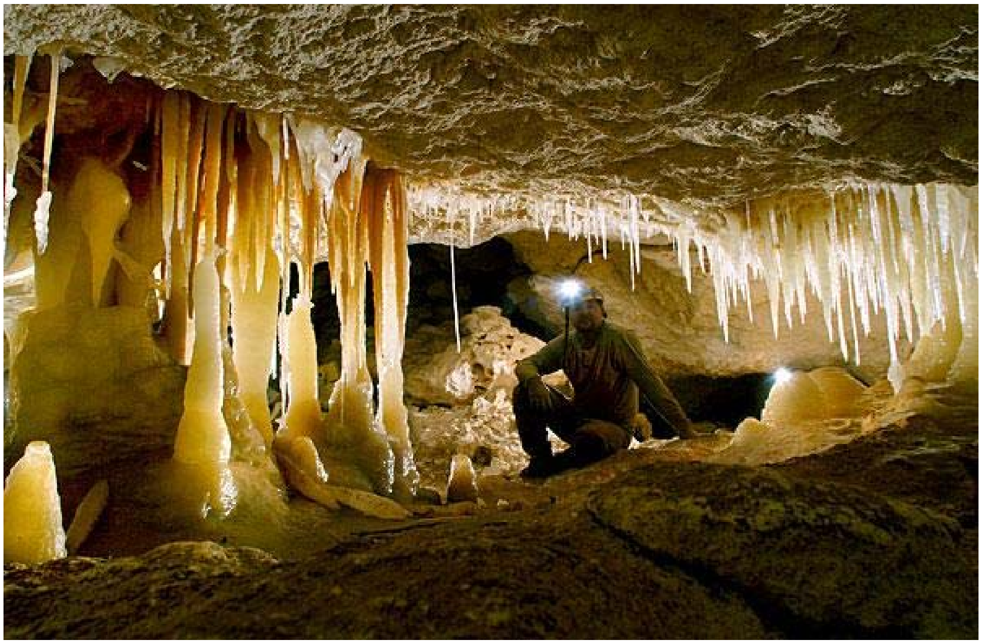

Figure 31. Robert Brooks poses amidst translucent stalactites and stalagmites, BRC (photo by Bruce Brewer).

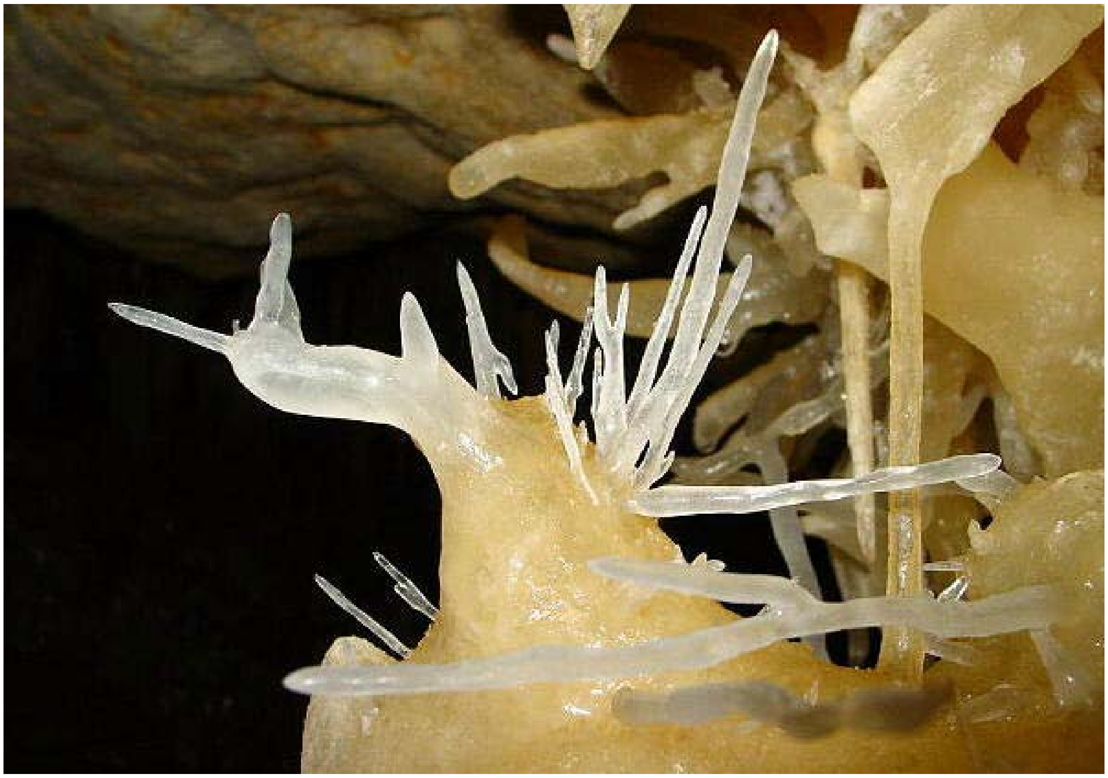
Figure 32. Delicate helictite bush, BRC (photo by Bruce Brewer).

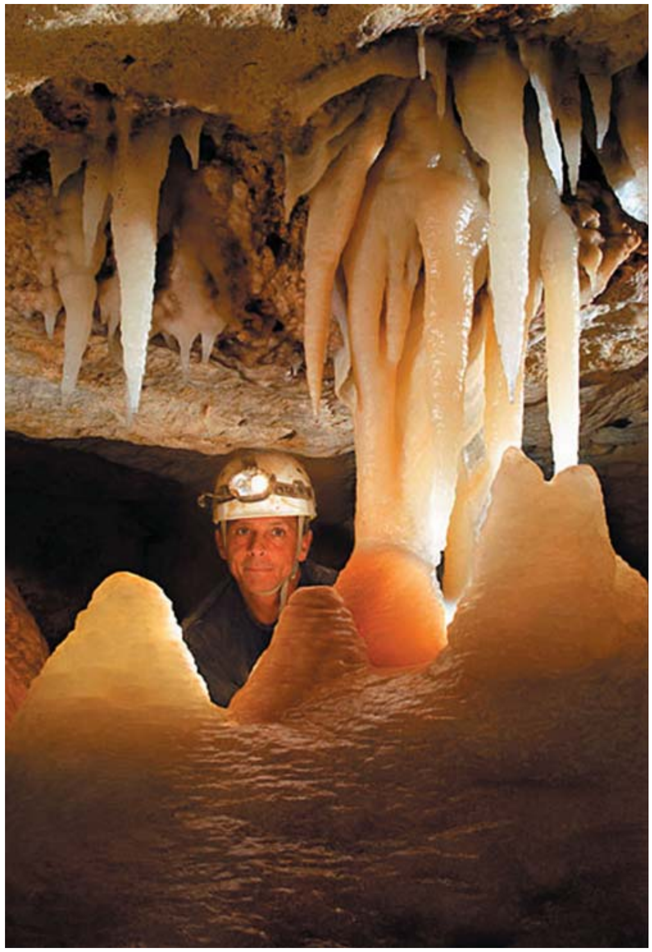

Figure 33. Tom Turner poses behind large stalactites and stalagmites, BRC (photo by Bruce Brewer).

The tragedy of BRC Cave is that it remains unmanaged. Unlike Briar Cave, caver-landowner relations are not positive. A management plan for the cave was drafted by members of TBAG and students at the University of South Florida, but was not adopted or implemented by the landowner. As a result, BRC Cave has suffered increased disturbance since its discovery (Turner, personal communication 2007). Figures 34 and 35 demonstrate before and after disturbance to sensitive resources within BRC. The before photograph of the cave entrance was taken on the night of the discovery by Tom Turner, and the after photograph was recently taken by an anonymous caver interested in the preservation of the cave. Additional photographs of BRC can be seen in Appendix G. Even though disturbance increased in BRC Cave since its discovery, the overall sensitivity of the cave remains high. In fact, BRC Cave received the highest score on the sensitivity index at 0.83, which is comparable to the sensitivity score of Briar Cave. In terms of disturbance, the cave received a score of 0.28 and ranks as the 6th least disturbed cave that was inventoried. It is important to realize that at one time, before its discovery, BRC Cave was pristine. The disturbance score would be much lower if the inventory was conducted closer to when the cave was discovered. This is an inherent flaw in the knowledge and management practices of west-central Florida caves.

Similar to Briar Cave, BRC Cave contains highly sensitive resources. However, the moderate level of disturbance found in BRC during inventory could have been mitigated by actively managing the cave. This reiterates that sensitivity, ownership, disturbance, and management status must all be considered when determining a cave's management immediacy, even when privately owned.

Figure 34. Just inside BRC entrance on night of discovery in December, 2002 (photo by Tom Turner).

Figure 35. Recent photo just inside BRC entrance after vandalism (photo by anonymous).

Blowing Hole Cave

The previous two case studies illustrated private caves with varying degrees of management and disturbance. Blowing Hole Cave is located in the WSF, which is public, state-owned land. Blowing Hole developed within the Suwannee Limestone and is considered a managed cave (Werner, personal communication 2007). The cave is not located in close proximity to any type of forestry road. In the sensitivity index, Blowing Hole Cave ranks as one of the two most sensitive caves in the WSF with a score of 0.56. It contained widespread speleothems, drips, seeps, and pools in multiple locations, multiple individuals of a single species, and mineral deposits other then calcite in multiple locations (Figure 38). However, the cave was found to be moderately disturbed, with a score of 0.45. Blowing Hole contained graffiti, damaged speleothems, and damage fossils in multiple locations, as well as widespread floor disturbances, localized speleothem desiccation, and agriculture and urbanization covered 0-19% of the proximity buffer around the cave (Figures 36 and 37).

Figure 36. Desiccated stalagmite, Railroad Tunnel Passage, Blowing Hole Cave.

Figure 37. Phil van Beynen stands in front of graffiti near Blowing Hole Cave entrance.

Figure 38. Seeping drapery, Formation Room, Blowing Hole Cave.

Even though Blowing Hole is considered a sensitive, managed cave, the current management status must be considered when determining the management priority of the cave. Blowing Hole was gated several years ago by a collaborative effort between the WSF and Tampa Bay Area Grotto (Figure 39). The state forest also requires a special use permit for anyone wishing to enter the cave, and it remains closed to visitation from May through October for bat maternity season (Appendix D). However, most of the disturbance to Blowing

Hole Cave happened before the gate was constructed and access controlled, for it has been a well-known cave for decades (Werner, personal communication 2007). Since a management strategy was not implemented at the cave's discovery, this resulted in the moderate level of disturbance found in Blowing Hole. Thus, a detailed examination of sensitivity, disturbance, management status, ownership, and the social context of the cave within the community is needed in order to understand management priority.

Figure 39. Blowing Hole Cave gate installed by TBAG and Withlacoochee State Forest.

Peace Sign Cave

Peace Sign Cave is also a public cave located in the WSF, however it remains unmanaged. Unlike Blowing Hole Cave, Peace Sign is located in close proximity to a paved road and parking lot, and a clearly marked trail leads recreational weekend cavers directly to the site. Separate studies on the geomorphology and sedimentology were conducted in the past (Brinkmann and Reeder 1993; 1994; Wood 1996). Peace Sign Cave is a part of the Dames Cave area, a group of caves all within a couple meters from each other that probably once existed as a single cave system (Brinkmann and Reeder 1994). Peace Sign is developed within the Suwannee Limestone (Oligocene), which overlies the Ocala Limestone (Eocene) in the area. Brinkmann and Reeder (1994) suggest that the cave formed from phreatic movement when the water table was higher during the Cenozoic. It is possible the cave formed from mixing-zone corrosion, which is a condition where lenses of fresh water and salt water meet to enhance dissolution of rock (Brinkmann and Reeder 1994).

Regardless of the cave's formation process, it has been a popular destination for many recreationists for over 60 years (Turner, personal communication, 2007; Werner, personal communication, 2007). The WSF currently treats Peace Sign Cave as "open access," which means people wishing to visit the cave are not required to have a special use permit, unless you are part of a group (e.g. Boy Scout trip). It is not uncommon to see numerous recreationists at Peace Sign Cave during the weekend. In fact, while conducting the inventory, I noticed at least 15 people who were there to visit the cave system. As a result of the cave's lack of management, over the years, recreationists have highly disturbed the cave environment. Peace Sign Cave ranks as one of the most disturbed caves in the WSF, with a score of 0.56. In fact, the cave is the fourth-most disturbed cave in the entire dataset. Widespread graffiti, damaged speleothems, widespread trash abound (Figures 40-43). The cave contained a localized drip in the main passage, and floor disturbances were catastrophic with holes, trenches, and high sediment compaction. Furthermore, cave sedimentation in the cave has increased over the years and remains at a high level due to the construction of dirt roads by the WSF. The roads tend to be topographically low, thus acting as ephemeral stream beds that transport water and sediment to the cave during high energy rainfall events (Brinkmann 1993).

Peace Sign Cave is highly disturbed and has a low level of sensitivity. The cave received a score of 0.22 on the sensitivity index because biota, speleothems, mineral deposits, and fossils were absent during inventory. However, one localized drip was noticed and the cave is recognized as an archaeological site on the Florida Master Site File. At one point in time, Peace Sign Cave was a pristine environment of dripping soda straws, stalactites, stalagmites, drapery, and flowstone. However, through the years, vandals and over-visitation have destroyed the cave due to its lack of management. Although the WSF is managed land, the caves are unmanaged because their sensitivity and disturbance are unknown.

In this case, the management protection of the land does not extent into the subsurface.

Figure 40. Jason Polk poses in front of widespread graffiti, Peace Sign Cave.

Figure 41. Jason Polk kneels beside four damaged stalagmites, Peace Sign Cave.

Figure 42. Hundreds of damaged/removed soda straws and graffiti, Peace Sign Cave.

Figure 43. Trash in main passage, Peace Sign Cave.

Using Inventory Data to Determine Management Priority

Given the lack of information regarding cave contents, sensitivity, and disturbance of caves in west-central Florida, the inventory data presented in this thesis are intended to be a guideline to progress cave management in the study area. This progression of cave management is aided by determining the management priority of caves based on several factors: cave sensitivity, disturbance, inherent resources, and current management status. The case studies illustrate the sensitivity of a cave differs from the amount of disturbance found in a cave. Additionally, BRC and Briar Cave are privately owned, yet their management statuses differ. The case study data also show publicly owned caves differ in sensitivity, disturbance, and management status.

Ultimately, management priority depends on the objectives of the person or group of people wishing to draft a management strategy. Some of these objectives include conservation or restoration of the cave as a whole, as well as the conservation or restoration of an individual resource within a cave, such as an endangered species, or rare speleothems. Therefore, when determining management priority, one cannot only consider the current sensitivity or disturbance score a cave received on the index. Rather, cave sensitivity, disturbance, resource data, ownership, and current management practices should be studied in detail before making decisions of management priority and developing management plans.

For example, if cave conservation is the objective of the management strategy, caves with higher sensitivity scores would likely hold priority over caves with lower scores. In contrast, if the objective of management is restoration, caves with higher disturbance scores would likely hold priority over caves with lower scores. However, in reality, it is unlikely for a management strategy's goal to only consider conservation or restoration, which is why it is necessary to use a holistic management strategy.

Since cave management depends heavily on the objectives of the person or group wishing to formulate a management strategy, any inventory needs to produce malleable data. By using a refined cave inventory, the data in this thesis serves both as a database of cave resources and is used to determine sensitivity and disturbance of a cave system. In combining sensitivity and disturbance scores with an assessment of current management practices and ownership status, this approach provides a guide to management priority.

Cave Management Policy

Before a management strategy for a cave is developed, a cave must be understood as a natural, living system. "Our conservation ethic must be born out of understanding caves as natural processes—as systems that are greater than the sum of their parts" (Kerbo 2006, pg. 1). Cave management, or best management practices, is a multi-faceted consideration that extends beyond visiting a cave once and conducting an inventory. An inventory is a crucial part of any conservation ethic, but it will not suffice on its own. Even though a cave is considered “managed,” it does not mean the cave is protected.

Like Briar Cave, Jenning’s Cave, Marion County, Florida, is another example of a private, managed cave by the FSS. Jenning’s Cave developed within the Ocala Limestone and received a sensitivity score of 0.50 and a disturbance score of 0.53. A management plan for the cave was drafted, adopted, and implemented. A gate was constructed in the entrance and the management plan stipulates that access is controlled to 15 cavers per trip, to be led by a FSS member. However, unlike Briar Cave, the management plan is not actively enforced and the gate is never locked. Even though Jenning’s Cave appears as a “managed” cave on paper, the best management practice is not being actively enforced, which is the key to cave and karst conservation and protection.

Developing a cave management strategy adheres to the general model of the environmental policy process, as described in Vaughn (2007). First, a problem is identified. In this stage, an inventory is conducted to better understand and document the current condition of a cave system. Next, a management plan is drafted. After considering all aspects of cave conservation and restoration, a management strategy is outlined by a group of cave specialists. After the management plan is drafted, it must be adopted by the landowner or cave manager. Following the adoption of the plan, the management strategy must be implemented and actively enforced. Enforcement includes restricting access, monitoring sensitive resources, and restoration processes. Finally, the management strategy must be continually evaluated to ensure the protection of the cave.

Jenning’s Cave is a disastrous example of a “managed” cave for several reasons: 1) the gate is never locked; 2) access is not controlled; and 3) graffiti removal did not follow best management practices (Figure 44). In the recent past, the FSS attempted to remove graffiti from the walls of Jenning’s. As a solution, they heavily pressure-washed the walls of the main passage, which is not an accepted method of graffiti removal because of the potential damage to microbial habitats and general destructive nature to cave walls (Hildreth-Werker and Werker 2006).

Perhaps Jenning’s Cave is not actively enforced because the FSS lacks certain resources, like money, time, or personnel. Similar obstacles are involved with the management of public caves in the WSF. The lack of money, personnel, and cave knowledge are the possible factors inhibiting progress in WSF cave management. The WSF relies on monies allocated by the state of Florida to operate. Unfortunately, terrestrial caves are low on the list of WSF natural resources. The WSF does not currently staff a cave specialist, therefore, personnel with cave knowledge are limited (Werner, personal communication 2007). However, cave management in the WSF is progressing. In the recent past, the WSF was able to collaboratively construct, with the Florida Fish and Wildlife Conservation Commission, a fence around three caves that are known habitats for the southeastern bat: Trail 10, Werner, and Big Mouth. This offers some form of protection, but is not holistic in its conservation approach. This further illustrates when determining cave management priority, the current status of cave management must be included in the examination.

Figure 44. Jenning's Cave, Main Passage. Note the destruction from pressure-washing the walls of the passage.

The Complexities of Cave Management

One of the goals of this study was to determine how ownership and current management status affect the overall management priority of a cave. The answer to this question depends on many factors regarding a cave, or group of caves, and varies across regional landscapes, states, or even countries. Due to the uniqueness of individual caves, perhaps it is best to approach the question at a regional level, as the caves inventoried within this thesis have demonstrated the complex relationship between caves, community, and landscape.

The process of managing a cave transcends ownership. Sensitivity and disturbance must be considered before management immediacy can be determined. However, the ownership of a cave, whether public or private, may dictate the ease with which a management plan is implemented and enforced. My results show several caves within the study area are highly sensitive, yet remain unmanaged. The mean disturbance score is the same for public and private caves, yet management status differs throughout the study area. Privately owned caves remain unmanaged, yet are still highly sensitive and undisturbed. Publicly owned and well-managed caves are not sensitive, yet are still highly disturbed. Consequently, neither the sensitivity, disturbance, ownership, nor management status of a cave solely indicates management priority. Rather, the management priority of caves in west-central Florida depends on a number of complicated, interwoven factors, and the goal of management must be examined holistically. Each cave must be individually examined for its sensitivity, disturbance, resources, management, and social and physical context in order to gain an understanding of management immediacy (Table 10).

Rank	Name	Ownership	SI Score	DI Score	Justification
1	BRC	Private	0.83	0.28	widespread speleothems; rare helictite formations, cave pearls; development threats; recent vandalism; management plan drafted, but landowner not cooperating; remains unmanaged
2	Belleview Formation	Private	0.66	0.42	highly decorated; entire cave area deforested; immediate cave area used as cattle land; recent threats to fill cave in and develop over cave; cave not managed
3	Ocala Caverns East	Private	0.33	0.63	unclear of landowner intentions for cave; property fenced in but a couple holes in fence offers easy access; no gate; widespread direct connection to aquifer; abundant troglobitic crayfish; frequent trips by scouts
4	Sneak	Private	0.44	0.30	located in active quarry; blind minnows and several species of troglobitic crayfish; direct aquifer connection; no gate.
5	Goat Mummy	Private	0.61	0.50	past quarry practices opened large entrance, likely caused condensation corrosion; large southeastern bat roost; wide variety of speleothems; rare helictites; perhaps largest speleothem in Florida; unidentified mineral deposits on wall; no gate
6	Thornton's	Private	0.61	0.26	no protection; southeastern bat roost; widespread direct aquifer connections; fish in deep water area; acts as estevelle between Gum Slough and Withlacoochee River; unidentified mineral resource: "corn flakes."
7	Maynard's	Private	0.44	0.42	recent developmental threats from Sun Coast Highway; human skull found few decades ago, but not documented-archaeological excavation needed; speleothems; possible largest chamber in Florida; no gate; no management plan
8	Girl Scout	Public	0.28	0.63	no gate; treated as open access; sedimentation filling in cave; cave is arch-site for cultural resources; no management plan

Table 10. Example of management priority list of west-central Florida caves included in this study. The issue is more complex than determining sensitivity and disturbance for each cave.

Rank	Name	Ownership	SI Score	DI Score	Justification
9	Peace Sign	Public	0.22	0.56	treated as open access; sedimentation filling in cave; cave is arch-site for cultural resources; no gate or management plan
10	Sick Bat	Public	0.28	0.56	no gate; treated as open access; sedimentation filling in cave; cave is arch-site for cultural resources; no management plan
11	Vandal	Public	0.28	0.56	no gate; treated as open access; sedimentation filling in cave; cave is arch-site for cultural resources; no management plan
12	Bottle Cap	Public	0.61	0.36	newly discovered, pristine speleothems; area quarried in 1960s, but no longer active; bat roost found near entrance, but no bats-possible maternity site; no gate or management plan
13	Crumbling Rock	Private	0.78	0.25	shrimp-like invertebrate found, currently being identified; crayfish; aquifer connections; speleothems; secure, locked gate; surveillance cameras; no management plan
14	Briar	Private	0.83	0.18	widespread speleothems; aquifer connections; fossils; unique size of passages; secure, locked gate; managed, but needs best management practices implemented
15	Turpentine	Private	0.72	0.17	newly discovered passage added 70+ meters to original survey; rare species of shrimp-like invertebrate found in aquifer; troglobitic crayfish; aquifer connection; no gate; no management plan
16	Big Mouth	Public	0.33	0.37	fenced and locked; bat maternity site; crayfish currently being identified by DNA test; unique entrance size; no gate; no management plan

Table 10. (continued)

Rank	Name	Ownership	SI Score	DI Score	Justification
17	Werner	Public	0.61	0.37	fenced and locked; bat maternity site; once believed to have bat population up to 10,000, but numbers have declined over recent years; habitat to certain tick that lives only on southeastern myotis; species of crayfish currently being DNA tested for identification; no management plan
18	Legend	Public	0.61	0.44	area quarried in 1960s, but no longer active; no gate; active speleothems; widespread bones; active dig in back room-possible connection to Bottle Cap; no management plan
19	Jenning's	Private	0.50	0.53	southeastern bat site; unique size-most passage allows walking; seasonal pool; gate installed, but never locked; great educational resource; management plan, but not actively enforced
20	Jeep	Public	0.05	0.39	close to hiking trail; widespread graffiti, but contains historic graffiti on wall; no gate; no management plan
21	Jackpot	Public	0.56	0.11	pristine fish fossil in wall; aquifer; close proximity to another cave which is well-known; technical entrance, so not likely enterable by many people; no gate; no management plan
22	Finch's	Private	0.44	0.26	unique size of passages; aquifer connections; no gate; no management plans; fossils; bones
23	Football	Private	0.55	0.48	unique size of passages; speleothems; intermittent stream from surface; developmental threats; no gate; no management plan

Table 10. (continued)

Rank	Name	Ownership	SI Score	DI Score	Justification
24	Trail 10	Public	0.33	0.31	fenced and locked; bat maternity site; unknown biological invertebrates that live on guano-biological study needed; no gate; no management plan
25	Blowing Hole	Public	0.56	0.45	bat maternity site; speleothems; widespread hydrologic influence; secure, locked gate; no management plan
26	Dog Drop	Public	0.22	0.33	no gate; safety hazard because of entrance pit drop; bones
27	Quarter	Public	0.11	0.37	current dig in cave, but safety hazard because of unstable condition; no gate
28	Rattlesnake	Public	0.16	0.53	current dig in cave, but safety hazard because of unstable condition; no gate
29	Indigo	Public	0.06	0.33	current dig in cave, but safety hazard because of unstable condition; no gate
30	Heroine	Private	0.00	0.63	no gate; safety hazard
31	Hitchhiker	Private	0.17	0.64	surrounded by urban area; no protection/gate; hydrologic study needed; unique entrance size
32	Holy Oak	Public	0.17	0.44	no gate; visible entrance, no management plan
33	Reuff's	Private	0.06	0.37	located in active quarry; no gate; no management plan; frogs and crickets
34	Fallen Oak	Public	0.06	0.37	no gate; bones; no management plan
35	Ocala Caverns West	Private	0.16	0.70	once a show cave mid-century - historical value; no gate; no management plan
36	Floating Rock	Public	0.22	0.44	aquifer connections; biota; entrance filled in by sediment caused by past quarry mining; no management plan; required further study for best management practices

Table 10. (continued)

The list of caves displayed in Table 10 is intended to illustrate the complexities behind ranking caves by management priority. Based on a detailed description of cave contents, sensitivity, disturbance, current management status, and the social and physical context of a cave within the landscape, it is possible to rank caves by management priority. This complex system relies on the inclusion and balance of quantitative and qualitative data, which together make it possible to better understand a cave before a management plan is implemented, actively enforced, and analyzed.

Chapter Six: Conclusions

The goal of this project was to develop an inventory to rank caves in west-central Florida by management immediacy, based on relative sensitivity and disturbance. The novel measures developed in this research, which include the GIS-based cave inventory, cave sensitivity index, and cave disturbance index, were used to gain an understanding of the management priority of west-central Florida caves. Through analysis of the results, it became evident that by relying solely on sensitivity and disturbance scores, management immediacy may not be accurately determined. Further examination revealed that ownership and management status also affect management immediacy. The management of caves can serve to mitigate human disturbances and preserve cave sensitivity; however, cave management is a complex and controversial issue.

Since the 1700s, methods of systematically cataloguing the features and resources within caves have evolved (DuChene 2006), yet many inventories still involve the tabulation of cave resources on paper (Mylroie 1978, 1979, 1981; Smith 1981; Brown and Kirk 1999; Douglas 1999; Stokes and Griffiths 2000). More sophisticated techniques of cave inventory include the use of GIS; however, these inventories use GIS to store and analyze data, not to collect data in the field (Despain and Fryer 2002; Ohms and Reece 2002; Horrocks and Szukalski 2002; Walz and Spoelman 2005).

This thesis steps beyond these methods to a fully-functional GIS-based, paperless inventory system with the goal of ranking caves by management priority. Understanding the relative sensitivity and disturbance of a cave system is a critical step toward understanding management strategies. This thesis posed three questions:

1. Can current cave inventory methods be adapted to make data collection more efficient?
2. Can cave sensitivity and disturbance be used to determine management priority?
3. How do ownership and current management status affect the overall management priority of a cave?

To answer these questions, I used mobile GIS to collect data on cave features, sensitivity, and disturbance. After the data was collected, it was stored and analyzed in a desktop GIS.

The first part of this project involved the analysis, development, and refinement of cave inventory methodology, in order to suite the needs of this study. The most widely accepted cave inventory data collection method is the paper inventory form and pencil, which was used during the beginning stages of this project. However, after conducting the inventory in less than favorable conditions, I realized this method of data collection was not suitable for this study. Therefore, a change from a manual data collection method to a completely electronic inventory was made. By using GIS to collect inventory data in the field using a PDA and ArcPad 7.1, I was able to efficiently collect and transfer data directly into a GIS geodatabase, without the need for countless hours of data input from paper forms. This development in methodology saved time and human error, and was an advantage throughout this project.

Once data was collected in the field and stored in a desktop GIS, caves were ranked by sensitivity and disturbance scores in an attempt to understand management priority. The application of the inventory to 36 terrestrial caves in west-central Florida provided a vast geodatabase of data. Of the 36 caves included in the dataset, 17 are located on private property and 19 are located on public land. The inventory demonstrates a wide range of cave sensitivity and disturbance in the study area. BRC Cave and Briar Cave received the highest sensitivity score in the dataset (0.83). The lowest sensitivity score, 0.00, was given to one cave (Heroine). In terms of disturbance, Jackpot Cave received the lowest disturbance score (0.11) and Ocala Caverns West received the highest disturbance score (0.70).

Cave sensitivity and disturbance are crucial when considering the management priority of a group of caves, like in the study area. However, they cannot be used alone to determine which caves hold priority over others, for many other factors are involved. Current management strategies, ownership, and objectives of the cave manager(s) must also be considered. In the context of this research, data from caves in the WSF serve as a step towards progressing best management practices, which is virtually devoid of such conservation ethics.

The final goal of this thesis was to assess how ownership and current management status affect the overall management priority of a cave. The four case studies discussed in Chapter Five (Briar, BRC, Blowing Hole, and Peace Sign Cave) demonstrate the wide range of sensitivity and disturbance of caves in terms of management and ownership. Consequently, neither the sensitivity, disturbance, ownership, nor management status of a cave solely indicates management priority. Rather, the management priority of caves in west-central Florida depends on a number of complicated, interwoven factors, and the goal of management must be examined holistically. Each cave must be individually examined for its sensitivity, disturbance, resources, management, and social and physical context in order to gain an understanding of management immediacy.

During this study, each cave was inventoried once, providing a “snap-shot” of cave features, sensitivity, and disturbance. The possibility of missing certain biological species, or conducting the inventory during a drought could give a false impression of the condition of cave hydrology. Therefore, the detailed descriptions of cave contents, sensitivity, and disturbance scores noted during inventory are not an accurate representation of the cave over time.

Treating a cave inventory as an open-ended project provides a more accurate depiction of cave features, sensitivity, disturbance, and resources. Caves were inventoried once because time was a factor during this thesis; however, inventory data should be recorded on a regular basis. This reduces subjectivity and allows for cave resources and characteristics to be more accurately represented in an inventory and monitored over time. In the context of this study, the data gathered for public caves will be given to WSF personnel and used to draft management plans for priority caves, which are determined by their objectives.

This study revealed the need for both private and public cave management in west-central Florida in order to ensure the conservation and protection of sensitive cave resources. This thesis provides a step towards progressing cave management in the study area. The inventory is a tool with the ability to produce the information needed to accurately assess cave management priority. Yet, to date, no county or state law exists regarding the conservation and protection of terrestrial caves. In order to ensure the conservation and protection of caves in west-central Florida, support from county or state government, combined with cave inventory data, is crucial in developing sound policy regarding the management of terrestrial caves.

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Appendix A: Geodatabase Data Dictionary

Appendix A: Geodatabase Data Dictionary

Name	All known names of cave
Inv_Date	Date the inventory was conducted
Inv_ID	Unique ID given to each cave for geodatabase identification
Township	Township in which cave is located (Public Land Survey System)
Range	Range in which cave is located (Public Land Survey System)
Section	Section in which cave is locate (Public Land Survey System)
County	Florida county in which cave is located
Personnel	People who conducted inventory
Cave_Ownership	Ownership of cave. Values = Commercial, Private, Public, Government Park, Unknown Status
Equipment_Needed	Equipment needed to cave. Values = Boat or Floatation, Diving Equipment, Handline, Kneepads, Cable ladder, Normal Speleo Gear, Shovel-Blasting, Rope or Vertical Equipment, Other special equipment, Unknown, Wet-Suit, Mask/snorkel, None, NA
Other_Equipment_Needed	Same values as "Equipment needed" to list multiple equipment needs
Elevation_masl	Elevation of cave entrance in meters above sea-level
Cave_Map_Status	Current status of cave map. Values = Improved map, New map/survey, Redraw of old map, In progress, No map, Complete map, Sketch only, not to scale
Cave_Length_m	Current surveyed length of cave
Cave_Vertical_Extent_m	Current surveyed vertical extent of cave
Management_Notes	Notes pertaining to the management of cave
Entry_Status	Accessibility of cave. Values = Fees charged for entry, Destroyed or closed, Forbidden by owner, Locked/Gated, Navigable Waterway, Opwn access, Permission required, Waiver required, Temporarily blocked, Unknown status, NA

Appendix A: (Continued)

Multiple_Entrances	Indicates whether there are multiple entrances to cave. Values = Y (Yes) or N (No)
Type_Of_Entrance_Vertical	Indicates type of cave entrance if vertical. Values = Artificial shaft, Bottleneck/small but bells out, Chimney/climb, Very wide pit (+20 ft), Pit, Tight pit, Enlarged fissure, Tight squeeze, NA
Type_Of_Entrance_Horizontal_Or_Downward_Sloping	Indicates type of cave entrance if horizontal or downward sloping. Values = Large horizontal (+ 20 ft), Stoop/duck walk, Crawl, Artificial tunnel, Tight squeeze, NA
Entrance_Topo_Position	Describes the topographic position of the cave entrance. Values = Sinkhole, Hillside, Topographic low, Hilltop, Quarry, Floodplain
Ent_Visibility	Indicates visibility of cave entrance. Values = Clearly visible, Obscured by vegetation, Obscured by rocks
Entrance_Modification	Describes any modifications made to the cave entrance. Values = Widened, Artificial entrance, Gated, Road construction, Quarry, Blocked, Dug out/open
Ent_Min_Size	Indicates the minimum size of cave entrance. Values = Squeeze, Crawl, Stoop, Walk, Vertical drop
Ent_Drop_Depth	Depth of entrance drop if vertical in meters
Ease_Of_Access_Score	Describes the general ease at which a person can access the cave. Values = 1-5
Entrance_Notes	Any notes relating to cave entrance
Passage_Orientation	List of the majority of passage orientations in cave. Values = N-S, E-W, NE-SW, NW-SE, NE-SW & NW-SE, NE-SW & NW-SE & N-S & E-W
Passage_Types	List of the passage types in cave. Example: values could be enlarged fissure, key hole, plus-sign, breakdown, and/or phreatic.

Appendix A: (Continued)

Passage_Min_Sizes	List of all general sizes of passages in cave. Example: values could be squeeze, crawl, stoop, and/or walk
Passage_Hydrology	List of all hydrological resources in cave. Example: seeps, drips, pool, aquifer
Passage_Floor	List of all floor types in cave. Example: sediment, clay, breakdown, etc.
Passage_Hazards	List of all possible hazards in cave and location. Example: guano, unstable breakdown, steep drop, etc.
Passage_Notes	Notes pertaining to passage characteristics
Tites_Mites_Columns_Condition	Location of any stalactites, stalagmites, or columns and condition (depositing, dry, damaged)
Drapery_Condition	Location of drapery and condition
Helictites_Condition	Location of helictites and condition
Rimstone_Condition	Location of rimstone and condition
Popcorn_Condition	Location of popcorn and condition
Flowstone_Condition	Location of flowstone and condition
Spar_Condition	Location of spar and condition
Calcite_Coating	Location of calcite coating and description
Calcite_Rafts	Location of calcite rafts and description
Ripple Marks/Scallops	Location of ripple marks and/or scallops
Anastomosen	Location of anastomosen
Sediments	Describes sediments in cave. Example: sorted, unsorted, clay, fine lamination, organics present
Sediment_Notes	Any notes relating to cave sediments
Fossils	Location and description of fossils
Bones	Location and description of bones

Appendix A: (Continued)

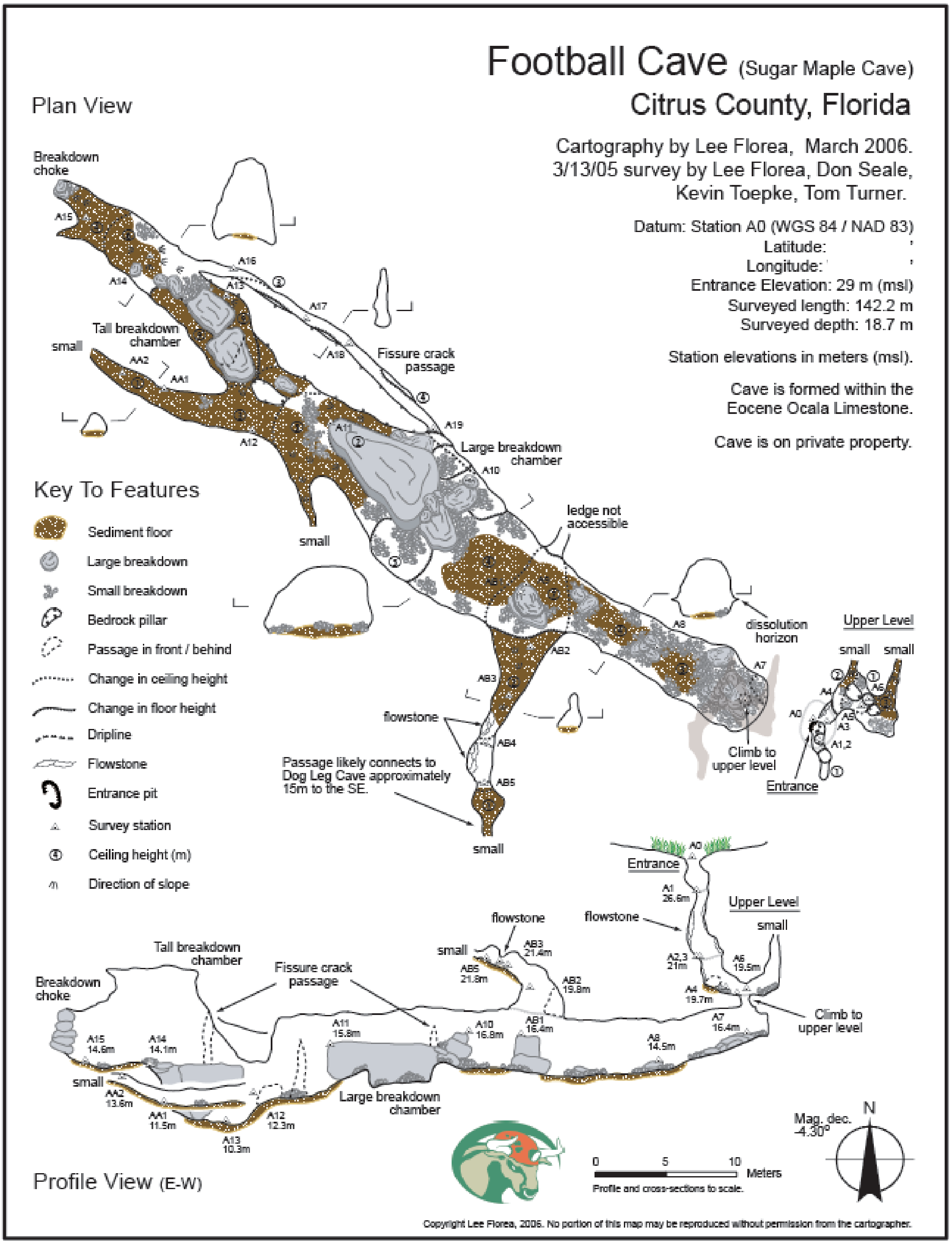
Geologic_Strata	Geologic unit found in cave. Values = Ocala limestone (Eocene), Suwannee Limestone (Oligocene), Avon Park Formation (Middle Eocene), Tampa Member (Arcadia Formation)(Upper Oligocene-Lower Miocene)
Other_Geologic_Strata	Other geologic unit found in cave. Same values as "Geologic_Strata"
Geologic_Notes	Any notes for geology of cave
Biological_Vertebrates	List and location of biological vertebrates
Biological_Invertebrates	List and location of biological invertebrates
Mold_Bacteria	List and location of any mold or bacteria in cave
Roots	Location of roots in cave
Roost Stains	Location of roost stains in cave
Guano Piles	Location of guano piles in cave
Biological_Notes	Any notes pertaining to cave biology
Artifcats_Historical	List and location of possible historical artifacts in cave
Cultural_Notes	Any notes pertaining to possible cave artifacts
Scientific_Potential_Areas_Notes	Notes for scientific potential areas (location and description)
Special_Interest_Areas_Notes	Notes for special interest areas that have no scientific potential (location and description)
Si_Biota	Cave sensitivity index Biological variable score. Values = 0-3
SI_Hydrology	Cave sensitivity index Hydrology variable score. Values = 0-3
SI_Speleothems	Cave sensitivity index Speleothems variable score. Values = 0-3
SI_Mineralogy	Cave sensitivity index Mineralogy variable score. Values = 0-3
SI_Paleontology	Cave sensitivity index Paleontology variable score. Values = 0-3
SI_Cultural	Cave sensitivity index Cultural variable score. Values = 0-3
SI_Score	Aggregate sensitivity score compiled for each cave. Represents relative sensitivity of cave to human disturbance. Values range from 0-1.

Appendix A: (Continued)

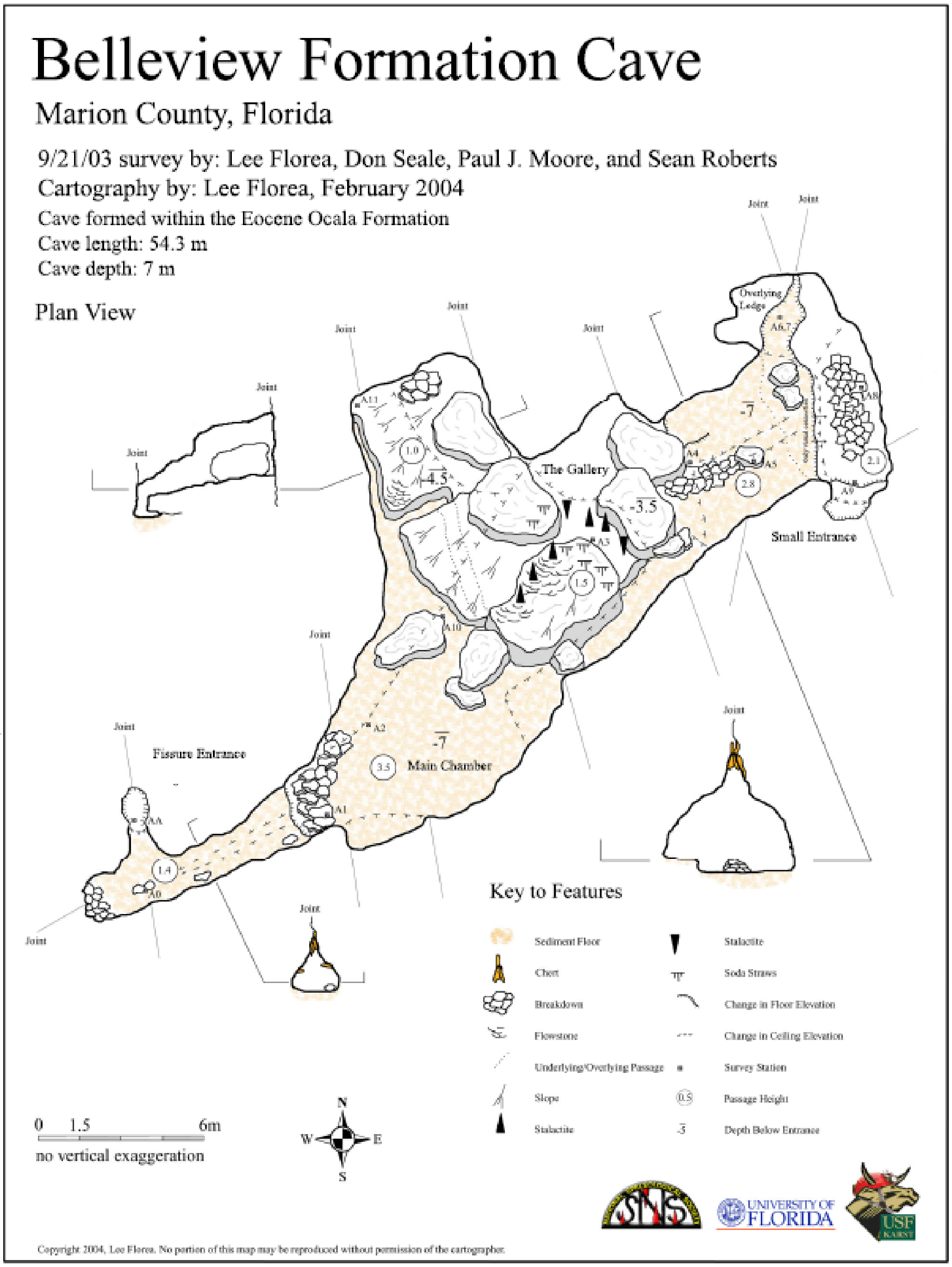
DI_Speleothems	Cave disturbance index Damaged Speleothems variable score. Values = 0-3; LD; NA
DI_Graffiti	Cave disturbance index Graffiti variable score. Values = 0-3; LD; NA
DI_Trash	Cave disturbance index Trash variable score. Values = 0-3; LD; NA
DI_Floor_Dist	Cave disturbance index Floor Disturbance variable score. Values = 0-3; LD; NA
DI_Cultural	Cave disturbance index Destroyed Cultural variable score. Values = 0-3; LD; NA
DI_CC	Cave disturbance index Condensation Corrosion variable score. Values = 0-3
DI_Desiccation	Cave disturbance index Desiccation variable score. Values = 0-3; LD; NA
DI_Sedimentation	Cave disturbance index Sedimentation variable score. Values = 0-3; LD; NA
DI_Biota_Pop_Den	Cave disturbance index Biota Population Density variable score. Values = 0-3; LD; NA
DI_Biota_Spec_Rich	Cave disturbance index Biota Species Richness variable score. Values = 0-3; LD; NA
DI_Fossils	Cave disturbance index Fossils variable score. Values = 0-3; LD; NA
DI_Deforestation	Cave disturbance index Deforestation variable score. Values = 0-3; LD; NA
DI_Urbanization	Cave disturbance index Urbanization variable score. Values = 0-3; LD; NA
DI_Agriculture	Cave disturbance index Agriculture variable score. Values = 0-3; LD; NA
DI_Score	Aggregate disturbance score compiled for each cave. Represents the approximate human-induced disturbance in each cave. Values range from 0-1.

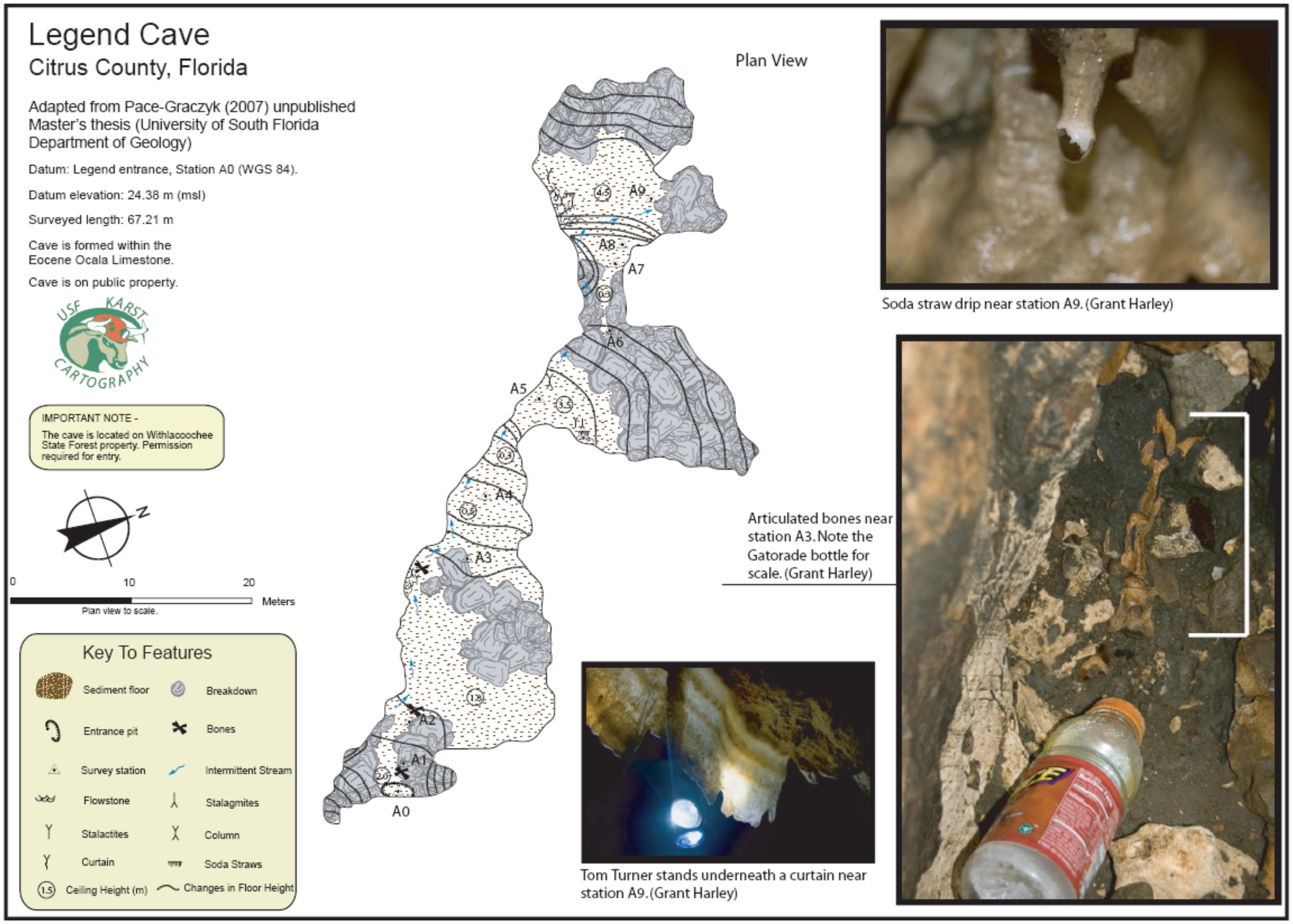
Appendix B: Cave Maps

Appendix B. Cave Maps

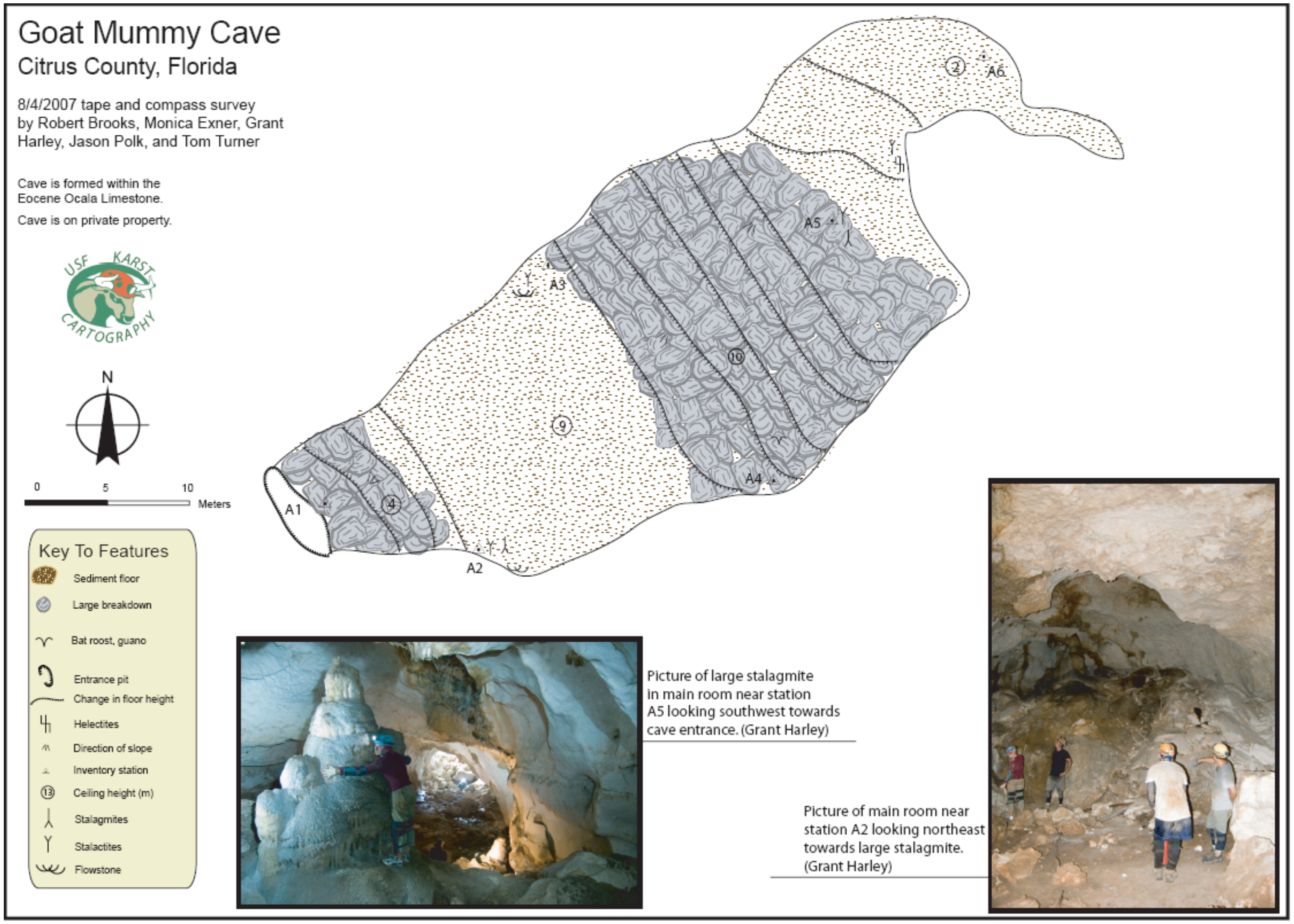


Appendix B: (Continued)



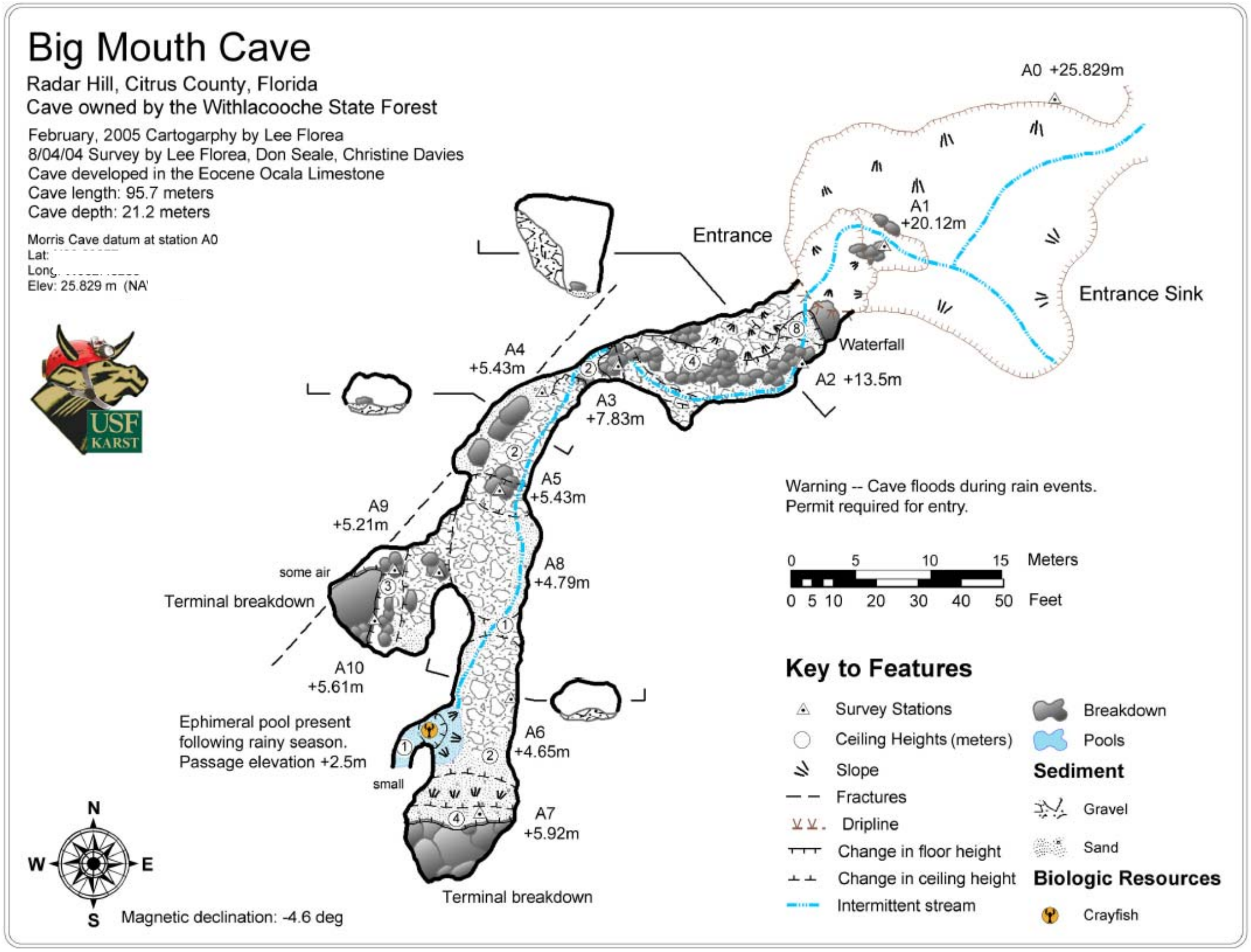

Legend Cave
Citrus County, Florida
Adapted from Pace-Graczyk (2007) unpublished Master's thesis (University of South Florida Department of Geology)
Datum: Legend entrance, Station A0 (WGS 84).
Datum elevation: 24.38 m (msl)
Surveyed length: 67.21 m
Cave is formed within the Eocene Ocala Limestone.
Cave is on public property.
USF KARST CARTOGRAPHY
IMPORTANT NOTE -
The cave is located on Withlacoochee State Forest property. Permission required for entry.
N
0
10
20
Meters
Plan view to scale.
Key To Features
Sediment floor
Breakdown
Entrance pit
Bones
Survey station
Intermittent Stream
Flowstone
Stalagmites
Stalactites
Column
Curtain
Soda Straws
Ceiling Height (m)
Changes in Floor Height
Plan View
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
Soda straw drip near station A9. (Grant Harley)
Articulated bones near station A3. Note the Gatorade bottle for scale. (Grant Harley)
Tom Turner stands underneath a curtain near station A9. (Grant Harley)

Appendix B: (Continued)

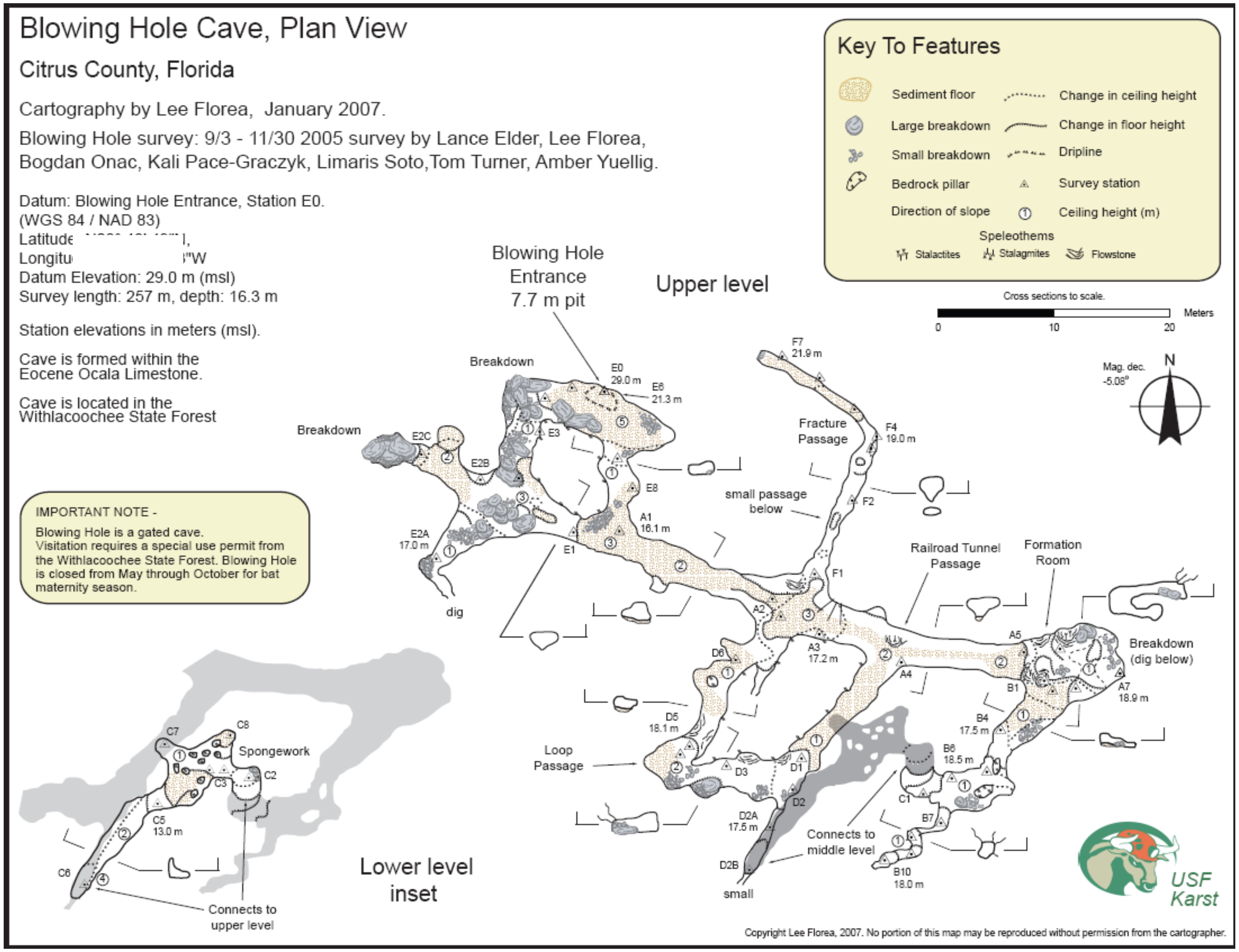


Picture of large stalagmite in main room near station A5 looking southwest towards cave entrance. (Grant Harley)

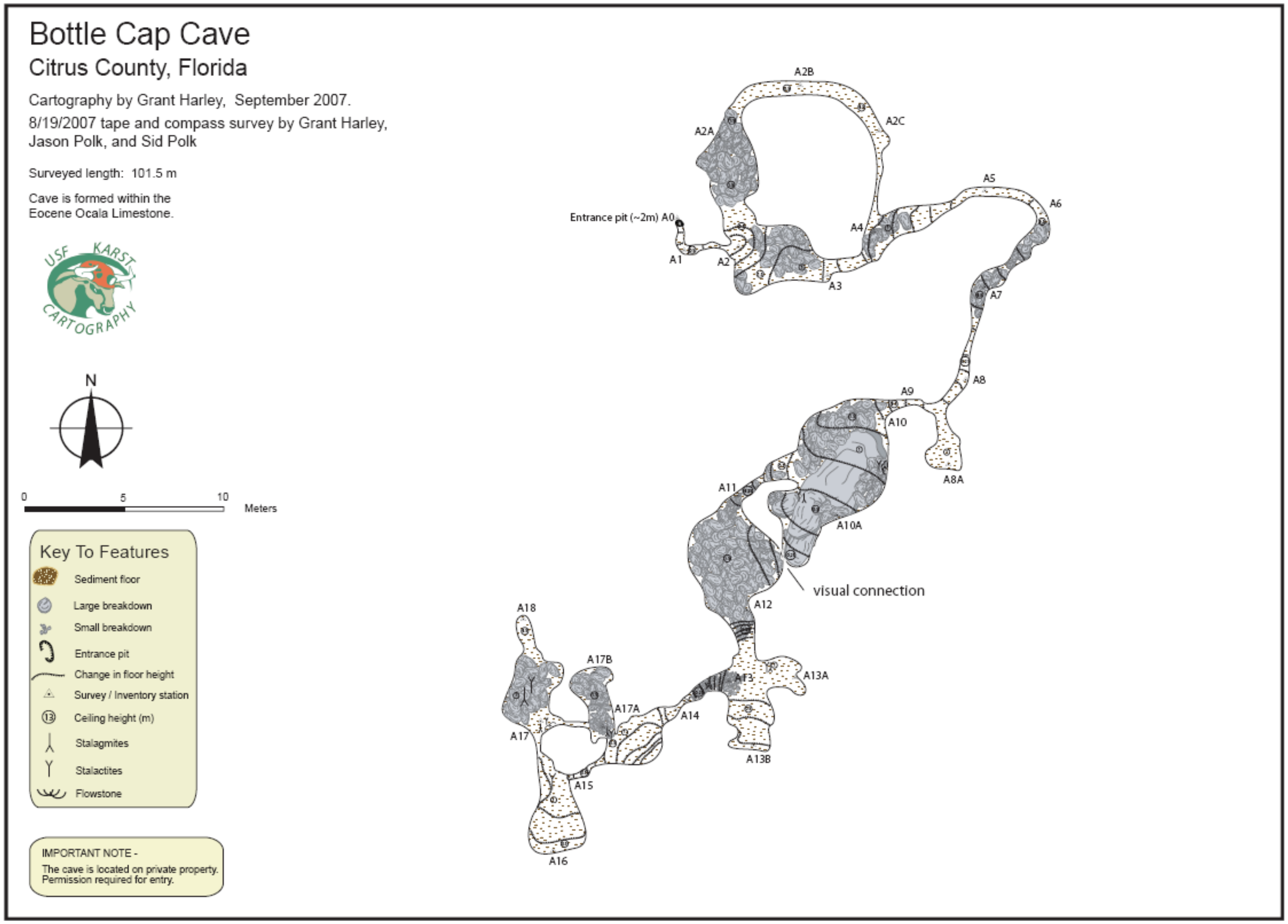
Picture of main room near station A2 looking northeast towards large stalagmite. (Grant Harley)


Big Mouth Cave
Radar Hill, Citrus County, Florida
Cave owned by the Withlacooche State Forest
February, 2005 Cartogarphy by Lee Florea
8/04/04 Survey by Lee Florea, Don Seale, Christine Davies
Cave developed in the Eocene Ocala Limestone
Cave length: 95.7 meters
Cave depth: 21.2 meters
Morris Cave datum at station A0
Lat:
Elev: 25.829 m
USF
KARST
A0 +25.829m
A1
+20.12m
Entrance
Entrance Sink
Waterfall
A2 +13.5m
A3
+7.83m
A4
+5.43m
A5
+5.43m
A8
+4.79m
A9
+5.21m
some air
Terminal breakdown
A10
+5.61m
Ephemeral pool present
following rainy season.
Passage elevation +2.5m
small
A6
+4.65m
A7
+5.92m
Terminal breakdown
Warning -- Cave floods during rain events.
Permit required for entry.
0 5 10 15 Meters
0 5 10 20 30 40 50 Feet
Key to Features
Survey Stations
Ceiling Heights (meters)
Slope
Fractures
Dripline
Change in floor height
Change in ceiling height
Intermittent stream
Breakdown
Pools
Sediment
Gravel
Sand
Biologic Resources
Crayfish
N
W
E
S
Magnetic declination: -4.6 deg

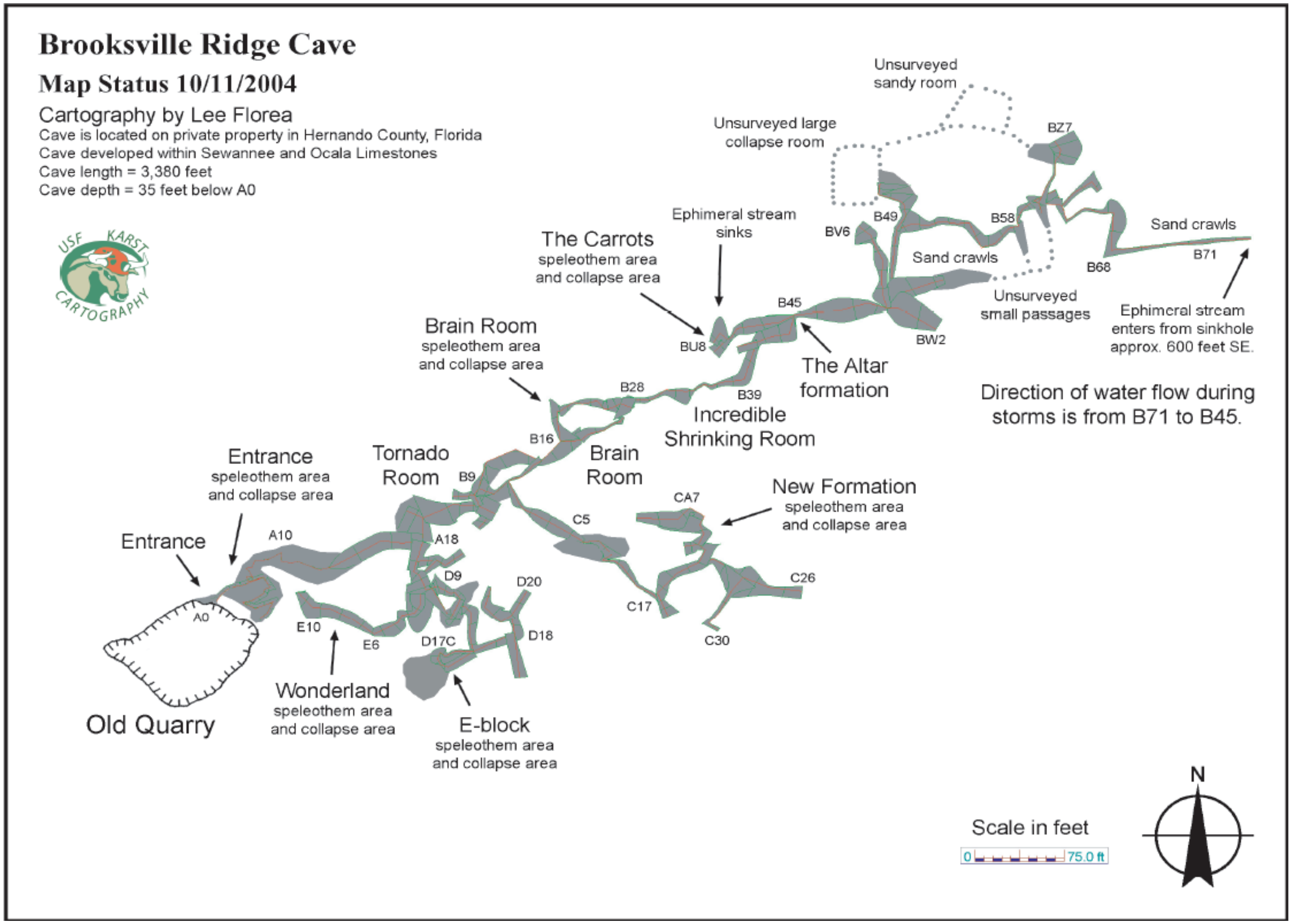
Appendix B: (Continued)



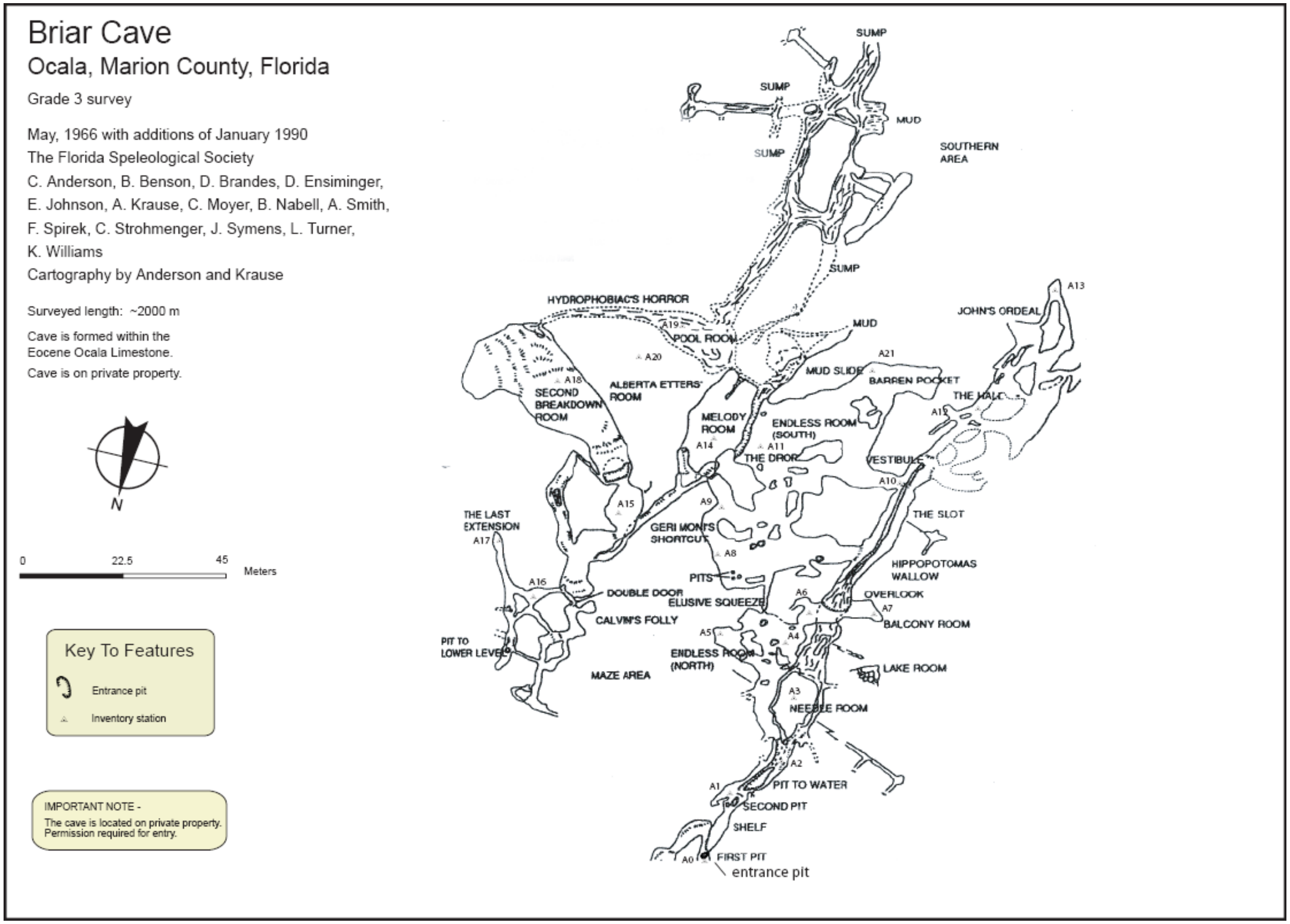
Appendix B: (Continued)



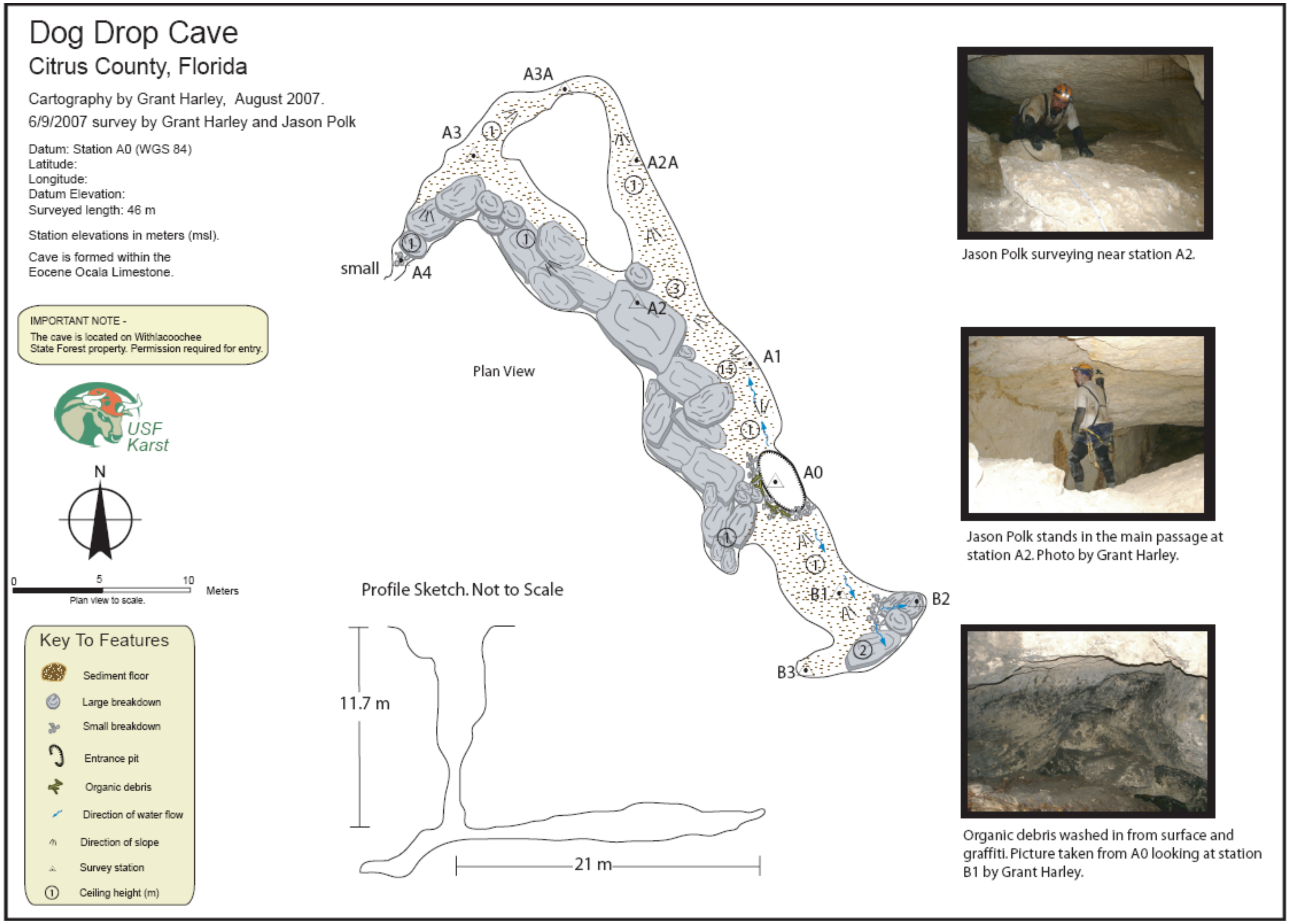
Appendix B: (Continued)



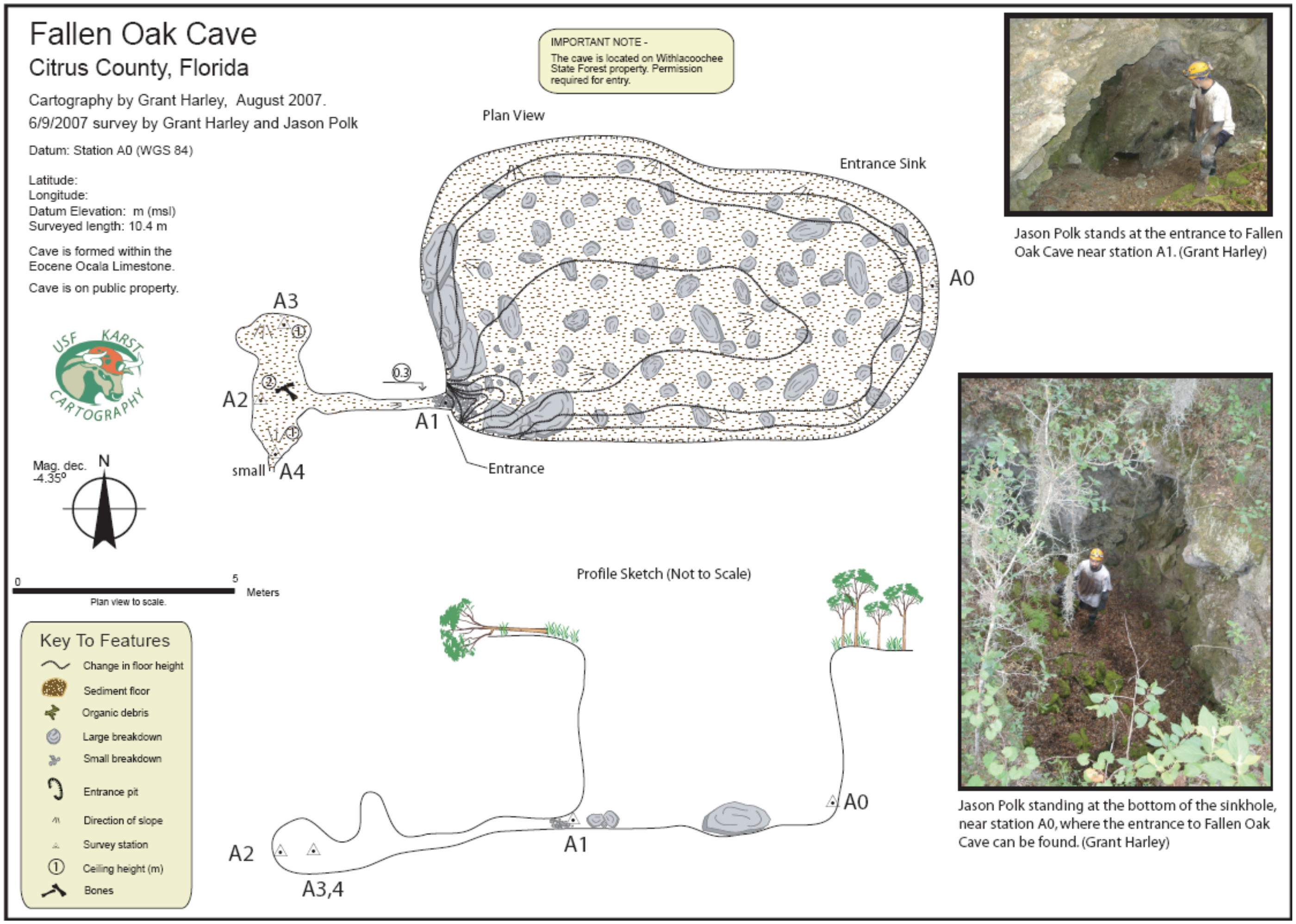
Appendix B: (Continued)



Appendix B: (Continued)



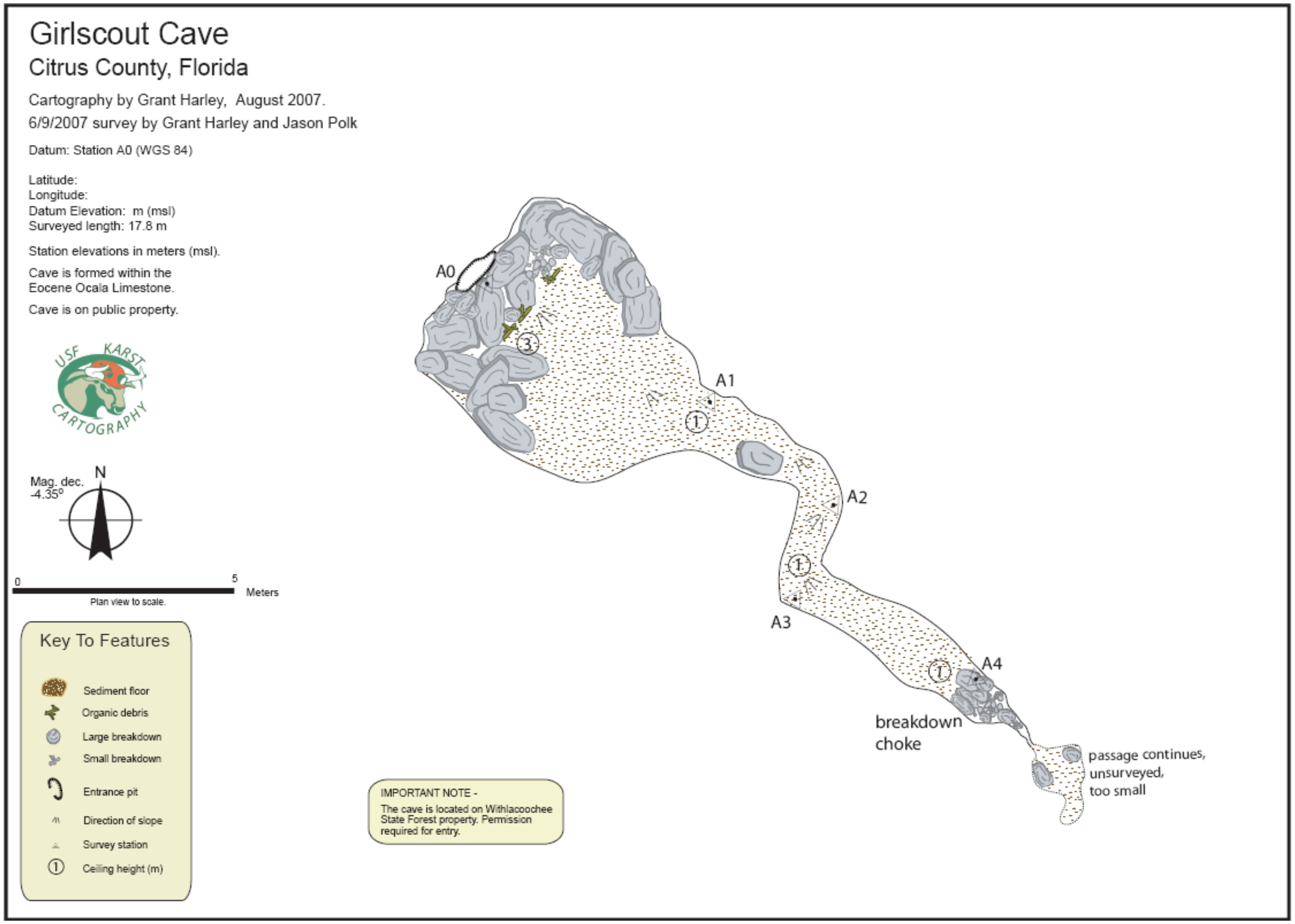
Appendix B: (Continued)



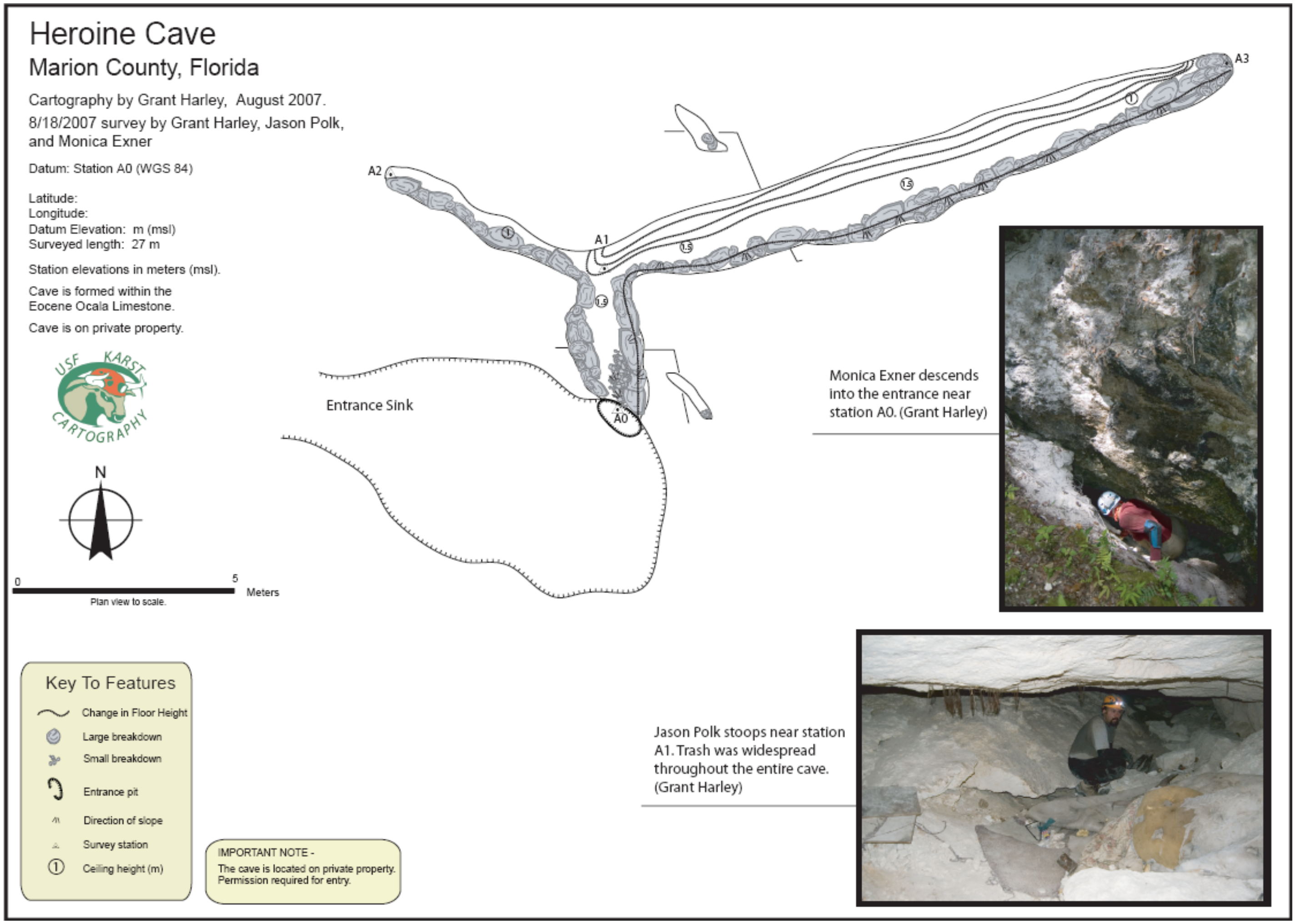
Jason Polk stands at the entrance to Fallen Oak Cave near station A1. (Grant Harley)

Jason Polk standing at the bottom of the sinkhole, near station A0, where the entrance to Fallen Oak Cave can be found. (Grant Harley)

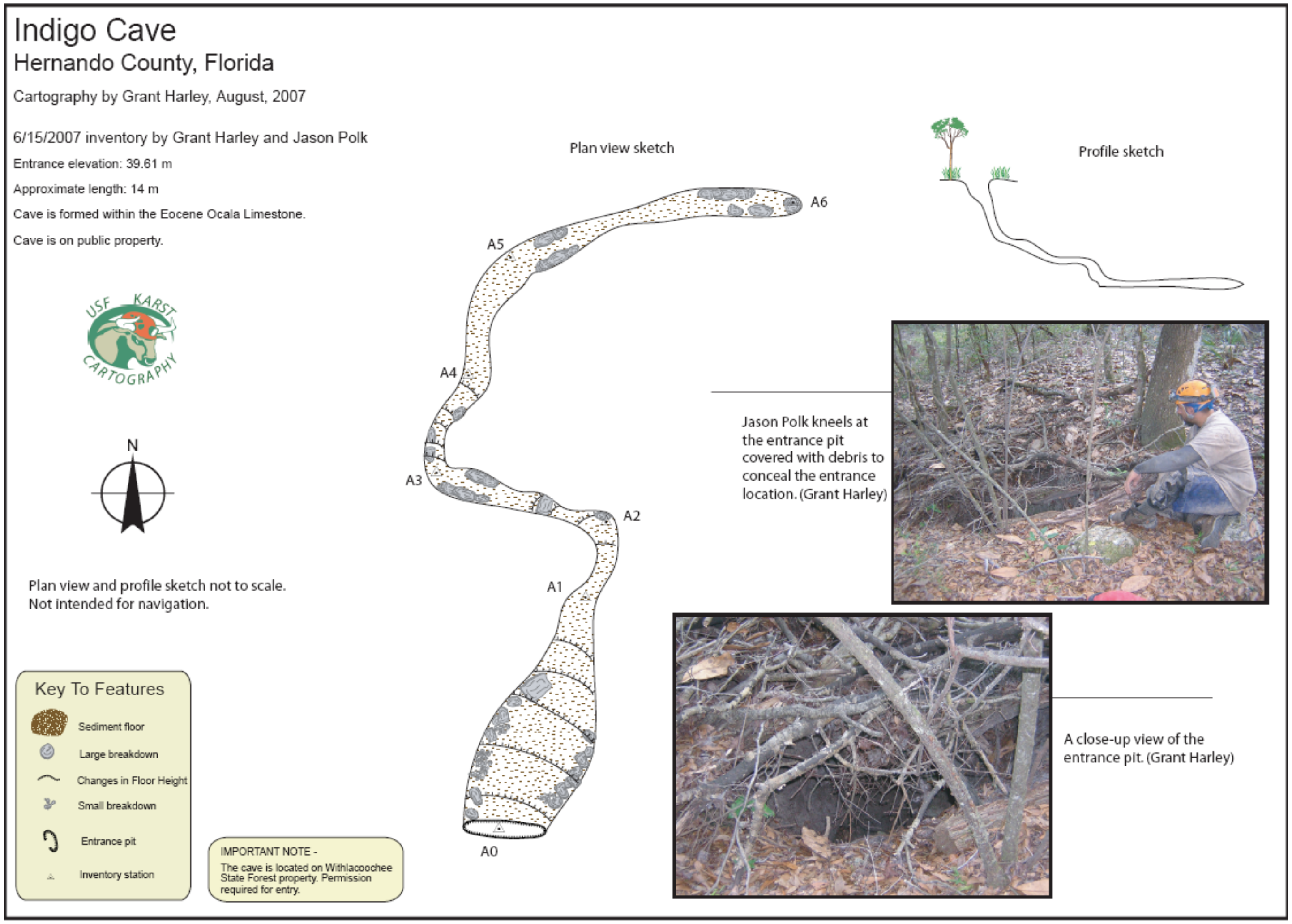
Appendix B: (Continued)



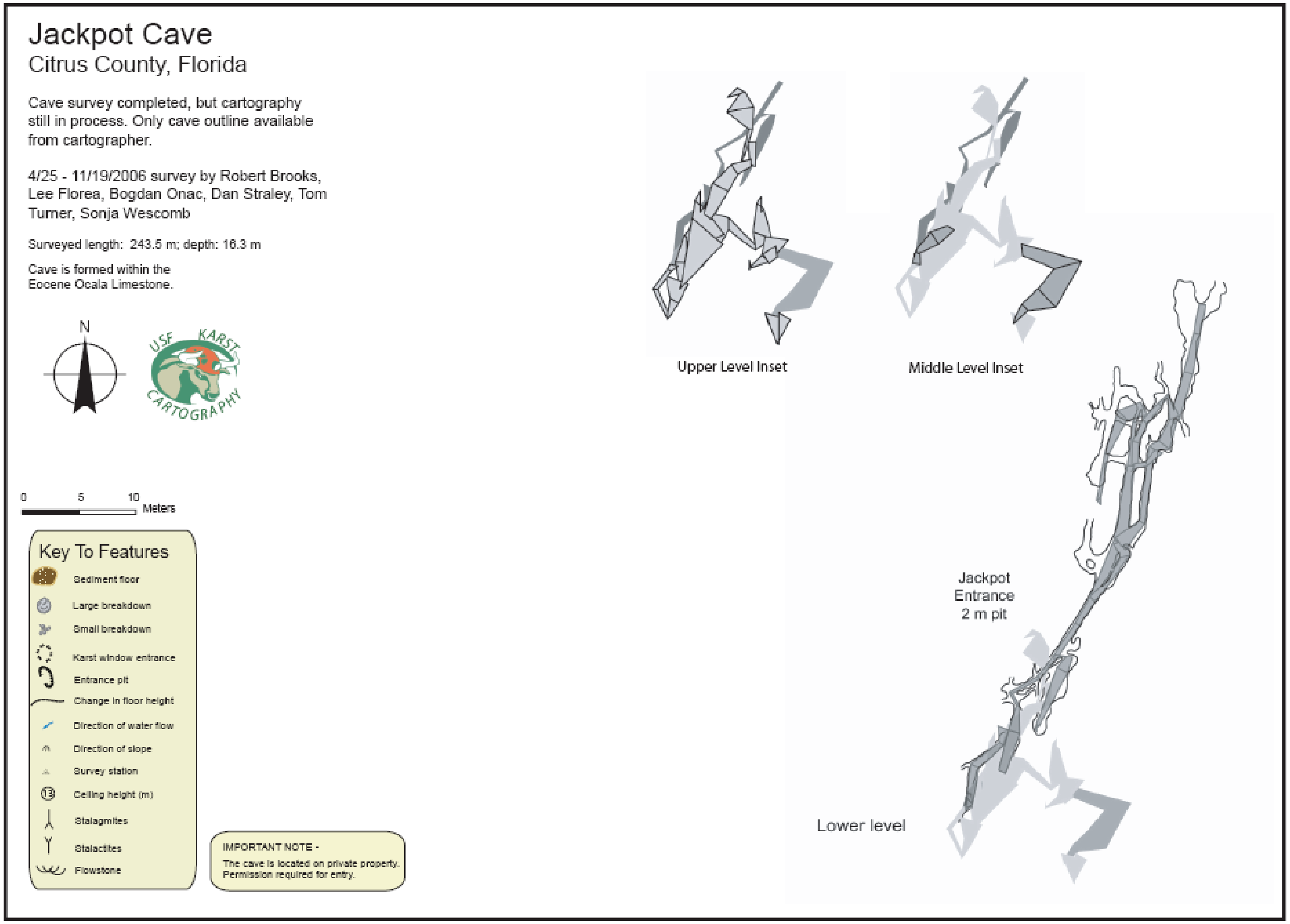
Appendix B: (Continued)



Appendix B: (Continued)



Appendix B: (Continued)



Appendix B: (Continued)

Jeep Cave
Citrus County, Florida

Cartography by Grant Harley, July 2007.
6/9/2007 survey by Grant Harley and Jason Polk

Datum: Station A0 (WGS 84)
Latitude:
Longitude:
Datum Elevation: m (msl)
Surveyed length: 17 m
Surveyed depth: 3.01 m

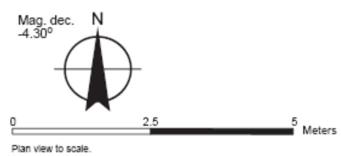
Station elevations in meters (msl).

Cave is formed within the Eocene Ocala Limestone.

Cave is on Withlacoochee State Forest land.

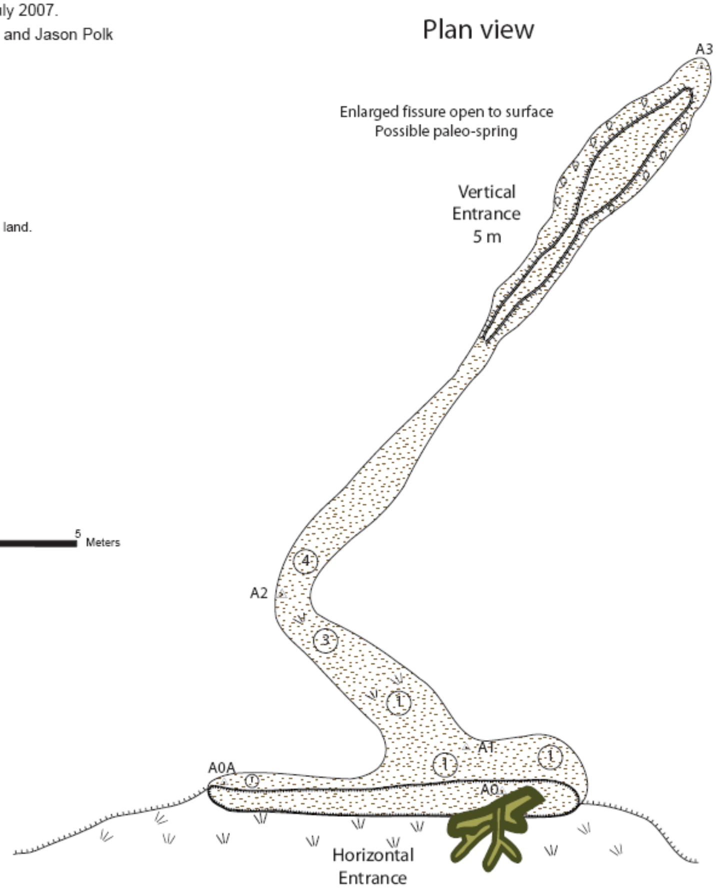
IMPORTANT NOTE - Permit required for entry issued by Withlacoochee State Forest

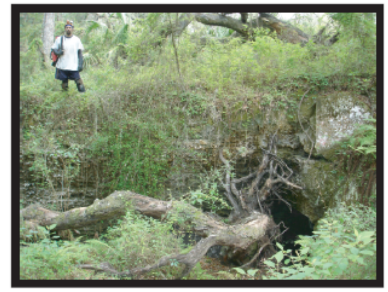
USF Karst



Key To Features

- Sediment floor
- Entrance pit
- Direction of slope
- Survey station
- Ceiling height (m)
- Organic debris
- Cliff
- Scallops

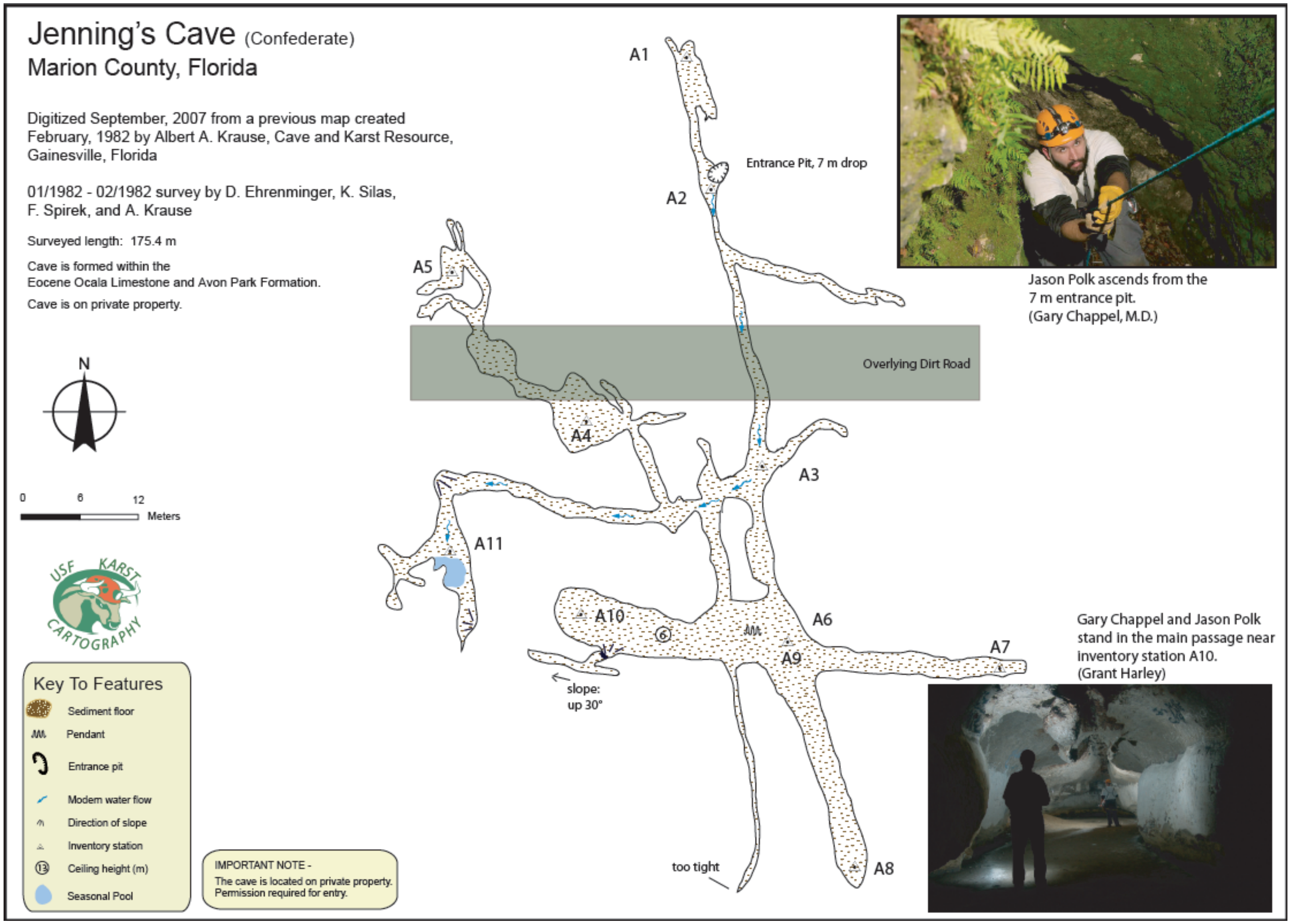




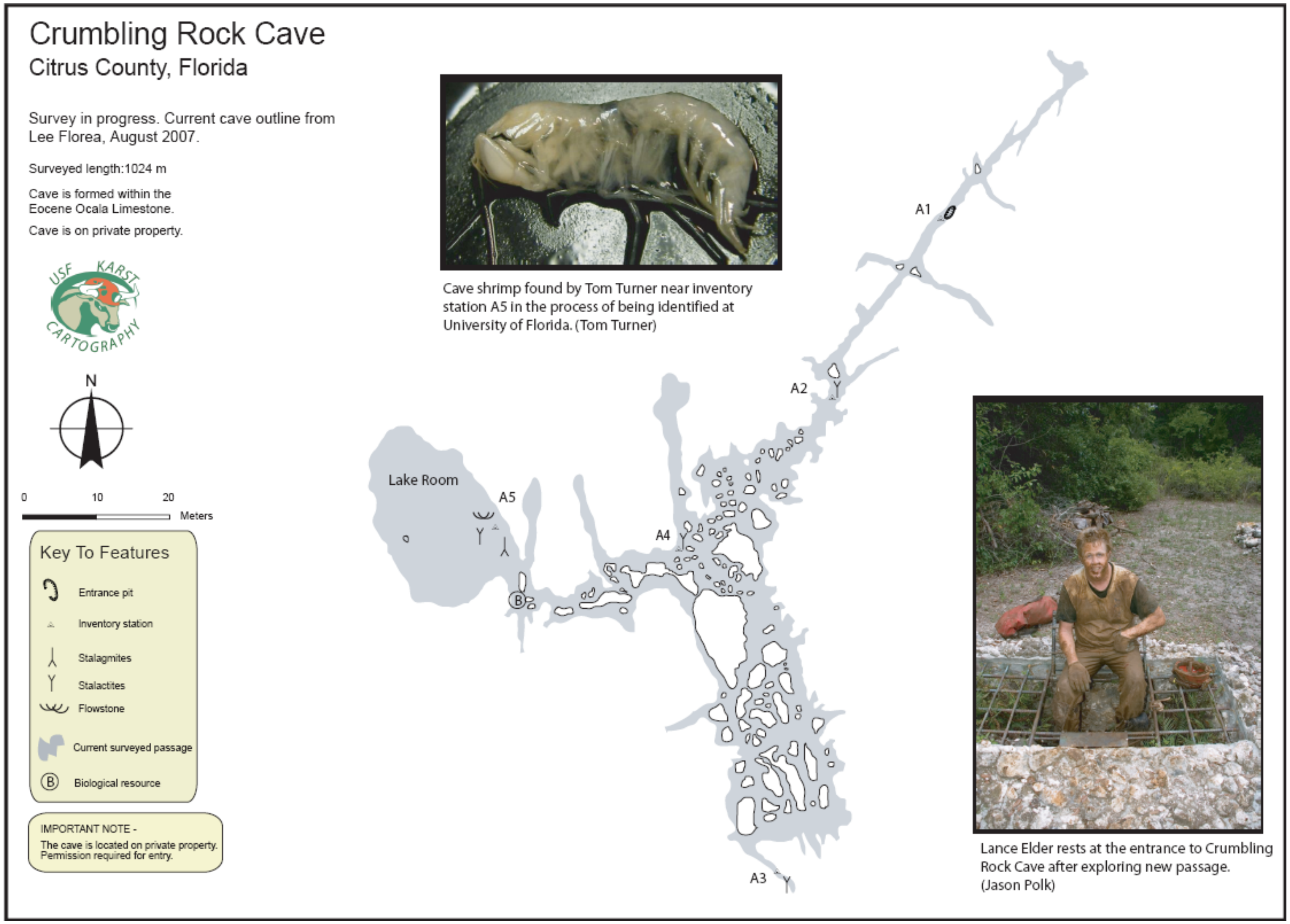
Jason Polk of the Karst Research Group stands on top of a cliff overlooking the Jeep Cave horizontal entrance. Photo by Grant Harley.

Jason Polk stands in front of graffiti at the entrance of Jeep Cave. Photo by Grant Harley.

Appendix B: (Continued)



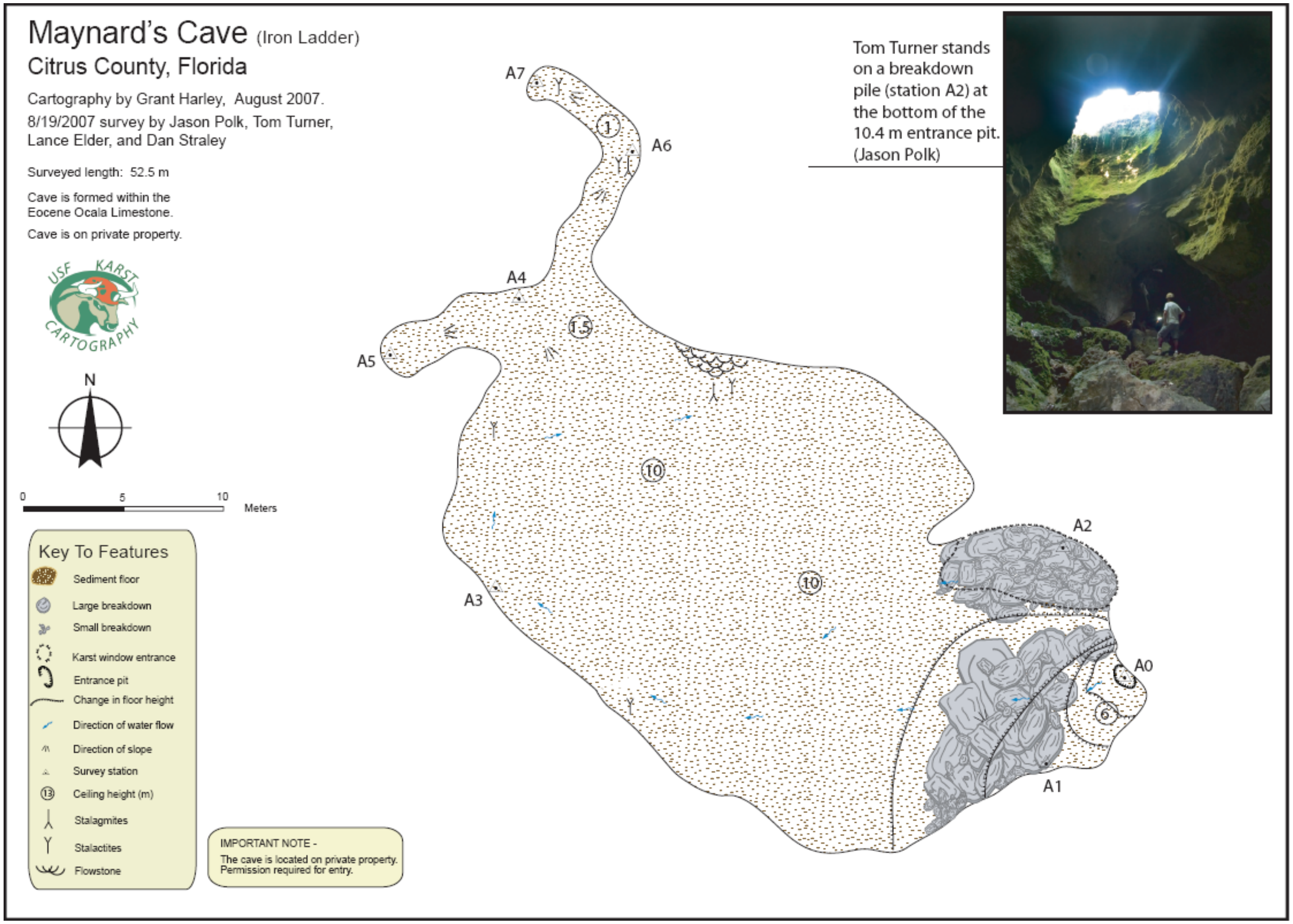
Appendix B: (Continued)



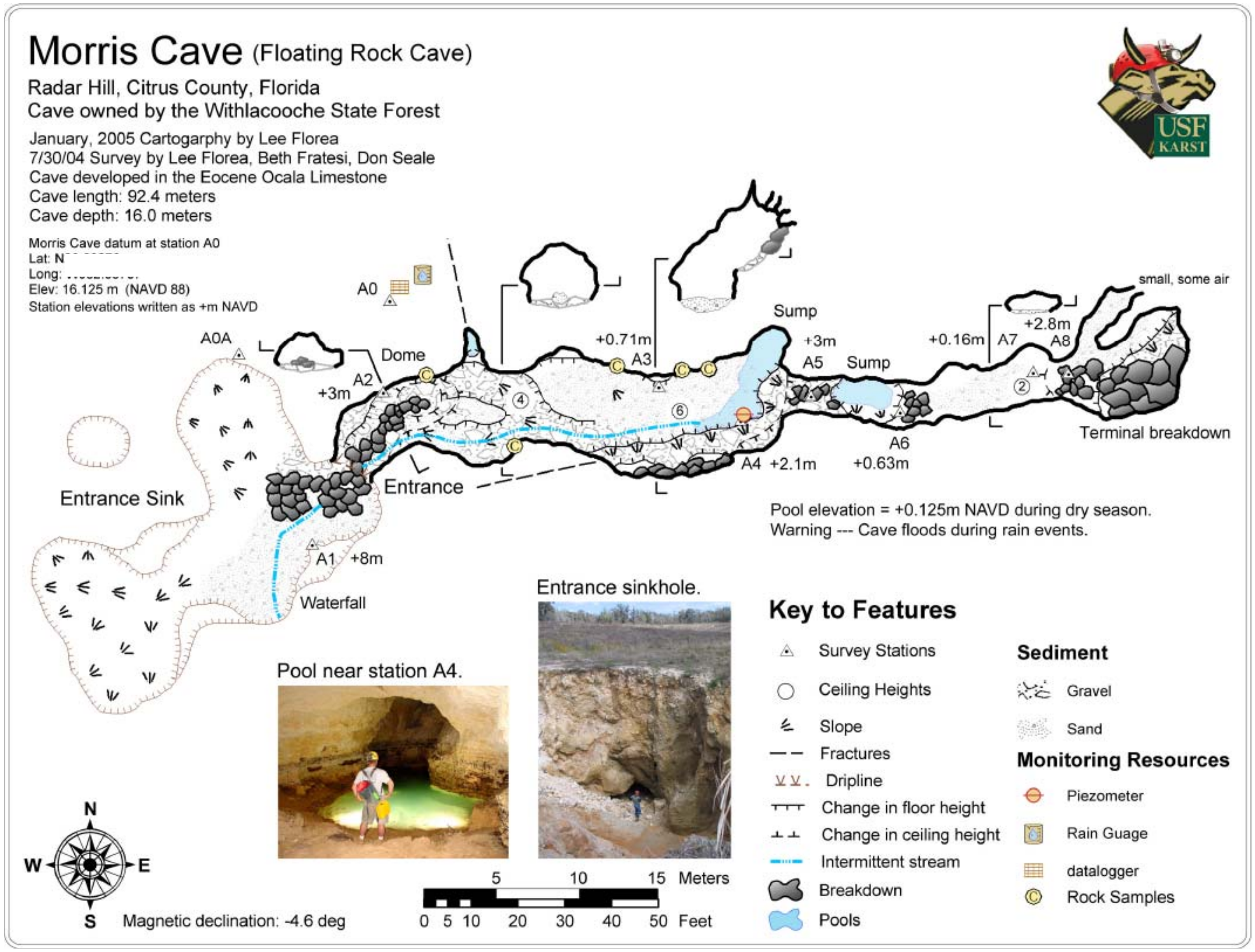
Cave shrimp found by Tom Turner near inventory station A5 in the process of being identified at University of Florida. (Tom Turner)

Lance Elder rests at the entrance to Crumbling Rock Cave after exploring new passage. (Jason Polk)

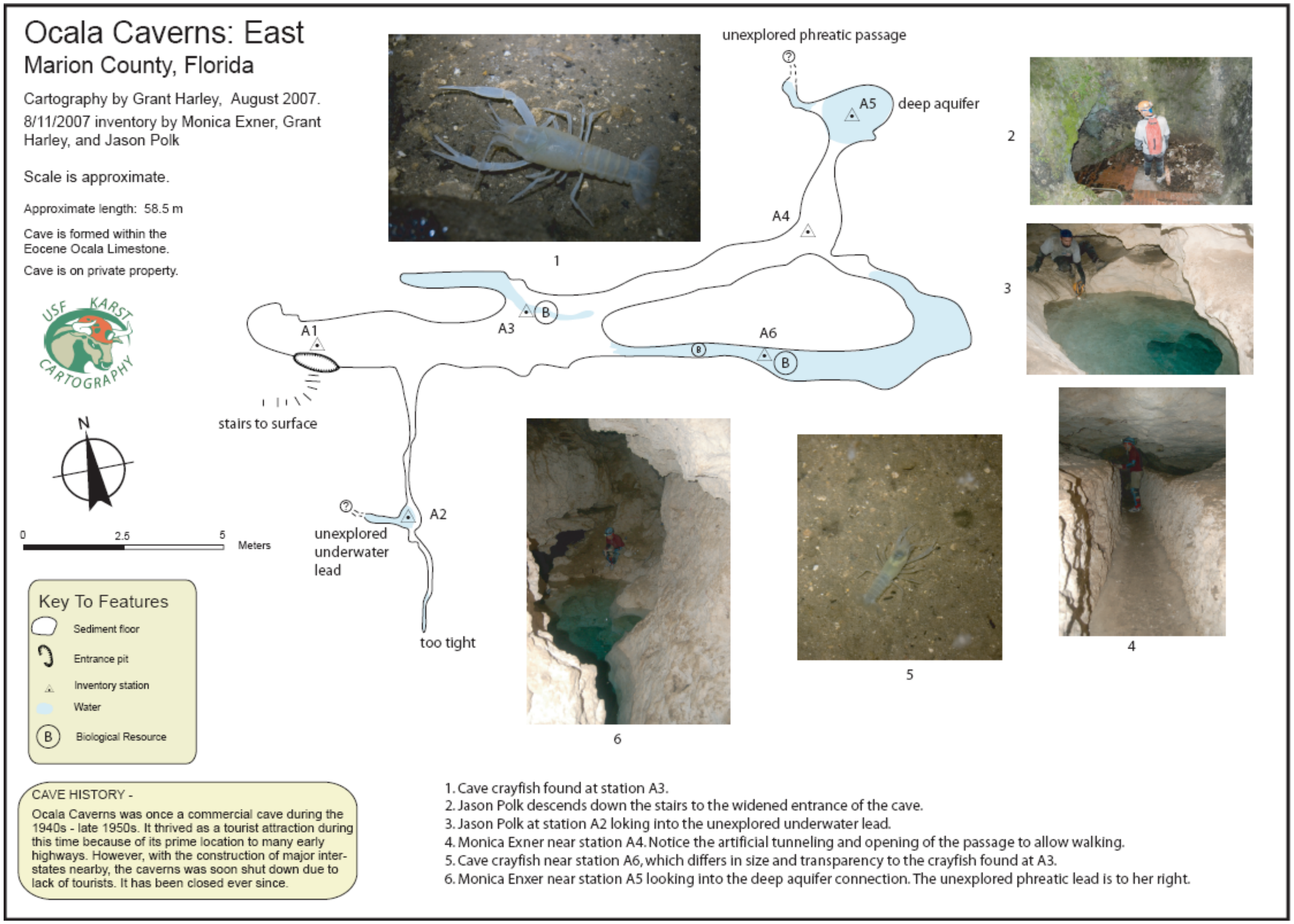
Appendix B: (Continued)



Appendix B: (Continued)



Appendix B: (Continued)



Ocala Caverns: West

Marion County, Florida

Cartography by Grant Harley, September 2007.

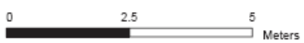
8/18/2007 inventory by Monica Exner, Grant Harley, and Jason Polk

Scale is approximate.

Approximate length: 23 m

Cave is formed within the Eocene Ocala Limestone.

Cave is on private property.

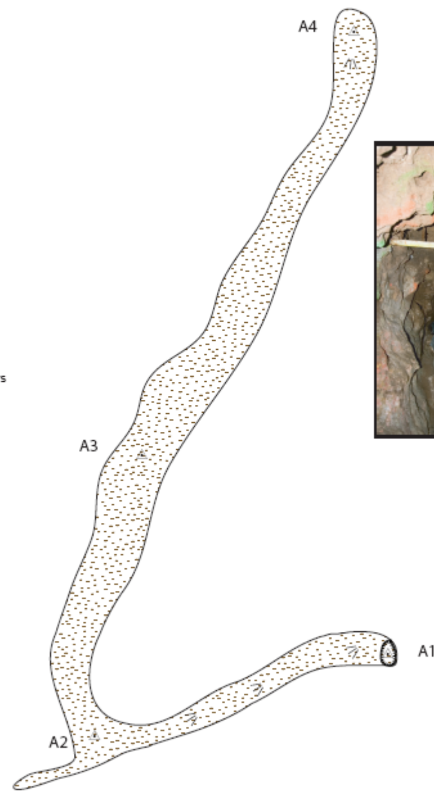


Key To Features

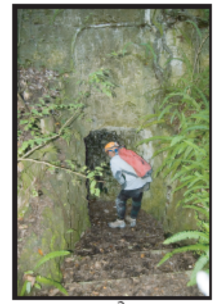
- Sediment floor
- Entrance pit
- Direction of slope
- Inventory station
- Ceiling height (m)

CAVE HISTORY -

Ocala Caverns was once a commercial cave during the 1940s - late 1950s. It thrived as a tourist attraction during this time because of its prime location to many early highways. However, with the construction of major inter-states nearby, the caverns was soon shut down due to lack of tourists. It has been closed ever since.




1


2


3


4


5


6

1. Near A3. Notice graffiti and artificial passage widening.
2. Jason Polk at the horizontal, artificial entrance to the cave.
3. Monica Exner near A4. Notice heavy graffiti and metal structure that was installed when Ocala Caverns was developed into a commercial.
4. Remnants of the old commercial cave - an old light fixture. near A3. These were scattered throughout the cave.
5. The natural vertical entrance near A4. When the cave was developed, a horizontal entrance was installed with stairs to make visitation more efficient.
6. Monica Exner near A2. Notice the cave is fissure controlled, but has been artificially altered into a commercial cave.

Appendix B: (Continued)

Peace Sign Cave

Citrus County, Florida

Digitized August, 2007 from a previous map created January, 1993 by Philip Reeder.

1/17/1993 survey by Robert Brinkmann, Shelly Happel, Philip Reeder, and Curtis Stabler

Entrance #1 Elevation: 27.43 m (msl)
Surveyed length: 41 m

Cave is formed within the Oligocene Suwannee Limestone.

Cave is on public property.

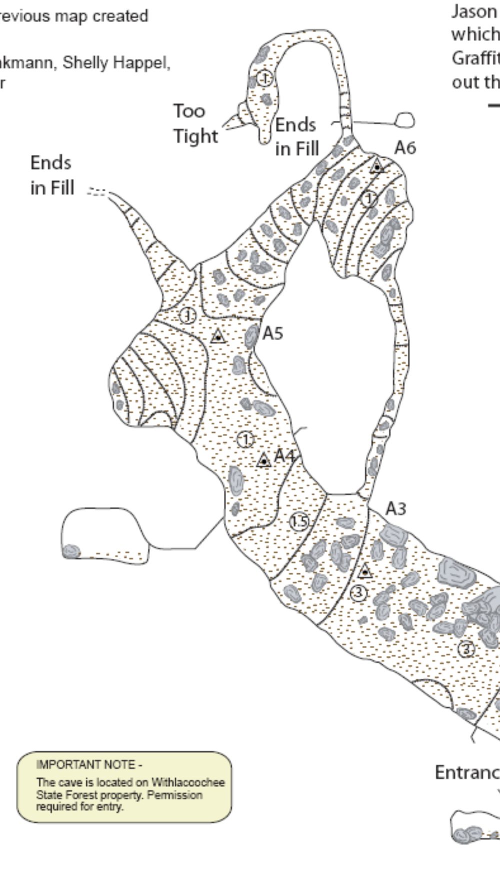
N

0 3 6 Meters
Plan view to scale.

Key To Features

- Change in floor height
- Sediment floor
- Large breakdown
- Small breakdown
- Entrance pit
- Inventory station
- Ceiling height (m)

IMPORTANT NOTE -
The cave is located on Withlacoochee State Forest property. Permission required for entry.




Jason Polk sits near station A5, which is riddled with graffiti. Graffiti is widespread throughout the cave. (Grant Harley)

Trash near station A3. Note the heavy caver traffic. (Grant Harley)

Jason Polk kneels beside 4 broken stalagmites near station A3. Broken speleothems are widespread throughout the cave. (Grant Harley)

Quarter Cave

Citrus County, Florida

Cartography by Grant Harley, August 2007

8/17/2007 survey by Jason Polk and Grant Harley

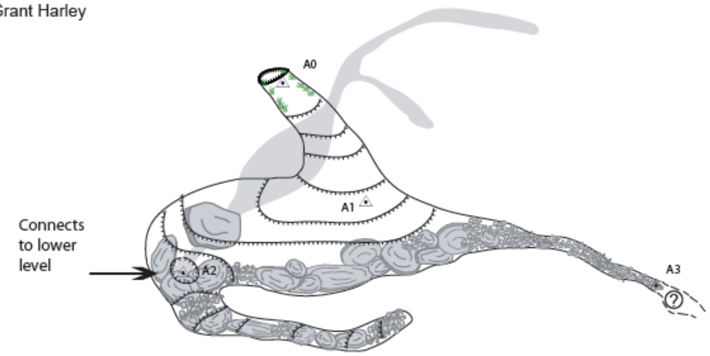
Surveyed length: 19.7 m

Cave is formed within the Eocene Ocala Limestone.

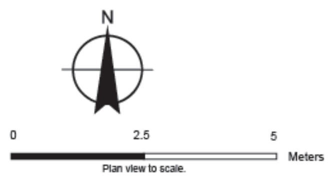
IMPORTANT NOTE -
The cave is located on Withlacoochee State Forest property. Permission required for entry.

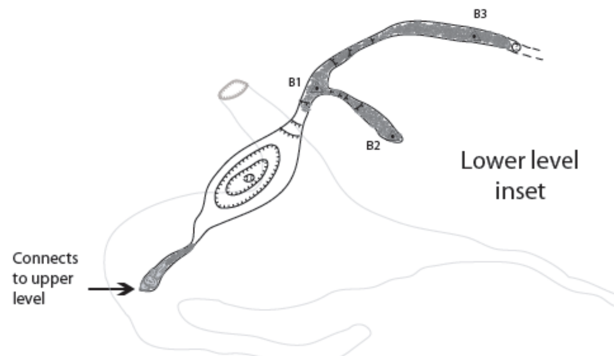
Warning: Cave is comprised of large, unstable breakdown!

Plan View



Jason Polk looks up the 2m deep entrance pit. (Grant Harley)

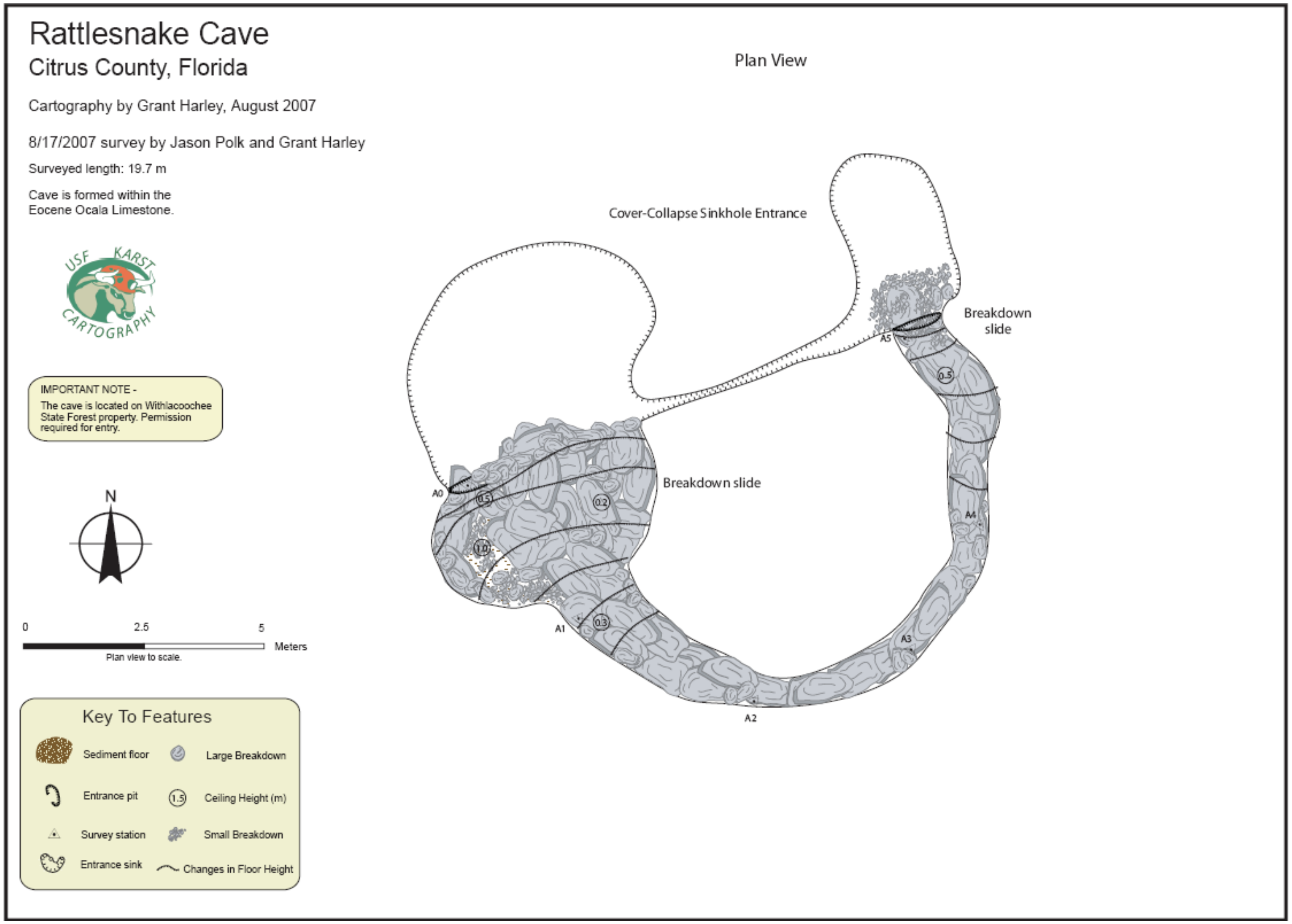




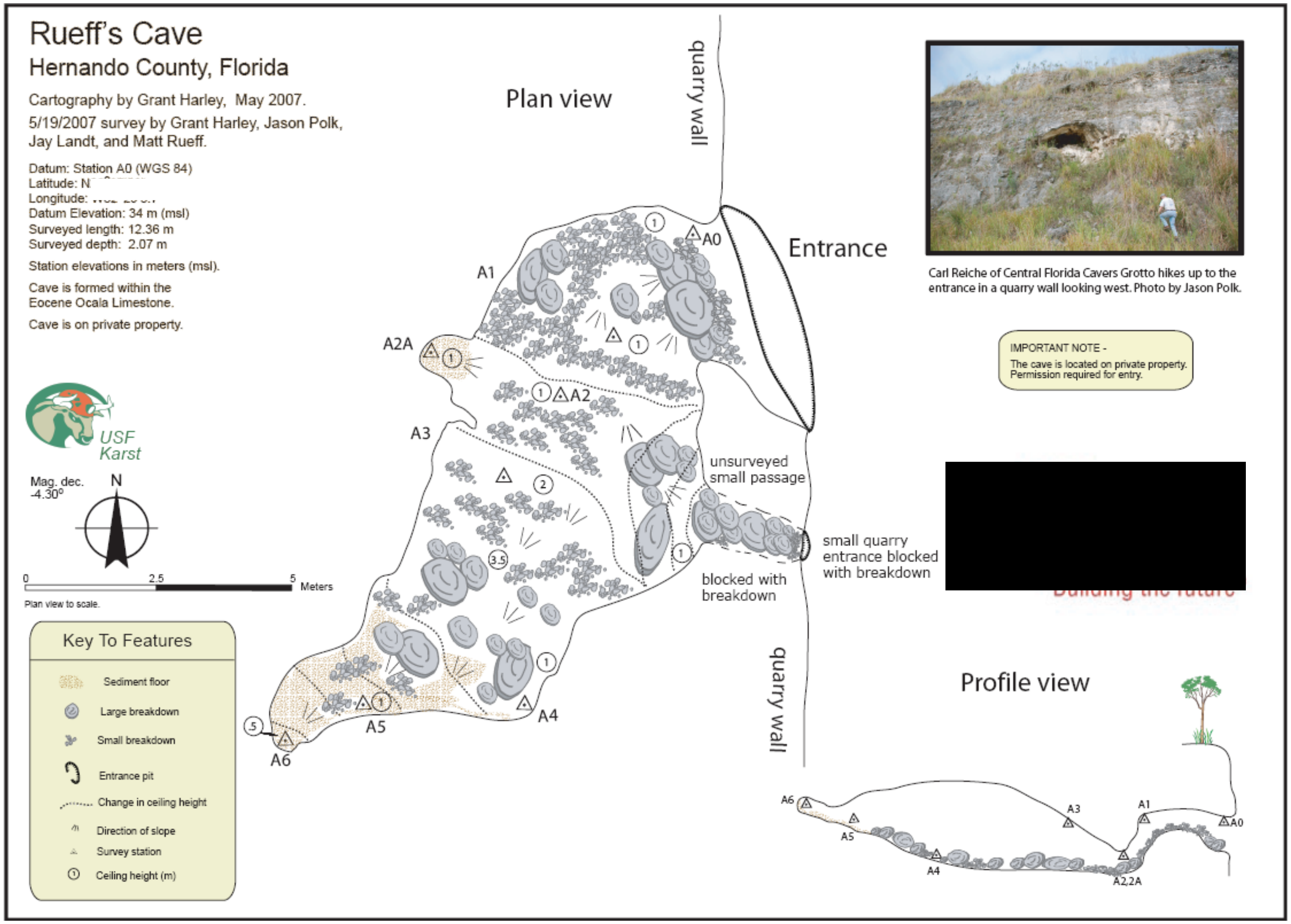
Breakdown passage near station A1. The entire cave consists of unstable breakdown passage. Note the small Pelican camera case for scale. (Grant Harley)

Key To Features

- Sediment floor
- Large Breakdown
- Entrance pit
- Ceiling Height (m)
- Survey station
- Small Breakdown
- Unexplored lead
- Fern
- Changes in Floor Height


Rattlesnake Cave
Citrus County, Florida
Cartography by Grant Harley, August 2007
8/17/2007 survey by Jason Polk and Grant Harley
Surveyed length: 19.7 m
Cave is formed within the Eocene Ocala Limestone.
USF KARST CARTOGRAPHY
IMPORTANT NOTE - The cave is located on Withlacoochee State Forest property. Permission required for entry.
N
0
2.5
5
Meters
Plan view to scale.
Key To Features
Sediment floor
Large Breakdown
Entrance pit
Ceiling Height (m)
Survey station
Small Breakdown
Entrance sink
Changes in Floor Height
Plan View
Cover-Collapse Sinkhole Entrance
Breakdown slide
Breakdown slide
A0
A1
A2
A3
A4
A5
0.5
0.2
1.0
0.3
0.5

Appendix B: (Continued)



Appendix B: (Continued)

Sick Bat Cave

Citrus County, Florida

Digitized August August, 2007 from a previous map created January, 1993 by Philip Reeder

1/16/1993 survey by Robert Brinkmann, Shelly Happel, Philip Reeder, and Curtis Stabler

Entrance #1 elevation: 27.43 m

Surveyed length: 6 m

Cave is formed within the Oligicene Suwannee Limestone.

Cave is on public property.

N

0 1 2 Meters

Plan view to scale.

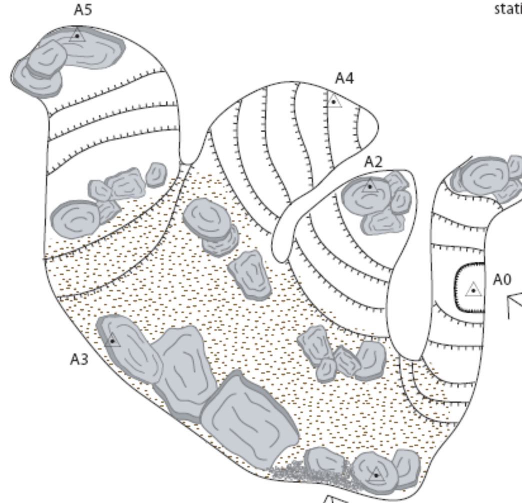
Key To Features

- Sediment floor
- Large breakdown
- Changes in Floor Height
- Small breakdown
- Entrance pit
- Inventory station

IMPORTANT NOTE - The cave is located on Withlacoochee State Forest property. Permission required for entry.

An Eastern pipistrelle bat (*Pipistrellus subflavus*) near station A3. (Grant Harley)

Jason Polk squeezes through a restriction between stations A0 and A1. (Grant Harley)



Appendix B: (Continued)

Sneak Cave

Marion County, Florida

Cartography by Grant Harley, August 2007.

8/18/2007 survey by Grant Harley, Jason Polk, and Monica Exner

Datum: Station A0 (WGS 84)

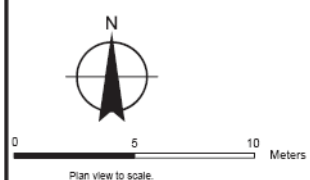
Latitude:
Longitude:
Datum Elevation: m (msl)
Surveyed length: 91 m

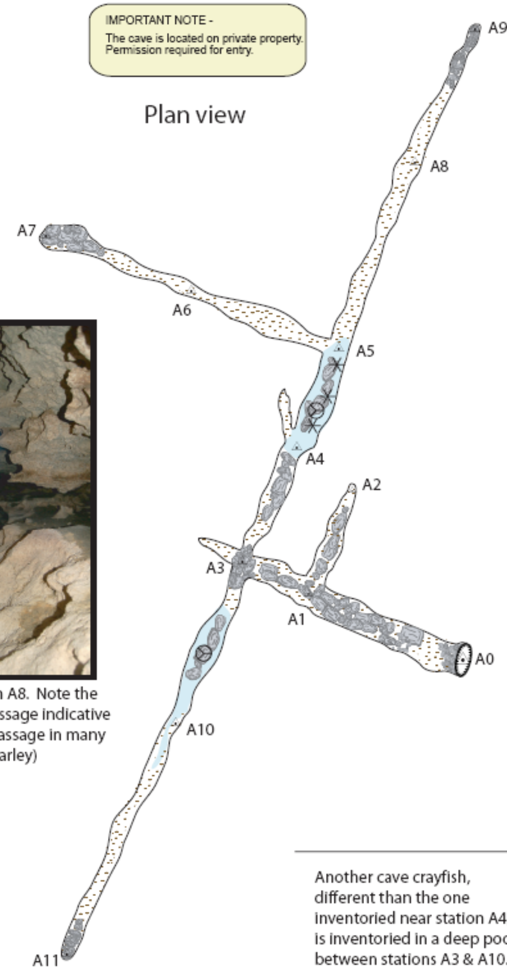
Cave is formed within the Eocene Ocala Limestone.

Cave is on private property.

IMPORTANT NOTE -
The cave is located on private property. Permission required for entry.

Plan view





Key To Features

- Sediment floor
- Large breakdown
- Small breakdown
- Entrance pit
- Survey station
- Water

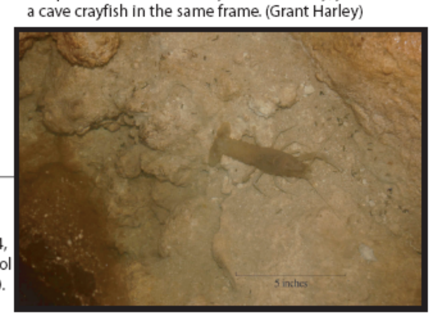
Biological Resources

- Minnow
- Cave crayfish

Jason Polk near station A8. Note the definitive plus-sign passage indicative of fissure-controlled passage in many Florida caves. (Grant Harley)

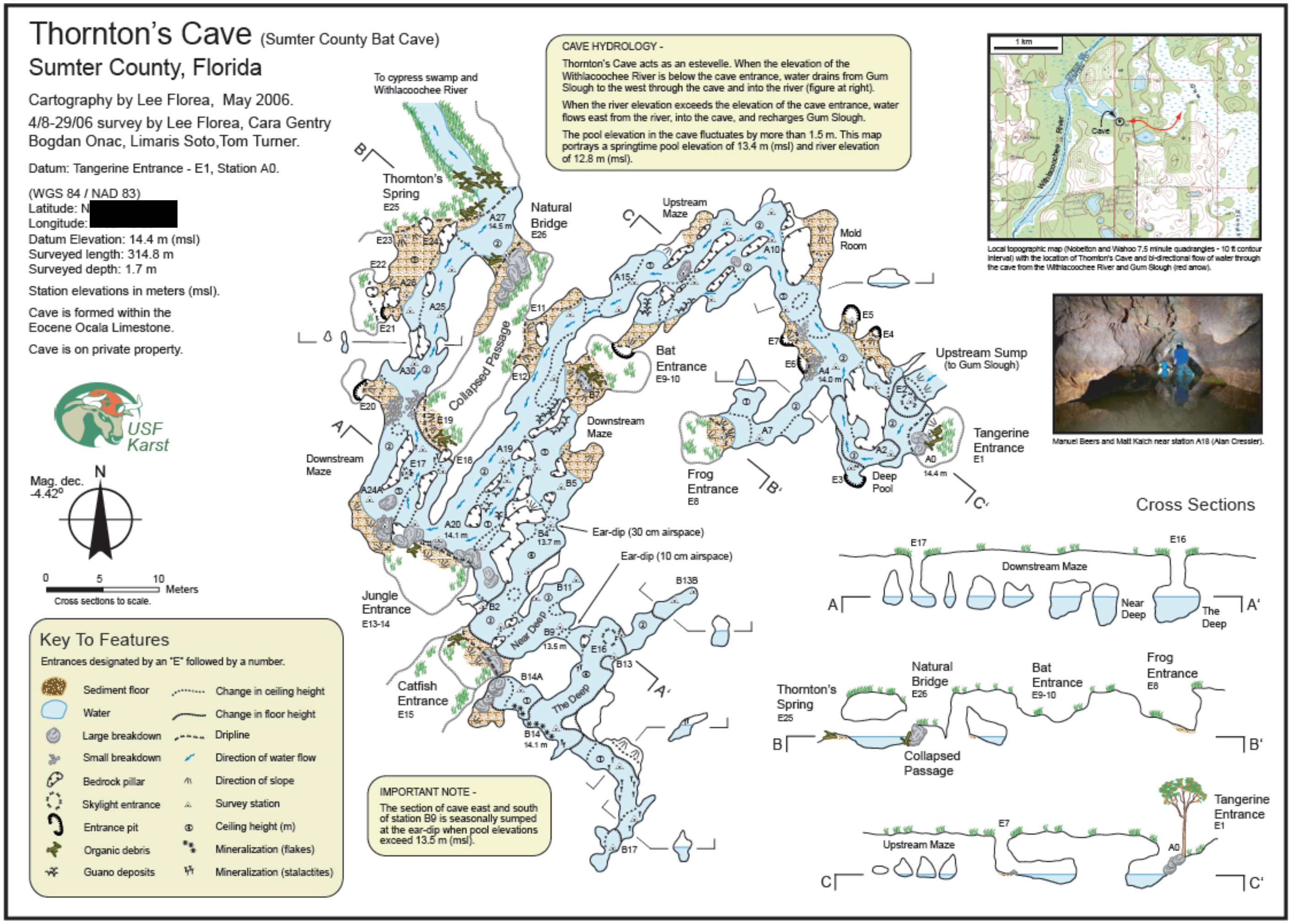
Monica Exner squeezes into the entrance at station A0. (Grant Harley)

At least 6 minnows, which had no eyes, were inventoried in a pool near station A4. If you look closely, you can see a cave crayfish in the same frame. (Grant Harley)

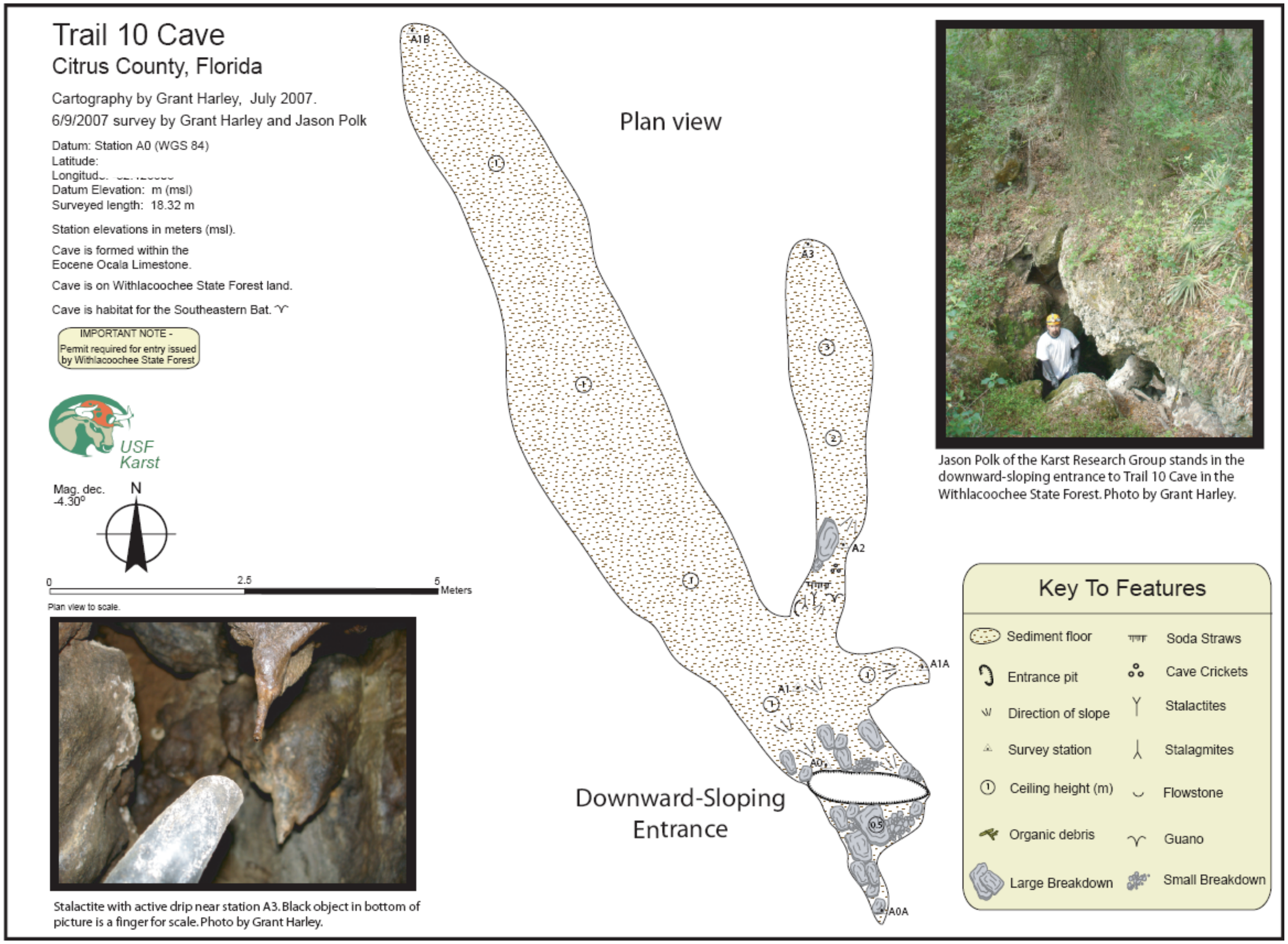


Another cave crayfish, different than the one inventoried near station A4, is inventoried in a deep pool between stations A3 & A10.

Appendix B: (Continued)



Appendix B: (Continued)



Turpentine Cave

Citrus County, Florida

Prelimenary map of cave from tape and compass survey.
Scale is approximate.
For inventory reference purposes only.

Surveyed length: 140 m

Cave is formed within the Eocene Ocala Limestone.

Cave is on private property.

USF KARST CARTOGRAPHY

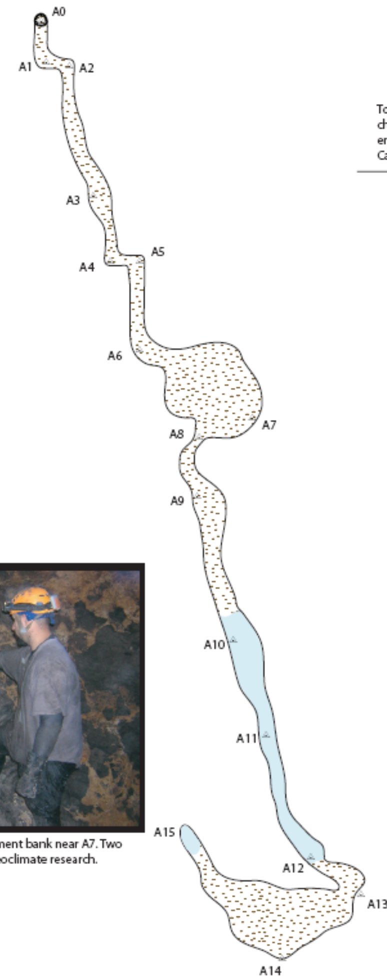
N

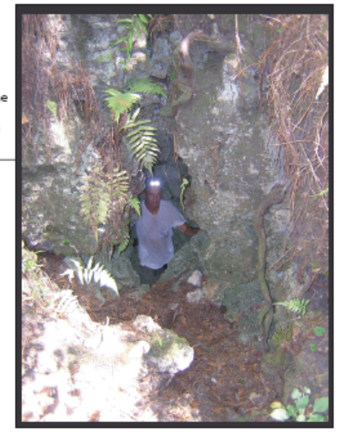
0 12.5 25 Meters

Key To Features

- Sediment floor
- Entrance pit
- Inventory station
- Water

IMPORTANT NOTE -
The cave is located on private property. Permission required for entry.



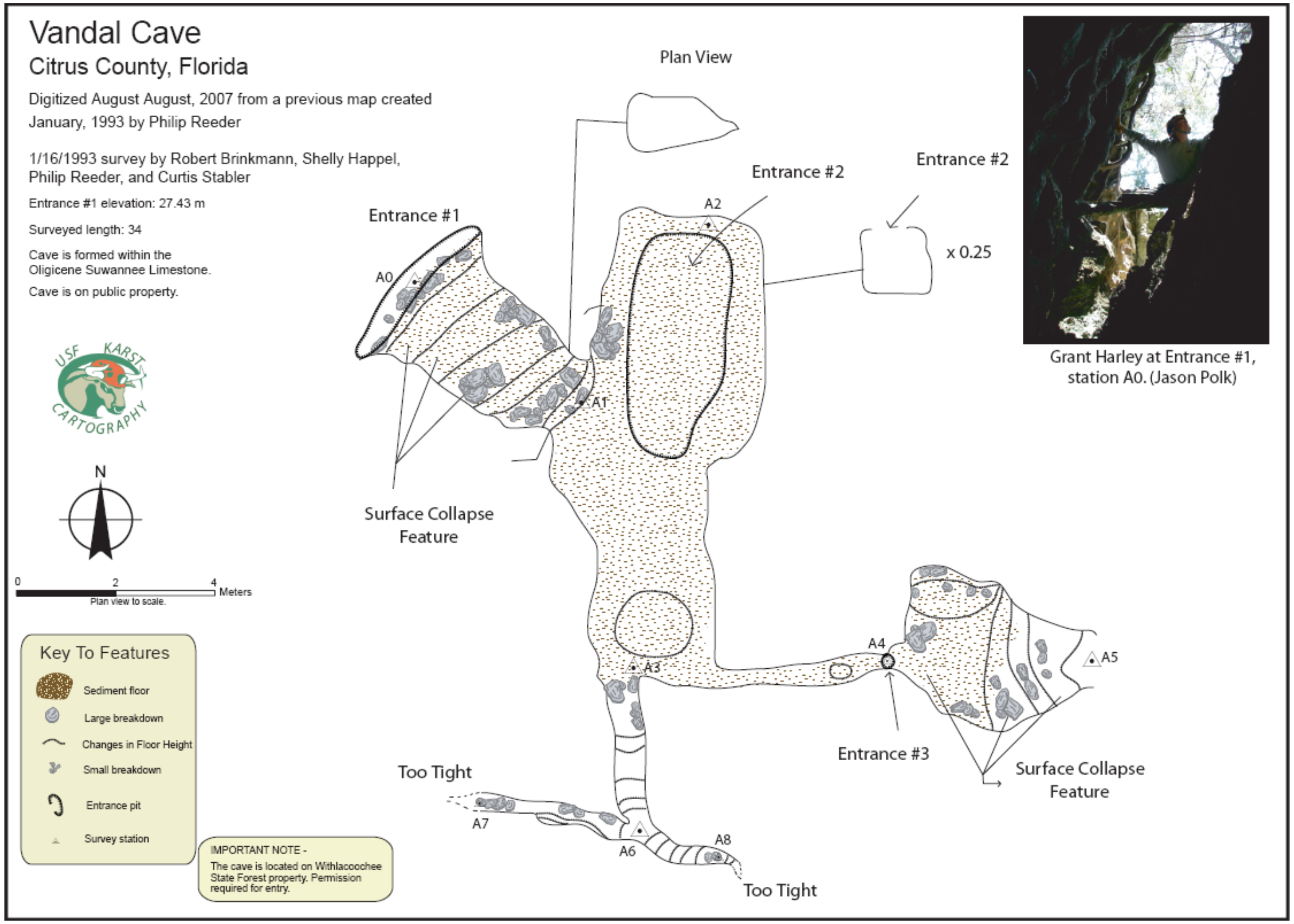


Tom Turner stand at the chimney climb-down entranceof Turpentine Cave. (Grant Harley)

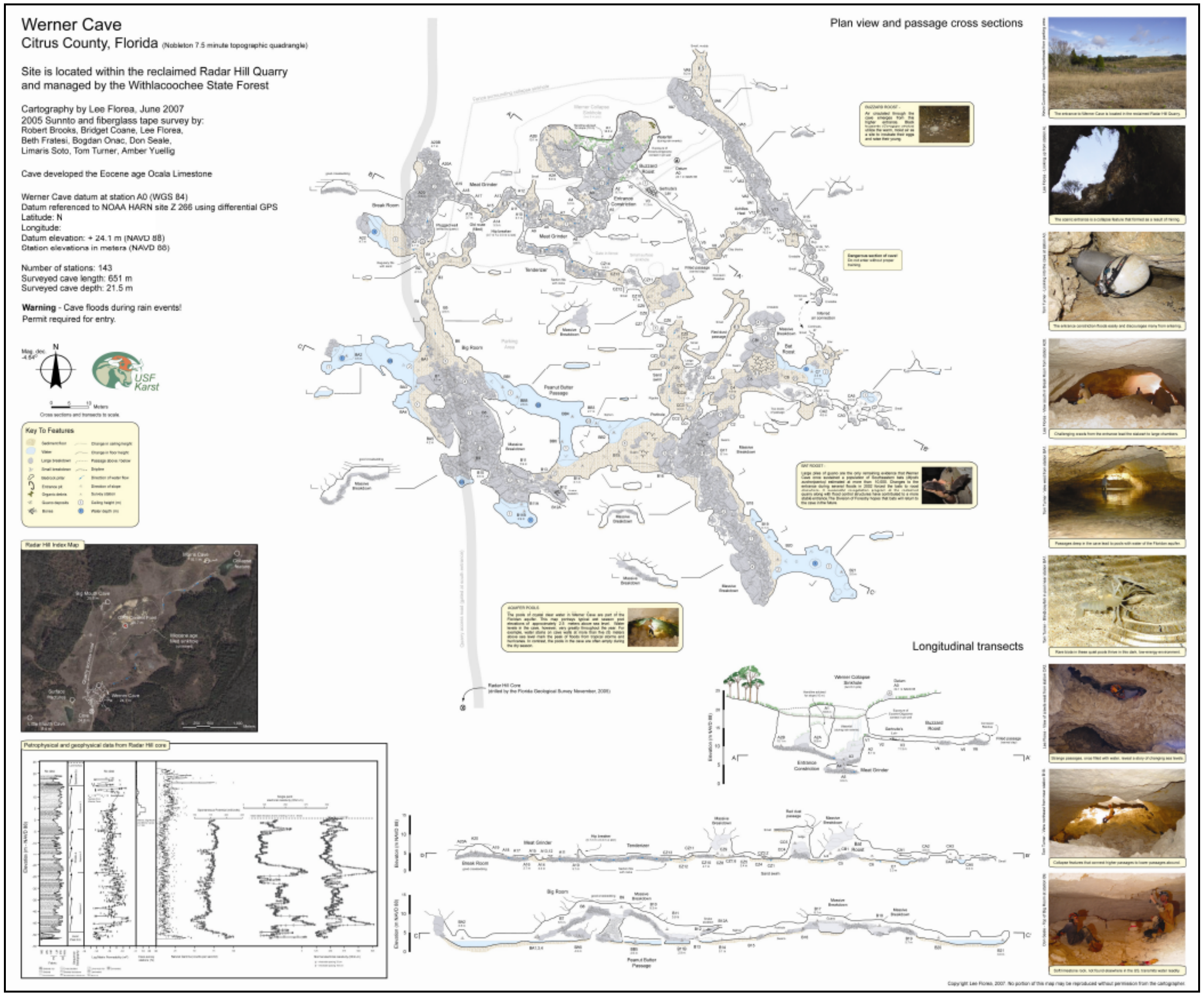
Jason Polk stand at the edge of a sediment bank near A7. Two sediment cores were collected for paleoclimate research. (Grant Harley)

Grant Harley during the prelimenary tape and compass durvey of water passage near station A11. (Jason Polk)

Appendix B: (Continued)



Appendix B: (Continued)



Appendix B: (Continued)

Hitch-Hiker Cave

Marion County, Florida

Cartography by Grant Harley, October 2007.
Prelimenary map from compass and tape survey.

Scale is approximate.

Surveyed length: 58 m

Cave is formed within the Eocene Ocala Limestone.

Cave is on private property.

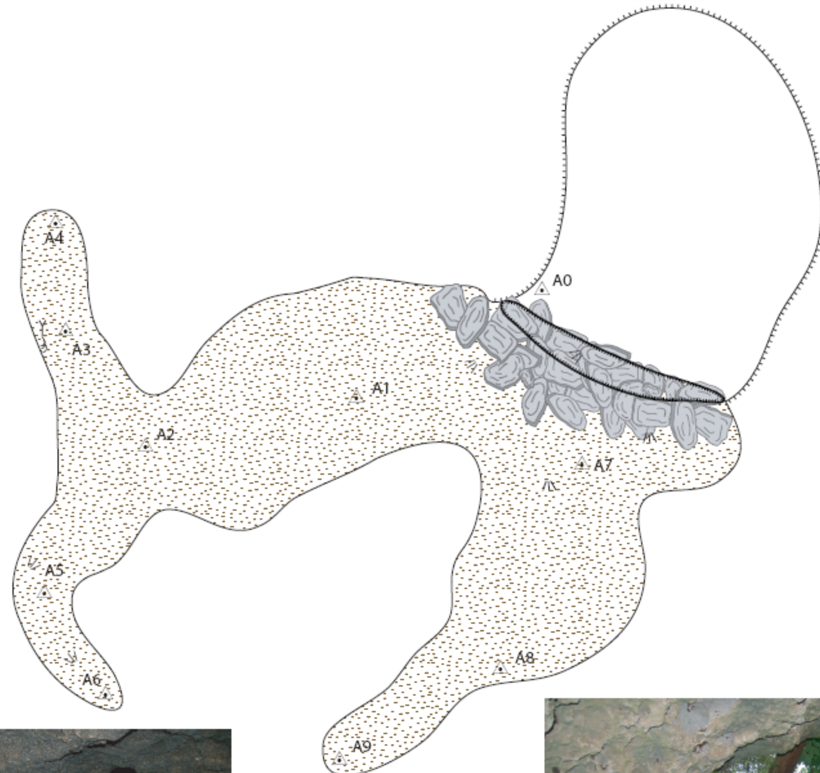
N

0 5 10 Meters

Key To Features

- Sediment floor
- Large breakdown
- Small breakdown
- Entrance pit
- Entrance sink
- Direction of slope
- Survey station
- Stalactites
- Flowstone

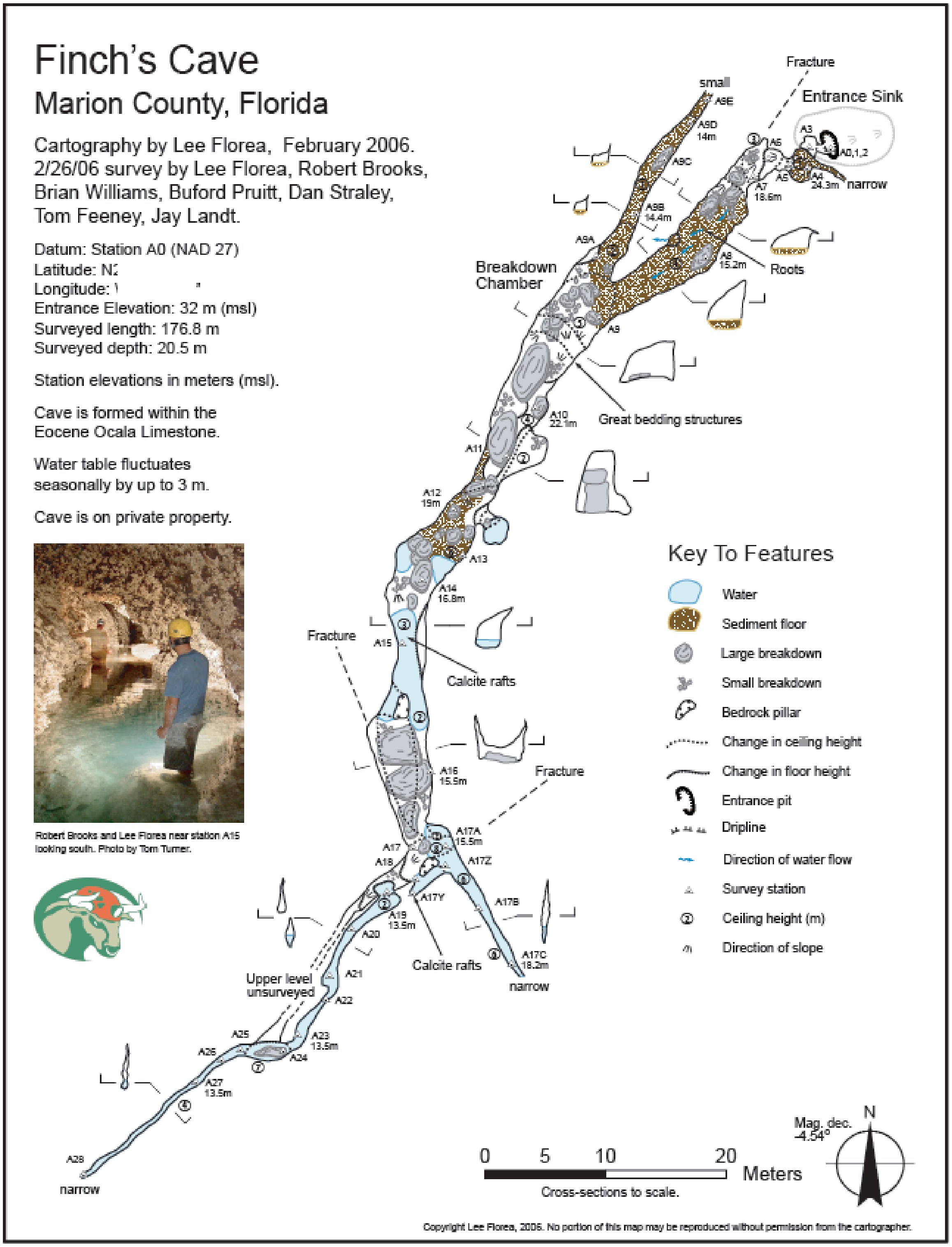
IMPORTANT NOTE -
The cave is located on private property. Permission required for entry.



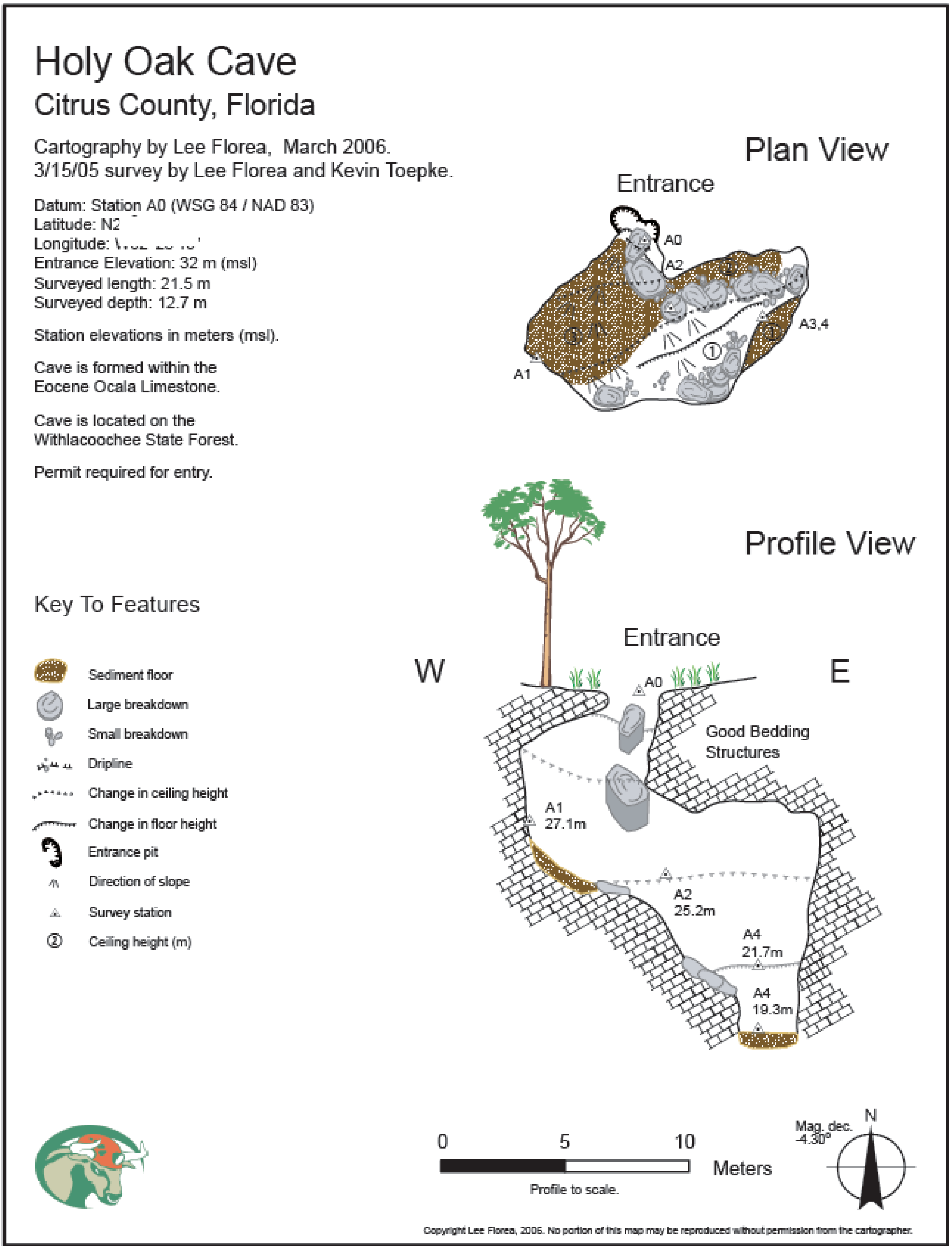
Graffiti on flowstone near A3. (Grant Harley)

Jason Polk at the entrance near A0. (Grant Harley)

Appendix B: (Continued)



Appendix B: (Continued)



Appendix C: Briar Cave Release of Liability

Appendix C: Briar Cave Release of Liability

RELEASE OF LIABILITY

In consideration of receiving permission from the ____ Farm, Inc., the owner of Briar Cave, Marion county, Florida, to enter Briar Cave, I, the undersigned, agree to the following stipulations, terms, and conditions:

1. I understand and have been fully informed that this is an unimproved, dangerous cave and that such difficult conditions as falling rocks, unfenced cliffs, low ceilings, deep water, slippery mud, narrow passageways and dangerous rock climbing may be encountered, and bites from bats and other animals as well as numerous other hazards may be encountered. I enter entirely at my own risk.

2. I agree to abide by all rules and regulations of THE FLORIDA SPELEOLOGICAL SOCIETY, INC. regarding safety and the use of any and all equipment. I understand that no drugs or alcoholic beverages of any type are allowed in the cave, and that I will be asked to leave the premises if I am suspected to be under the influence of the same.

3. I hereby covenant and agree for myself, my successors and assigns, that I will not make any claim or institute any suit or action against the ____ Farm or its respective agents, representatives, employees or assigns and shall indemnify the ____ k Farm and hold it harmless against any loss or damage which it may suffer by reason of any claim which it may hereafter acquire relating to any accident, incident or occurrence arising out of or in connection with my entrance upon and use of the premises of Briar Cave.

Date	Printed Name	Signature
______	______________	______________
______	______________	______________
______	______________	______________
______	______________	______________
______	______________	______________
______	______________	______________
______	______________	______________
______	______________	______________

Date/approximate time of entry: ______________________________

Date/expected time of exit: ______________________________

In emergency, please notify: ____________________ **Tel.** __________

Appendix D: Withlacoochee State Forest Special Use Permits

Appendix D: Withlacoochee State Forest Special Use Permits

Permit No. 455
C ✓ PB ✓ NL _

STATE OF FLORIDA
DEPARTMENT OF AGRICULTURE CONSUMER SERVICES
DIVISION OF FORESTRY
STATE FOREST USE PERMIT

University of South Florida, Department of Geography
Name of Group

has permission to use the Citrus Hiking Trails and Terrestrial Caves
Facilities and Location

in the Citrus Tract on the Withlacoochee State Forest.

From April 1, 2007 (Arrival Date) to September 30, 2007 (Departure Date)

Number in-group 3-5

Person in charge of group Grant Harley, USF Graduate Assistant

Address 4202 E. Fowler Avenue, NES 107
Tampa, FL 33620

Phone # (813) 974-8498

Fax#/Email (8. ., ...184 glharley@gmail.com

SPECIAL ARRANGEMENT OR ACCOMODA... D... Forestry and Wildlife Management Rules and Regulations apply.

Investigators will not enter bat caves without specific permission from WSF Biologist. Grant Harley and other associated members may drive on closed roads for cave mapping and inventory work. Permit requested per Colleen Werner, Forest Biologist.

The person or group granted this permit will be responsible for any damages to the facilities and /or furnishings as a result of their use of these facilities. Use all State Forest lands and facilities at your own risk.

State Forest Officer — March 23, 2007 (Date)

Distribute: RVC Permit Book; W-6; W-16; W-17; Taylor, Washburn; Camp Host-Kuburski's

W15 01-17-07

Appendix D: (Continued)

Permit # 009
C✓ PB __ NL __

☐-JLY ☐-AUG ☐-SEP ☐-OCT ☐-NOV ☐-DEC
☐-JAN ☐-FEB ☐-MAR ☐-APR ☐-MAY ☐-JUN

State of Florida
Department of Agriculture and Consumer Services
Division of Forestry

State Forest Use Permit

Citrus Cave & Karst Volunteers/Resource Survey

University of South Florida/Department of Geology/Grant Hartley
Name of Group

Has permission to use the Terrestrial Caves & Closed Road Access
Facilities and Location

On the Citrus Tract On the Withlacoochee State Forest.

From: July 1, 2007 To: June 30, 2008 - day use only
Permit excludes holidays, holiday weekends and Muzzleloading & General Gun hunt dates.

Number in Group 3-5 participants

Person in charge of group Grant Harley, USF Graduate Assistant

Address University of South Florida
4202 E. Fowler Ave., NES 107

Tampa, FL 33620

Telephone (813) 974-8498

Fax/Email (813) 974-2184 Fax / glharley@gmail.com

Special Arrangement or Accommodatio... ision of Forestry and Wildlife Management Rules and Regulations apply.

> *Volunteers must have approval from C... ner, W... going out on assignment. Investigators will not enter bat caves without specific permission from WFC Biiologist. Grant Harley & other associated survey members may drive on closed roads for cave mapping & inventory work. No ground disturbance or any alterations to cave area or surroundings. Permit approved by Colleen Werner/Resource Section.*

The person or group granted this permit will be responsible for any damages to the facilities and /or furnishings as a result of their use of these facilities. Use all State Forest lands and facilities at your own risk.

[signature]
State Forest Officer

July 1, 2007
Date

Distribution: RVC Permit Book-monthly; W-16; W-17; Taylor, Washburn, TBAG Volunteer Files

Appendix E: Caves Geodatabase

Appendix E: Caves Geodatabase (Belleview Formation – Jeep)

Name	Inv_date	Inv_id	County
BELLEVIEW FORMATION	9/21/2003	INV033	MARION
BIG MOUTH	6/3/2007	INV008	CITRUS
BLOWING HOLE	6/15/2007	INV027	CITRUS
BOTTLE CAP	8/12/2007	INV030	CITRUS
BRC	6/1/2003	INV009	HERNANDO
BRIAR	9/23/2007	INV040	MARION
CRUMBLING ROCK	5/19/2007	INV002	CITRUS
DOG DROP	6/9/2007	INV019	CITRUS
FALLEN OAK	6/9/2007	INV017	CITRUS
FINCH'S	5/26/2007	INV003	MARION
FLOATING ROCK	5/11/2007	INV012	CITRUS
FOOTBALL	8/4/2007	INV028	CITRUS
GIRL SCOUT	6/9/2007	INV020	CITRUS
GOAT MUMMY	8/4/2007	INV029	CITRUS
HEROINE	8/18/2007	INV034	MARION
HITCHHIKER	9/23/2007	INV041	MARION
HOLY OAK	5/11/2007	INV001	CITRUS
INDIGO	6/15/2007	INV025	HERNANDO

Appendix E: (Continued)

Name	Personnel
BELLEVIEW FORMATION	GRANT HARLEY, JASON POLK, MONICA EXNER
BIG MOUTH	GRANT HARLEY, JASON POLK, SONJA WESCOMB
BLOWING HOLE	GRANT HARLEY, JASON POLK, PHIL VAN BEYNEN
BOTTLE CAP	GRANT HARLEY, TOM TURNER, MONICA EXNER
BRC	GRANT HARLEY, TOM TURNER, ROBERT BROOKS, JASON POLK
BRIAR	GRANT HARLEY, JASON POLK, JUSTIN MARKS
CRUMBLING ROCK	GRANT HARLEY, JASON POLK, TOM TURNER
DOG DROP	GRANT HARLEY, JASON POLK
FALLEN OAK	GRANT HARLEY, JASON POLK
FINCH'S	GRANT HARLEY, JASON POLK
FLOATING ROCK	LEE FLOREA, BETH FRATESI, DON SEALE
FOOTBALL	GRANT HARLEY, JASON POLK, TOM TURNER, ROBERT BROOKS, MONICA EXNER
GIRL SCOUT	GRANT HARLEY, JASON POLK
GOAT MUMMY	GRANT HARLEY, JASON POLK, TOM TURNER, ROBERT BROOKS, MONICA EXNER
HEROINE	GRANT HARLEY, JASON POLK, MONICA EXNER
HITCHHIKER	GRANT HARLEY, JASON POLK
HOLY OAK	GRANT HARLEY, JASON POLK, COLLEEN WERNER, MONICA EXNER
INDIGO	GRANT HARLEY, JASON POLK

Appendix E: (Continued)

Name	Cave Ownership	Equipment Needed
BELLEVIEW FORMATION	PRIVATE PROPERTY	NORMAL SPELEO GEAR
BIG MOUTH	PUBLIC PROPERTY	NORMAL SPELEO GEAR
BLOWING HOLE	PUBLIC PROPERTY	CABLE LADDER
BOTTLE CAP	PUBLIC PROPERTY	KNEEPADS
BRC	PRIVATE PROPERTY	NORMAL SPELEO GEAR
BRIAR	PRIVATE PROPERTY	WET-SUIT
CRUMBLING ROCK	PRIVATE PROPERTY	NORMAL SPELEO GEAR
DOG DROP	PUBLIC PROPERTY	ROPE OR VERTICAL EQUIPMENT
FALLEN OAK	PUBLIC PROPERTY	NORMAL SPELEO GEAR
FINCH'S	PRIVATE PROPERTY	NORMAL SPELEO GEAR
FLOATING ROCK	PUBLIC PROPERTY	NONE
FOOTBALL	PRIVATE PROPERTY	KNEEPADS
GIRL SCOUT	PUBLIC PROPERTY	NORMAL SPELEO GEAR
GOAT MUMMY	PRIVATE PROPERTY	NORMAL SPELEO GEAR
HEROINE	PRIVATE PROPERTY	NORMAL SPELEO GEAR
HITCHHIKER	PRIVATE PROPERTY	NORMAL SPELEO GEAR
HOLY OAK	PUBLIC PROPERTY	NORMAL SPELEO GEAR
INDIGO	PUBLIC PROPERTY	NORMAL SPELEO GEAR

Appendix E: (Continued)

Name	Other_Equipment_Needed	Elevation_masl	Cave_Map_Status	Cave_Length_Meters
BELLEVIEW FORMATION	NA	-9999	COMPLETE MAP	54.3
BIG MOUTH	NA	25.829	COMPLETE MAP	95.7
BLOWING HOLE	KNEEPADS	30.17	COMPLETE MAP	257
BOTTLE CAP	NA	22.66	IN PROGRESS	101.5
BRC	KNEEPADS	30.48	COMPLETE MAP	1030.22
BRIAR	BOAT OR FLOATATION	-9999	COMPLETE MAP	2000
CRUMBLING ROCK	WET-SUIT	16.46	COMPLETE MAP	1024
DOG DROP	NA	31.97	COMPLETE MAP	46
FALLEN OAK	NA	-9999	COMPLETE MAP	10.4
FINCH'S	NA	32	COMPLETE MAP	176.8
FLOATING ROCK	NA	16.125	COMPLETE MAP	92.4
FOOTBALL	NA	29.69	COMPLETE MAP	142.2
GIRL SCOUT	KNEEPADS	31.4	COMPLETE MAP	17.8
GOAT MUMMY	NA	27.94	COMPLETE MAP	50.4
HEROINE	NA	-9999	COMPLETE MAP	27
HITCHHIKER	NA	-9999	COMPLETE MAP	-9999
HOLY OAK	NA	30.57	COMPLETE MAP	21.5
INDIGO	NA	39.61	COMPLETE MAP	14

Appendix E: (Continued)

Name	Cave_Vertical_Extent_Meters
BELLEVIEW FORMATION	7
BIG MOUTH	21.2
BLOWING HOLE	16.3
BOTTLE CAP	-9999
BRC	10.67
BRIAR	-9999
CRUMBLING ROCK	-9999
DOG DROP	-9999
FALLEN OAK	-9999
FINCH'S	20.5
FLOATING ROCK	16.0
FOOTBALL	18.7
GIRL SCOUT	-9999
GOAT MUMMY	-9999
HEROINE	-9999
HITCHHIKER	-9999
HOLY OAK	12.7
INDIGO	-9999

Appendix E: (Continued)

Name	Management Notes
BELLEVIEW FORMATION	UNMANAGED, NEEDS MANAGEMENT STRATEGY, DEVELOPMENTAL THREATS
BIG MOUTH	FENCED-IN BY WSF BC BAT AND WITHLACOOCHEE LIGHT-FLEEING CRAYFISH HABITAT
BLOWING HOLE	GATED, ACCESS CONTROLLED, MANAGED BY WSF
BOTTLE CAP	UNMANAGED
BRC	MANAGEMENT PLAN DRAFTED, BUT NOT ACCEPTED BY LAND OWNER, UNMANAGED
BRIAR	MANAGED BY FSS AND LANDOWNER; CURRENT SPELEOTHEM RESTORATION, TRAFFIC LOCALIZED ON TRAIL
CRUMBLING ROCK	PRIVATELY MANAGED BY LANDOWNER, GATED, 2 SURVEILLANCE CAMERAS
DOG DROP	UNMANAGED, FENCE NEEDED BECAUSE OF ENTRANCE DROP DEPTH
FALLEN OAK	UNMANAGED
FINCH'S	UNMANAGED, SPOKE WITH OWNER, NO ONE ELSE ALLOWED ACCESS AFTER 5/26/2007
FLOATING ROCK	UNMANAGED; ENATRNCE FILLED IN WITH SEDIMENT OCTOBER 2007
FOOTBALL	UNMANAGED; DEVELOPMENTAL THREATS
GIRL SCOUT	UNMANAGED, GREAT CAVE FOR GROUPS/RECREATIONAL FIELD TRIPS, ALREADY DISTURBED
GOAT MUMMY	UNANAGED, NEEDS ACCESS CONTROL DUE TO SE BAT ROOST
HEROINE	UNMANAGED, CAVE CLEAN-UP NECESSARY
HITCHHIKER	UNMANAGED, RESTORATION NECESSARY
HOLY OAK	UNMANAGED
INDIGO	UNMANAGED

Appendix E: (Continued)

Name	Entry_Status	Other_Entry_Status	Multiple_Entrances
BELLEVIEW FORMATION	FORBIDDEN BY OWNER	NA	Y
BIG MOUTH	LOCKED OR GATED	WAIVER REQUIRED	N
BLOWING HOLE	LOCKED OR GATED	WAIVER REQUIRED	N
BOTTLE CAP	WAIVER REQUIRED	PERMISSION REQUIRED	N
BRC	FORBIDDEN BY OWNER	TEMPORARILY BLOCKED	N
BRIAR	PERMISSION REQUIRED	WAIVER REQUIRED	N
CRUMBLING ROCK	LOCKED OR GATED	PERMISSION REQUIRED	N
DOG DROP	WAIVER REQUIRED	PERMISSION REQUIRED	N
FALLEN OAK	WAIVER REQUIRED	PERMISSION REQUIRED	N
FINCH'S	FORBIDDEN BY OWNER	TEMPORARILY BLOCKED	N
FLOATING ROCK	TEMPORARILY BLOCKED	DESTROYED OR CLOSED	N
FOOTBALL	PERMISSION REQUIRED	NA	N
GIRL SCOUT	OPEN ACCESS	NA	N
GOAT MUMMY	PERMISSION REQUIRED	FORBIDDEN BY OWNER	N
HEROINE	UNKNOWN STATUS	NA	N
HITCHHIKER	UNKNOWN STATUS	NA	N
HOLY OAK	PERMISSION REQUIRED	WAIVER REQUIRED	N
INDIGO	WAIVER REQUIRED	PERMISSION REQUIRED	N

Appendix E: (Continued)

Name	Type_of_Entrance_Vertical	Type_of_Entrance_Horizontal_or_Downward_Sloping
BELLEVIEW FORMATION	ENLARGED FISSURE	NA
BIG MOUTH	NA	LARGE HORIZONTAL (20 FT +)
BLOWING HOLE	BOTTLENECK/SMALL BUT BELLS OUT	NA
BOTTLE CAP	NA	TIGHT SQUEEZE
BRC	NA	TIGHT SQUEEZE
BRIAR	CHIMNEY OR CLIMB	NA
CRUMBLING ROCK	ENLARGED FISSURE	NA
DOG DROP	PIT	NA
FALLEN OAK	NA	TIGHT SQUEEZE
FINCH'S	TIGHT PIT	NA
FLOATING ROCK	NA	STOOP OR DUCK WALK
FOOTBALL	CHIMNEY OR CLIMB	NA
GIRL SCOUT	NA	STOOP OR DUCK WALK
GOAT MUMMY	NA	LARGE HORIZONTAL (20 FT +)
HEROINE	NA	TIGHT SQUEEZE
HITCHHIKER	NA	LARGE HORIZONTAL (20 FT +)
HOLY OAK	CHIMNEY OR CLIMB	NA
INDIGO	NA	TIGHT SQUEEZE

Appendix E: (Continued)

Name	Entrance Topo Position	Ent Visibility	Ent modification
BELLEVIEW FORMATION	SINKHOLE	OBSCURED BY VEGETATION	NONE
BIG MOUTH	SINKHOLE	CLEARLY VISIBLE	QUARRY
BLOWING HOLE	HILLSIDE	CLEARLY VISIBLE	GATED
BOTTLE CAP	HILLSIDE	OBSCURED BY ROCKS	NONE
BRC	SINKHOLE	OBSCURED BY VEGETATION	WIDENED
BRIAR	SINKHOLE	OBSCURED BY VEGETATION	GATED
CRUMBLING ROCK	QUARRY	OBSCURED BY VEGETATION	QUARRY
DOG DROP	HILLSIDE	CLEARLY VISIBLE	WIDENED
FALLEN OAK	SINKHOLE	CLEARLY VISIBLE	DUG OUT/OPEN
FINCH'S	SINKHOLE	OBSCURED BY VEGETATION	BLOCKED
FLOATING ROCK	SINKHOLE	CLEARLY VISIBLE	WIDENED
FOOTBALL	SINKHOLE	OBSCURED BY VEGETATION	WIDENED
GIRL SCOUT	SINKHOLE	CLEARLY VISIBLE	WIDENED
GOAT MUMMY	QUARRY	OBSCURED BY VEGETATION	QUARRY
HEROINE	SINKHOLE	OBSCURED BY ROCKS	WIDENED
HITCHHIKER	SINKHOLE	OBSCURED BY VEGETATION	NONE
HOLY OAK	HILLTOP	CLEARLY VISIBLE	WIDENED
INDIGO	HILLSIDE	OBSCURED BY VEGETATION	DUG OUT/OPEN

Appendix E: (Continued)

Name	Ent_minimum_size	Entrance_Drop_Depth
BELLEVIEW FORMATION	SQUEEZE	4
BIG MOUTH	WALK	0
BLOWING HOLE	SQUEEZE	8
BOTTLE CAP	SQUEEZE	0
BRC	SQUEEZE	0
BRIAR	SQUEEZE	2
CRUMBLING ROCK	SQUEEZE	3
DOG DROP	VERTICAL DROP	12
FALLEN OAK	SQUEEZE	0
FINCH'S	SQUEEZE	2
FLOATING ROCK	STOOP	0
FOOTBALL	SQUEEZE	0
GIRL SCOUT	STOOP	0
GOAT MUMMY	WALK	0
HEROINE	SQUEEZE	0
HITCHHIKER	WALK	0
HOLY OAK	SQUEEZE	4
INDIGO	SQUEEZE	0

Appendix E: (Continued)

Name	Entrance_Notes
BELLEVIEW FORMATION	TWO ENTRANCES, SINKHOLE
BIG MOUTH	LARGE DOWNWARD-SLOPING ENTRANCE
BLOWING HOLE	ENTRANCE WAS WIDENED. CAVE IS GATED AND LOCKED. PERMISSION FROM STATE FOREST REQUIRED FOR ENTRY.
BOTTLE CAP	TIGHT DROP DOWN
BRC	VERY TIGHT SQUEEZE, TEMPORARILY BLOCKED TO DISCOURAGE VISITORS
BRIAR	ENTRANCE GATED AND LOCKED, ENTRYALLOWED ONE SUNDAY EACH MONTH
CRUMBLING ROCK	ENTRANCE LOCATED IN SHALLOW QUARRY, NOT NATURAL
DOG DROP	PHREATIC/BREAKDOWN ENTRANCE PIT
FALLEN OAK	MUST TRAVERSE DOWN COVER-COLLAPSE SINKHOLE TO ACCESS ENTRANCE
FINCH'S	ENTRANCE BLOCKED WITH 2 HEAVY ROCKS, PLYWOOD,AND DEBRIS
FLOATING ROCK	ENTRANCE BLOCKED WITH SEDIMENT, NO LONGER ACCESSIBLE
FOOTBALL	TIGHT SQUEEZE, VERY TECHNICAL
GIRL SCOUT	BREAKDOWN ENTRANCE, EASILY ACCESIBLE
GOAT MUMMY	LARGE, WALK-IN ENTRANCE NOT TYPICAL TO FLORIDA
HEROINE	BREAKDOWN ENTRANCE
HITCHHIKER	LARGEST CAVE ENTRANCE IN FLORIDA
HOLY OAK	SINKHOLE ENTRANCE, TIGHT
INDIGO	ENTRANCE DUG OUT, COVERED WITH VEGETATION AND DEBRIS

Appendix E: (Continued)

Name	Passage_Orientation	Passage_Types
BELLEVIEW FORMATION	NE-SW	ENLARGED FISSURE
BIG MOUTH	NE-SW	BREAKDOWN, ENLARGED FISSURE
BLOWING HOLE	NE-SW & NW-SE	PHREATIC TUBES, BREAKDOWN, ENLARGED FISSURE, PLUS-SIGN
BOTTLE CAP	NE-SW	BREAKDOWN
BRC	NE-SW & NW-SE	ENLARGED FISSURE, BREAKDOWN
BRIAR	NE-SW, NW-SE, N-S, & E-W	ENLARGED FISSURE, PHREATIC, JOINT CONTROLLED
CRUMBLING ROCK	NE-SW & NW-SE	PHREATIC, ENLARGED FISSURE, HORIZONTALLY EXTENSIVE
DOG DROP	NW-SE	BREAKDOWN
FALLEN OAK	NW-SE	BREAKDOWN
FINCH'S	NE-SW	BREAKDOWN, ENLARGED FISSURE
FLOATING ROCK	NE-SW	BREAKDOWN, ENLARGED FISSURE
FOOTBALL	NW-SE	BREAKDOWN, ENLARGED FISSURE
GIRL SCOUT	NW-SE	BREAKDOWN
GOAT MUMMY	NE-SW	BREAKDOWN, SOLUTION CHAMBER
HEROINE	NE-SW	BREAKDOWN
HITCHHIKER		BREAKDOWN
HOLY OAK	NE-SW	ENLARGED FISSURE: A1,2; BREAKDOWN:A0,3,4
INDIGO	NE-SW	BREAKDOWN

Appendix E: (Continued)

Name	Passage_Min_Sizes
BELLEVIEW FORMATION	SQUEEZE, CRAWL, STOOP, WALK
BIG MOUTH	CRAWL, STOOP, WALK
BLOWING HOLE	CRAWL, STOOP, WALK
BOTTLE CAP	SQUEEZE, CRAWL
BRC	SQUEEZEM CRAWL, STOOP, WALK
BRIAR	SQUEEZE, CRAWL, STOOP, WALK
CRUMBLING ROCK	SQUEEZE, CRAWL, STOOP, WALK
DOG DROP	CRAWL, STOOP, WALK
FALLEN OAK	SQUEEZE, CRAWL
FINCH'S	SQUEEZE, CRAWL, WALK
FLOATING ROCK	STOOP, WALK
FOOTBALL	SQUEEZE, CRAWL, STOOP, WALK
GIRL SCOUT	STOOP, CRAWL
GOAT MUMMY	WALK
HEROINE	SQUEEZE, CRAWL, STOOP
HITCHHIKER	STOOP, WALK
HOLY OAK	CRAWL:A0,2,3; WALK:A1,4
INDIGO	SQUEEZE, CRAWL

Appendix E: (Continued)

Name	Passage_Hydrology
BELLEVIEW FORMATION	INTERMITTENT STREAM, SEEPS, DRIPS
BIG MOUTH	POOLS, INTERMITTENT STREAM, WATERFALL
BLOWING HOLE	DRIPS:E3,2A,8,A2,3,5,7,D1; POOL:D4;SEEPING:D4
BOTTLE CAP	NA
BRC	DRIPS, SEEPS, POOLS, EPHIMERAL STREAM ENTERS CAVE FROM SINKHOLE AT B71 AND SINKS AT B45
BRIAR	DRIPS, SEEPS, POOL, AQUIFER
CRUMBLING ROCK	DRIPS, SEEPS, POOLED, AQUIFER
DOG DROP	MODERN WATER FLOW NOTED ON MAP WASH-IN FROM ENTRANCE PIT
FALLEN OAK	NA
FINCH'S	POOL-A15,17-17C,19-28
FLOATING ROCK	POOLS, INTERMITTENT STREAM, WATERFALL, SUMP
FOOTBALL	A1,2,3-DRIP
GIRL SCOUT	NA
GOAT MUMMY	DRIPS, SEEPS
HEROINE	NA
HITCHHIKER	NA
HOLY OAK	NA
INDIGO	NA

Appendix E: (Continued)

Name	Passage_Floor	Passage_Hazards
BELLEVIEW FORMATION	SEDIMENT, BREAKDOWN	NA
BIG MOUTH	SEDIMENT, WATER, BREAKDOWN	MOLD ON GUANO, LOOSE BREAKDOWN:A1
BLOWING HOLE	SEDIMENT, BREAKDOWN	UNSTABLE BREAKDOWN, TIGHT-VERTICAL PIT:E0
BOTTLE CAP	SEDIMENT, BREAKDOWN	UNSTABLE BREAKDOWN, LOOSE CEILING ROCKS
BRC	SEDIMENT, BREAKDOWN	SOME PASSAGES ARE TECHNICAL, VERY TIGHT
BRIAR	SEDIMENT, BREAKDOWN, DEEP AQUIFER	DEEP AQUIFER, STEEP DROPS, UNSTABLE BREAKDOWN, BAD AIR IN BACK OF CAVE
CRUMBLING ROCK	BREAKDOWN, VARVED CLAY SEDIMENTS	NA
DOG DROP	SEDIMENT, BREAKDOWN	UNSTABLE BREAKDOWN:A1
FALLEN OAK	GRAVEL, SEDIMENT	TOO TIGHT NEAR STATION A4
FINCH'S	SEDIMENT, BREAKDOWN	UNSTABLE BREAKDOWN:A9-18;DEEP CREVASSE:A11
FLOATING ROCK	SEDIMENT, BREAKDOWN	UNSTABLE BREAKDOWN, SUMP
FOOTBALL	SEDIMENT, BREAKDOWN	STEEP DROPS BETWEEN LARGE BREAKDOWN, UNSTABLE BREAKDOWN, BRITTLE LIMESTONE WALLS
GIRL SCOUT	BREAKDOWN, SEDIMENT	NA
GOAT MUMMY	SEDIMENT, BREAKDOWN	GUANO
HEROINE	BREAKDOWN	HYPODERMIC NEEDLES, BIOHAZARD TRASH, LOOSE BREAKDOWN
HITCHHIKER	SEDIMENT, BREAKDOWN	NA
HOLY OAK	SEDIMENT:A0,A1,A4; BREAKDOWN:A2,A3	VERTICAL PIT:A0; UNSTABLE BREAKDOWN:A2,A3,A4; STEEP SLOPE:A0,A2,A3
INDIGO	BREAKDOWN	UNSTABLE CEILING AND WALL BREAKDOWN

Appendix E: (Continued)

Name	Passage_Notes	Tites_Mites_Columns_Condition
BELLEVIEW FORMATION	FISSURE CONTROLLED	A9,10,11,3
BIG MOUTH	LARGE PASSAGE	NA
BLOWING HOLE	MAZE CAVE. FEEDER TUBES IN MAIN PASSAGE NEAR STATIONS A2-4	A4:REMOVED;A5,B1:DEPOSITING, DRY;D4:DEPOSITING; D5,6:DRY; C6:DEPOSITING, DRY
BOTTLE CAP	BREAKDOWN PASAGE	A13,13A,14,15,17,17A:DEPOSITING; A10A:DRY
BRC	BREAKDOWN	A3,E6-10,D17C,B16,CA7,B48,B45:DEPOSITING
BRIAR	PASSAGED LIKELY FORMED BY MIXING CORROSION, RISING/FALLING AQUIFER	A0-20:DEPOSITING
CRUMBLING ROCK	FISSURE CONTROLLED	A2:DRY; A3,4,5: DEPOSITING
DOG DROP	NA	A2A-SODA STRAW:DRY
FALLEN OAK	NA	NA
FINCH'S	MOST PASSAGE ALLOWS FOR WALKING WITH HIGH CEILING	NA
FLOATING ROCK	NA	NA
FOOTBALL	BREAKDOWN EVERYWHERE, SIMILAR TO FINCH'S	A10-DRY
GIRL SCOUT	NA	NA
GOAT MUMMY	LARGE CHAMBER	A2,3:DEPOSITING; A5:DRY
HEROINE	ALL PASSAGES ARE BREAKDOWN	NA
HITCHHIKER	LARGE PASSAGE	NA
HOLY OAK	NA	NA
INDIGO	CAVE HAS BEEN DUG OUT/OPEN	NA

Appendix E: (Continued)

Name	Drapery_Condition	Helictites_Condition
BELLEVIEW FORMATION	A9,3,5	NA
BIG MOUTH	NA	NA
BLOWING HOLE	B1,A4,D4:DEPOSITING; C6:DEPOSITING, DRY	NA
BOTTLE CAP	A13,13A,14,15,17,17A:DEPOSITING; A10A:DRY	A17:DEPOSITING
BRC	A3,E6-10,D17C,B16,CA7,B48,B45:DEPOSITING	A3,E6-10,D17C,B16,CA7,B48,B45:DEPOSITING
BRIAR	A0-15, 16-20; DEPOSITING	A3,5,11, 21
CRUMBLING ROCK	A5:DEPOSITING	NA
DOG DROP	NA	NA
FALLEN OAK	NA	NA
FINCH'S	NA	NA
FLOATING ROCK	NA	NA
FOOTBALL	A10-DRY	NA
GIRL SCOUT	NA	NA
GOAT MUMMY	A2:DEPOSITING; A5:DRY	A5:DRY
HEROINE	NA	NA
HITCHHIKER	NA	NA
HOLY OAK	NA	NA
INDIGO	NA	NA

Appendix E: (Continued)

Name	Rimstone_Condition	Popcorn_Condition	Flowstone_Condition
BELLEVIEW FORMATION	A5,10,11	NA	A9,10,11,3,4,5,9
BIG MOUTH	NA	NA	NA
BLOWING HOLE	A5,B1,D4:DEPOSITING; C6:DRY	C6:DRY	D5,6:DEPOSITING; A2:DRY; A4:DAMAGED; D1,3:DEPOSITING; A5,B1:DEPOSITING, DRY
BOTTLE CAP	A17,17A:DEPOSITING; A10A:DRY	NA	A13,13A,14,15,17,17A:DEPOSITING; A10A:DRY
BRC	A3,E6-10,D17C,B16,CA7,B48,B45:DEPOSITING	NA	A3,E6-10,D17C,B16,CA7,B48,B45:DEPOSITING
BRIAR	A0-20	A3,14	A0-20
CRUMBLING ROCK	NA	NA	A5:DEPOSITING
DOG DROP	NA	NA	A2A:DRY
FALLEN OAK	NA	NA	NA
FINCH'S	NA	NA	NA
FLOATING ROCK	NA	NA	NA
FOOTBALL	A10-DRY	NA	A1,2-DRY; A10-DRIP
GIRL SCOUT	NA	NA	A1-3:DAMAGED, REMOVED
GOAT MUMMY	A5:DRY	NA	A2:DEPOSITING; A5:DRY
HEROINE	NA	NA	NA
HITCHHIKER	NA	NA	NA
HOLY OAK	NA	NA	NA
INDIGO	NA	NA	NA

Appendix E: (Continued)

Name	Spar_Condition	Calcite_Coating_Condition	Calcite_Rafts	Scallops
BELLEVIEW FORMATION	NA	A1,2	NA	A1,2
BIG MOUTH	NA	NA	NA	NA
BLOWING HOLE	NA	B4:GREY	NA	NA
BOTTLE CAP	NA	NA	NA	NA
BRC	NA	NA	NA	NA
BRIAR	NA	A0-20:GRAY	A18,19	A0-20
CRUMBLING ROCK	NA	NA	NA	A1-5
DOG DROP	NA	NA	NA	NA
FALLEN OAK	NA	NA	NA	NA
FINCH'S	NA	NA	A15,17	NA
FLOATING ROCK	NA	NA	NA	NA
FOOTBALL	NA	A7-11-GREY	NA	A12
GIRL SCOUT	NA	NA	NA	NA
GOAT MUMMY	NA	NA	NA	NA
HEROINE	NA	NA	NA	NA
HITCHHIKER	NA	NA	NA	NA
HOLY OAK	NA	NA	NA	NA
INDIGO	NA	NA	NA	NA

Appendix E: (Continued)

Name	Anastomosen	Sediments
BELLEVIEW FORMATION	NA	LAYERED; HUMAN-INDUCED / NATURAL SEDIMENTATION
BIG MOUTH	NA	LAYERED; HUMAN-INDUCED / NATURAL SEDIMENTATION
BLOWING HOLE	NA	PACKED, UNSORTED CLAY; NATURAL SED.
BOTTLE CAP	NA	UNSORTED; HUMAN-INDUCED / NATURAL SED.
BRC	NA	LAYERED ORGANICS AND SAND; HUMAN-INDUCED / NATURAL SED.
BRIAR	NA	LAYERED SAND AND CLAY; NATURAL SED.
CRUMBLING ROCK	NA	LAYERED VARVED CLAY; HUMAN-INDUCED / NATURAL SED.
DOG DROP	NA	LAYERED, COMPACTED CLAY; NATURAL SED.
FALLEN OAK	NA	UNSORTED; NATURAL SED.
FINCH'S	NA	A0-9E,11-13; NATURAL SED.
FLOATING ROCK	NA	UNSORTED; HUMAN-INDUCED / NATURAL SED.
FOOTBALL	NA	LAYERED, COMPACTED; NATURAL SED.
GIRL SCOUT	NA	UNSORTED; HUMAN-INDUCED / NATURAL SED.
GOAT MUMMY	NA	LAYERED ORGANICS; HUMAN-INDUCED / NATURAL SED.
HEROINE	NA	NA
HITCHHIKER	NA	LAYERED; HUMAN-INDUCED / NATURAL SED.
HOLY OAK	NA	A0,1,4; NATURAL SED.
INDIGO	NA	NA; NATURAL SED.

Appendix E: (Continued)

Name	Sediments_Notes	Fossils
BELLEVIEW FORMATION	LAYERED ORGANIC WASH-IN FROM SURFACE, GOOD FOR CORE	NA
BIG MOUTH	NA	NA
BLOWING HOLE	CLAY FLOOR, HEAVY COMPACTION-LIKE CONCRETE	NA
BOTTLE CAP	ORGANIC WASH-IN FROM SURFACE, UNLAYERED-NOT GOOD FOR SEDIMENT CORE	NA
BRC	GOOD FOR CORE	NA
BRIAR	GOOD FOR CORE	ECHONOIDS, CRAB FOSSILED IN WALL
CRUMBLING ROCK	GOOD FOR SEDIMENT CORE	NA
DOG DROP	HIGH COMPACTION FROM HEAVY CAVER TRAFFIC	NA
FALLEN OAK	HEAVY IN ORGANICS	NA
FINCH'S	LAYERED SEDIMENT AND ORGANIC DEBRIS WASH-IN FROM SURFACE	MEGALODON VERTEBRAL CENTRA:A7; FULL TURTLE SHELL ~6 INCHES IN DIAMETER FOSSILIZED IN WALL:A7
FLOATING ROCK	SANDY SEDIMENTS, UNSORTED	NA
FOOTBALL	LOW SEDIMENT COMPACTION NEAR STATIONS A6,A9, GOOD FOR SEDIMENT CORE	NA
GIRL SCOUT	SEDIMENTS PRESENT, BUT NOT GOOD FOR SEDIMENT CORE	NA
GOAT MUMMY	GOOD FOR CORE	NA
HEROINE	SOME SEDIEMNTS WASHING IN FROM SURFACE	NA
HITCHHIKER	DISTURBED, COMPACTED, NOT GOOD FOR CORE	NA
HOLY OAK	LAYERED SEDIMENTS, FINE LAMINAE	NA
INDIGO	NA	NA

Appendix E: (Continued)

Name	Bones	Geologic_Strata	Other_Geologic_Strata
BELLEVIEW FORMATION	NA	OCALA LIMESTONE (EOCENE)	NA
BIG MOUTH	NA	OCALA LIMESTONE (EOCENE)	NA
BLOWING HOLE	NA	OCALA LIMESTONE (EOCENE)	NA
BOTTLE CAP	NA	OCALA LIMESTONE (EOCENE)	NA
BRC	NA	OCALA LIMESTONE (EOCENE)	SUWANNEE LIMESTONE (OLIGOCENE)
BRIAR	NA	OCALA LIMESTONE (EOCENE)	NA
CRUMBLING ROCK	NA	OCALA LIMESTONE (EOCENE)	NA
DOG DROP	DOG BONES:A0	OCALA LIMESTONE (EOCENE)	NA
FALLEN OAK	UNIDENTIFIED LARGE BONES:A2	OCALA LIMESTONE (EOCENE)	NA
FINCH'S	NA	OCALA LIMESTONE (EOCENE)	NA
FLOATING ROCK	NA	OCALA LIMESTONE (EOCENE)	NA
FOOTBALL	NA	OCALA LIMESTONE (EOCENE)	NA
GIRL SCOUT	NA	OCALA LIMESTONE (EOCENE)	NA
GOAT MUMMY	A1:GOAT	OCALA LIMESTONE (EOCENE)	NA
HEROINE	NA	OCALA LIMESTONE (EOCENE)	NA
HITCHHIKER	NA	OCALA LIMESTONE (EOCENE)	NA
HOLY OAK	NA	OCALA LIMESTONE (EOCENE)	NA
INDIGO	NA	OCALA LIMESTONE (EOCENE)	NA

Appendix E: (Continued)

Name	Geologic_Notes	Biological_Vertebrates
BELLEVIEW FORMATION	CHERT IMBEDDED FISSURE PASSAGES THROUGHOUT CAVE	NA
BIG MOUTH	NA	SOUTHEASTERN BATS NEAR STATIONS A5,7
BLOWING HOLE	SPONGEWORK:C2,3,5,7,8; INTERESTING GYPSUM CRYSTAL FORMATION NEAR STATION C7	SOUTHEASTERN BAT:A4
BOTTLE CAP	NA	NA
BRC	CAVE PROBABLY FORMED AT CONTACT BETWEEN OCALA AND SUWANNE LIMESTONES	NA
BRIAR	HAWTHORN GROUP SEDIMENTS OVERLIE OCALA LIMESTONE	NA
CRUMBLING ROCK	NA	NA
DOG DROP	GREAT BEDDING STRUCTURES; FLAT-ROOF BREAKDOWN SIMILAR TO FEATURES IN WERNER CAVE	NA
FALLEN OAK	DIPPING BEDDING STRUCTURE:A0	NA
FINCH'S	NUMEROUS CHERT NODULES IN WALL:A5-7; GREAT BEDDING STRUCTURES:A9-10; NE-SW FRACTURE:A6-A15,A17-28; NW-SE FRACTURE:A15-17C	NA
FLOATING ROCK	DOME NEAR STATION A2	NA
FOOTBALL	BEDROCK PILLAR NEAR STATION A12, HAWTHORNE GROUP FILLED IN SPONGEWORK	NA
GIRL SCOUT	NA	NA
GOAT MUMMY	VERY LARGE CHAMBER ROOM, NOT TYPICAL IN FLORIDA	SOUTHEASTERN BAT
HEROINE	CAVE CONSISTS ENTIRELY OF BREAKDOWN	NA
HITCHHIKER	NA	NA
HOLY OAK	GOOD BEDDING STRUCTURES	NA
INDIGO	NA	NA

Appendix E: (Continued)

Name	Invertebrates	Mold_Bacteria
BELLEVIEW FORMATION	BROWN CRICKET, FROG:AA, A9	MOLD ON ORGANICS:AO
BIG MOUTH	WITHLACOOCHEE LIGHT-FLEEING CRAYFISH NEAR STATION A6	WHITE MOLD ON BAT GUANO NEAR STATIONS A5,7
BLOWING HOLE	TREE HOUSE FROGS:E0	A4
BOTTLE CAP	BROWN CRICKETS, FROGS	A2A
BRC	CAVE CRAYFISH, SPIDERS, CAVE CRICKETS, FROGS	NA
BRIAR	CAVE CRAYFISH, SPIDERS, ROACHES, SNAKE	A0-1
CRUMBLING ROCK	SPIDERS, FROGS, CAVE SHRIMP	NA
DOG DROP	NA	NA
FALLEN OAK	FROGS; CAVE CRICKETS	ANIMAL DUNG MOLD:A3
FINCH'S	NUMEROUS SPIDERS, BROWN CRICKETS, YELLOW RAT SNAKE ~.5M LONG	NA
FLOATING ROCK	NA	NA
FOOTBALL	CRICKET; FROG:A0-7	NA
GIRL SCOUT	GARDER SNAKE LIVING IN SMALL SPONGEWORK:A2	MOLD ON ORGANIC MATERIAL, HUMAN WASTE
GOAT MUMMY	SPIDERS, FROGS, CRICKET	A4:ON GUANO
HEROINE	SPIDERS	MOLD ON BOTTLE FILLED WITH URINE
HITCHHIKER	SPIDERS	NA
HOLY OAK	BLACK WIDOW SPIDER:A3; BROWN CAVE CRICKETS:A0,1	NA
INDIGO	CRICKETS, INDIGO SNAKE:A0	NA

Appendix E: (Continued)

Name	Roots	Roost_Stains	Guano_Piles
BELLEVIEW FORMATION	AA,A0	NA	NA
BIG MOUTH	NA	A5,7	A5,7
BLOWING HOLE	NA	A4	A4
BOTTLE CAP	A1,2,3	A2	NA
BRC	NA	NA	NA
BRIAR	A0-5	NA	NA
CRUMBLING ROCK	A1	NA	NA
DOG DROP	A1,2,2A,4	NA	NA
FALLEN OAK	A1-3	NA	NA
FINCH'S	A0-8	NA	NA
FLOATING ROCK	NA	NA	NA
FOOTBALL	A0-6	NA	NA
GIRL SCOUT	A1,2	NA	NA
GOAT MUMMY	NA	A3,4,5	A3,4,5
HEROINE	A1	NA	NA
HITCHHIKER	NA	NA	NA
HOLY OAK	A1,3	NA	NA
INDIGO	A0,1	NA	NA

Appendix E: (Continued)

Name	Biological_Notes	Artifacts_Historical	Artifacts_Modern
BELLEVIEW FORMATION	NA	NA	NA
BIG MOUTH	NA	NA	NA
BLOWING HOLE	NA	NA	NA
BOTTLE CAP	CAVE ONCE WAS HABITAT FOR BATS, BUT VACANT IN RECENT YEARS	NA	NA
BRC	NA	NA	NA
BRIAR	NA	NA	NA
CRUMBLING ROCK	CAVE SHRIMP BEING IDENTIFIED AT UF	NA	NA
DOG DROP	NA	NA	NA
FALLEN OAK	NA	NA	NA
FINCH'S	NA	NA	NA
FLOATING ROCK	NA	NA	NA
FOOTBALL	NA	NA	NA
GIRL SCOUT	NA	NA	NA
GOAT MUMMY	ONE ROOST OF SE BAT NEAT STATION A4	NA	NA
HEROINE	NA	NA	NA
HITCHHIKER	NA	NA	NA
HOLY OAK	NA	NA	NA
INDIGO	NA	NA	NA

Appendix E: (Continued)

Name	Cultural_Notes	Scientific_Potential_Areas_Notes
BELLEVIEW FORMATION	NA	SEDIMENT CORE, SPELEOTHEM COLLECTION AND DRIP WATER COLLECTION
BIG MOUTH	NA	BIOTA, AQUIFER STUDY
BLOWING HOLE	NA	SPELEOTHEM WATER COLLECTION
BOTTLE CAP	NA	SPELEOTHEM WATER COLLECTION SITE
BRC	NA	SPELEOTHEM, WATER COLLECTION, SEDIMENT STUDY
BRIAR	NA	GREAT FOR STUDIES OF SPELEOGENESIS, SPELEOTHEMS, SEDIMENTS
CRUMBLING ROCK	NA	SPELEOTHEM, AQUIFER, SEDIMENT, BIOTA STUDIES
DOG DROP	NA	NA
FALLEN OAK	NA	NA
FINCH'S	NA	AQUIFER WATER COLLECTION SITE, SEDIMENT CORE COLLECTION SITE
FLOATING ROCK	NA	AQUIFER STUDY
FOOTBALL	NA	NA
GIRL SCOUT	ARCH SITE LISTED IN FLORIDA MASTER SITE FILE	NA
GOAT MUMMY	NA	NA
HEROINE	NA	NA
HITCHHIKER	NA	NA
HOLY OAK	NA	NA
INDIGO	NA	NA

Appendix E: (Continued)

Name	Special_Interest_Areas_Notes
BELLEVIEW FORMATION	CHERT IMBEDDED IN FISSURE
BIG MOUTH	NA
BLOWING HOLE	GOOOD DRIP WATER COLLECTION SITES SINCE CAVE IS GATED AND ACTIVELY DRIPPING IN MAY PLACES
BOTTLE CAP	NA
BRC	EPHIMERAL STREAMS ENTERS CAVE FROM SINKHOLE AT STATION B71 AND FLOWS TO B45 WHERE IT SINKS
BRIAR	NA
CRUMBLING ROCK	NA
DOG DROP	NA
FALLEN OAK	NA
FINCH'S	IMBEDDED CHERT NODULES:A5-7; CALCITE RAFTS:A15,17
FLOATING ROCK	NA
FOOTBALL	NA
GIRL SCOUT	NA
GOAT MUMMY	NA
HEROINE	NA
HITCHHIKER	NA
HOLY OAK	NA
INDIGO	NA

Appendix E: (Continued)

Name	SI_Biota	SI_Hydrology	SI_Speleothems	SI_Mineralogy	SI_Paleontology	SI_Cultural	SI_Score
BELLEVIEW FORMATION	2	3	3	3	1	0	0.66
BIG MOUTH	3	3	0	0	1	0	0.33
BLOWING HOLE	2	2	3	2	1	0	0.56
BOTTLE CAP	2	3	3	1	2	0	0.61
BRC	3	3	3	3	3	0	0.83
BRIAR	3	3	3	3	3	0	0.83
CRUMBLING ROCK	3	3	3	3	2	0	0.78
DOG DROP	2	1	1	0	1	0	0.22
FALLEN OAK	1	0	0	0	1	0	0.06
FINCH'S	2	3	1	1	1	0	0.44
FLOATING ROCK	0	3	0	0	1	0	0.22
FOOTBALL	2	3	2	2	1	0	0.55
GIRL SCOUT	1	1	0	0	1	3	0.28
GOAT MUMMY	3	2	3	2	1	0	0.61
HEROINE	0	0	0	0	1	0	0.00
HITCHHIKER	1	1	1	0	1	0	0.17
HOLY OAK	1	1	0	1	1	0	0.17
INDIGO	1	0	0	0	1	0	0.06

Appendix E: (Continued)

Name	DI_Speleothems	DI_Graffiti	DI_Trash	DI_Floor_Dist	DI_Cultural	DI_CC	DI_Desiccation
BELLEVIEW FORMATION	2	1	0	2	NA	0	0
BIG MOUTH	NA	0	1	2	NA	0	NA
BLOWING HOLE	2	2	2	3	NA	0	1
BOTTLE CAP	1	1	1	3	NA	0	0
BRC	2	0	0	2	NA	0	0
BRIAR	1	1	0	1	NA	0	0
CRUMBLING ROCK	1	0	0	1	NA	0	0
DOG DROP	NA	2	1	3	NA	0	NA
FALLEN OAK	NA	1	2	3	NA	0	NA
FINCH'S	NA	0	1	1	NA	0	NA
FLOATING ROCK	NA	0	0	2	NA	0	NA
FOOTBALL	2	3	1	3	NA	0	1
GIRL SCOUT	NA	3	3	3	NA	0	NA
GOAT MUMMY	2	1	1	2	NA	3	1
HEROINE	NA	3	3	3	NA	0	NA
HITCHHIKER	3	3	3	3	NA	0	0
HOLY OAK	NA	3	2	3	NA	0	NA
INDIGO	NA	0	1	3	NA	0	NA

Appendix E: (Continued)

Name	DI_Sedimentation	DI_Biota_Pop_Den	DI_Biota_Spec_Rich	DI_Fossils	DI_Deforestation
BELLEVIEW FORMATION	3	LD	LD	1	3
BIG MOUTH	1	LD	LD	2	1
BLOWING HOLE	NA	LD	LD	2	0
BOTTLE CAP	1	LD	LD	1	0
BRC	2	LD	LD	1	0
BRIAR	NA	LD	LD	0	0
CRUMBLING ROCK	2	LD	LD	0	1
DOG DROP	NA	LD	LD	2	0
FALLEN OAK	NA	LD	LD	3	0
FINCH'S	NA	LD	LD	1	1
FLOATING ROCK	3	LD	LD	1	1
FOOTBALL	NA	LD	LD	1	1
GIRL SCOUT	3	LD	LD	3	0
GOAT MUMMY	1	LD	LD	2	0
HEROINE	NA	LD	LD	3	0
HITCHHIKER	3	LD	LD	3	0
HOLY OAK	NA	LD	LD	2	0
INDIGO	NA	LD	LD	3	0

Appendix E: (Continued)

Name	DI_Urbanization	DI_Agriculture	DI_Score
BELLEVIEW FORMATION	2	1	0.42
BIG MOUTH	1	1	0.37
BLOWING HOLE	1	1	0.45
BOTTLE CAP	1	3	0.36
BRC	1	2	0.28
BRIAR	1	2	0.18
CRUMBLING ROCK	1	2	0.25
DOG DROP	1	0	0.33
FALLEN OAK	1	0	0.37
FINCH'S	1	2	0.26
FLOATING ROCK	1	2	0.44
FOOTBALL	1	3	0.48
GIRL SCOUT	1	1	0.63
GOAT MUMMY	1	3	0.50
HEROINE	3	2	0.63
HITCHHIKER	3	2	0.64
HOLY OAK	1	1	0.44
INDIGO	1	1	0.33

Appendix E: Caves Geodatabase (Jackpot - Werner)

Name	Inv_date	Inv_id	County	Personnel
JACKPOT	9/23/2007	INV041	CITRUS	GRANT HARLEY, JASON POLK, ROBERT BROOKS
JEEP	6/9/2007	INV016	CITRUS	GRANT HARLEY, JASON POLK
JENNING'S	8/18/2007	INV032	MARION	GRANT HARLEY, JASON POLK
LEGEND	8/12/2007	INV031	CITRUS	GRANT HARLEY, TOM TURNER, MONICA EXNER
MAYNARD'S	8/19/2007	INV038	CITRUS	JASON POLK, TOM TURNER, DAN STRALEY, LANCE ELDER, GRANT HARLEY, ROBERT BROOKS
OCALA CAVERNS EAST	8/18/2007	INV036	MARION	GRANT HARLEY, JASON POLK, MONICA EXNER
OCALA CAVERNS WEST	8/18/2007	INV035	MARION	GRANT HARLEY, JASON POLK, MONICA EXNER
PEACE SIGN	6/3/2007	INV006	CITRUS	GRANT HARLEY, JASON POLK
QUARTER	8/17/2007	INV032	HERNANDO	GRANT HARLEY, JASON POLK
RATTLESNAKE	8/12/2007	INV039	CITRUS	GRANT HARLEY, JASON POLK
REUFF'S	5/19/2007	INV005	HERNANDO	GRANT HARLEY, JASON POLK, JAY LANDT, MATT REUFF
SICK BAT	6/3/2007	INV011	CITRUS	GRANT HARLEY, JASON POLK
SNEAK	8/18/2007	INV037	MARION	GRANT HARLEY, JASON POLK, MONICA EXNER
THORNTON'S	5/26/2007	INV004	SUMTER	GRANT HARLEY, JASON POLK, TOM TURNER
TRAIL 10 BAT	6/9/2007	INV015	CITRUS	GRANT HARLEY, JASON POLK
TURPENTINE	6/15/2007	INV026	HERNANDO	GRANT HARLEY, JASON POLK, PHIL VAN BEYNEN
VANDAL	6/3/2007	INV007	CITRUS	GRANT HARLEY, JASON POLK
WERNER	6/3/2007	INV010	CITRUS	GRANT HARLEY, JASON POLK, TOM TURNER, ROBERT BROOKS

Appendix E: (Continued)

Name	Cave_Ownership	Equipment_Needed	Other_Equipment_Needed	Elevation_masl
JACKPOT	PUBLIC PROPERTY	CABLE LADDER	NORMAL SPELEO GEAR	33.35
JEEP	PUBLIC PROPERTY	NORMAL SPELEO GEAR	NA	-9999
JENNING'S	PRIVATE PROPERTY	CABLE LADDER	ROPE OR VERTICAL EQUIPMENT	-9999
LEGEND	PUBLIC PROPERTY	KNEEPADS	HANDLINE	24.38
MAYNARD'S	PRIVATE PROPERTY	ROPE OR VERTICAL EQUIPMENT	NORMAL SPELEO GEAR	-9999
OCALA CAVERNS EAST	PRIVATE PROPERTY	NORMAL SPELEO GEAR	BOAT OR FLOATATION	-9999
OCALA CAVERNS WEST	PRIVATE PROPERTY	NORMAL SPELEO GEAR	NA	-9999
PEACE SIGN	PUBLIC PROPERTY	NORMAL SPELEO GEAR	NA	27.43
QUARTER	PUBLIC PROPERTY	NORMAL SPELEO GEAR	SHOVEL-BLASTING	33.17
RATTLESNAKE	PUBLIC PROPERTY	SHOVEL-BLASTING	NA	8.4
REUFF'S	PRIVATE PROPERTY	NORMAL SPELEO GEAR	NA	34.57
SICK BAT	PUBLIC PROPERTY	NORMAL SPELEO GEAR	NA	27.43
SNEAK	PRIVATE PROPERTY	NORMAL SPELEO GEAR	NA	-9999
THORNTON'S	PRIVATE PROPERTY	BOAT OR FLOATATION	WET-SUIT	14.4
TRAIL 10 BAT	PUBLIC PROPERTY	KNEEPADS	NA	-9999
TURPENTINE	PRIVATE PROPERTY	WET-SUIT	KNEEPADS	27.43
VANDAL	PUBLIC PROPERTY	NORMAL SPELEO GEAR	NA	27.43
WERNER	PUBLIC PROPERTY	KNEEPADS	WET-SUIT	5

Appendix E: (Continued)

Name	Cave Map Status	Cave Length Meters	Cave Vertical Extent Meters	Management Notes
JACKPOT	COMPLETE MAP	243.5	16.3	UNMANAGED, BUT PLANS IN PROGRESS FOR GATE BY TBAG
JEEP	COMPLETE MAP	17	3.01	UNMANAGED
JENNING'S	COMPLETE MAP	175.4	-9999	“MANAGED” BY FSS, PROPERTY OWNED BY SOUTHEASTERN CAVE CONSERVANCY, PLAN NOT ACTIVELY ENFORCED
LEGEND	COMPLETE MAP	67.21	-9999	UNMANAGED
MAYNARD'S	COMPLETE MAP	52.5	-9999	UNMANAGED
OCALA CAVERNS EAST	COMPLETE MAP	58.5	-9999	UNMANAGED; CAVE WAS COMMERCIAL IN 1950'S-60'S AND HAS SINCE BEEN SHUT DOWN
OCALA CAVERNS WEST	COMPLETE MAP	23	-9999	UNMANAGED; CAVE WAS COMMERCIAL IN 1950'S-60'S AND HAS SINCE BEEN SHUT DOWN
PEACE SIGN	COMPLETE MAP	41	-9999	UNMANAGED; GOOD RECREATIONAL CAVE
QUARTER	COMPLETE MAP	19.7	-9999	UNMANAGED; CONSISTS OF LARGE, UNSTABLE BREAKDOWN. NEEDS GATE OR FENCE.
RATTLESNAKE	COMPLETE MAP	19.7	-9999	UNMANAGED; CAVE SHOULD BE CLOSED DUE TO UNSTABLE BREAKDOWN
REUFF'S	COMPLETE MAP	18.82	2.07	UNMANAGED
SICK BAT	COMPLETE MAP	6	-9999	UNMANAGED; GOOD RECREATIONAL CAVE
SNEAK	COMPLETE MAP	91	-9999	UNMANAGED
THORNTON'S	COMPLETE MAP	314.8	1.7	UNMANAGED
TRAIL 10 BAT	COMPLETE MAP	18.32	-9999	FENCED; HABITAT FOR SE BAT
TURPENTINE	COMPLETE MAP	140	-9999	UNMANAGED
VANDAL	COMPLETE MAP	15	-9999	UNMANAGED; GOOD RECREATIONAL CAVE
WERNER	COMPLETE MAP	651	21.5	FENCED; SE, CRAYFISH BAT HABITAT

Appendix E: (Continued)

Name	Entry_Status	Other_Entry_Status	Multiple_Entrances	Type_of_Entrance_Vertical
JACKPOT	WAIVER REQUIRED	PERMISSION REQUIRED	N	NA
JEEP	PERMISSION REQUIRED	WAIVER REQUIRED	N	NA
JENNING'S	LOCKED OR GATED	PERMISSION REQUIRED	N	PIT
LEGEND	WAIVER REQUIRED	PERMISSION REQUIRED	N	TIGHT PIT
MAYNARD'S	PERMISSION REQUIRED	NA	Y	BOTTLENECK/SMALL BUT BELLS OUT
OCALA CAVERNS EAST	PERMISSION REQUIRED	NA	N	NA
OCALA CAVERNS WEST	PERMISSION REQUIRED	NA	N	NA
PEACE SIGN	OPEN ACCESS	NA	N	CHIMNEY OR CLIMB
QUARTER	PERMISSION REQUIRED	WAIVER REQUIRED	N	PIT
RATTLESNAKE	WAIVER REQUIRED	PERMISSION REQUIRED	N	NA
REUFF'S	FORBIDDEN BY OWNER	PERMISSION REQUIRED	N	NA
SICK BAT	OPEN ACCESS	NA	N	NA
SNEAK	FORBIDDEN BY OWNER	NA	N	NA
THORNTON'S	PERMISSION REQUIRED	NAVIGABLE WATERWAY	Y	NA
TRAIL 10 BAT	LOCKED OR GATED	WAIVER REQUIRED	N	NA
TURPENTINE	PERMISSION REQUIRED	NA	N	CHIMNEY OR CLIMB
VANDAL	OPEN ACCESS	NA	Y	VERY WIDE PIT (20 FT +)
WERNER	LOCKED OR GATED	WAIVER REQUIRED	N	TIGHT SQUEEZE

Appendix E: (Continued)

Name	Type_of_Entrance_Horizontal_or_Downward_Sloping	Entrance_Topo_Position	Ent_Visibility
JACKPOT	TIGHT SQUEEZE	HILLSIDE	CLEARLY VISIBLE
JEEP	STOOP OR DUCK WALK	SINKHOLE	CLEARLY VISIBLE
JENNING'S	NA	TOPOGRAPHIC LOW	CLEARLY VISIBLE
LEGEND	NA	HILLSIDE	OBSCURED BY ROCKS
MAYNARD'S	LARGE WALK-IN	SINKHOLE	OBSCURED BY VEGETATION
OCALA CAVERNS EAST	ARTIFICIAL TUNNEL	QUARRY	OBSCURED BY VEGETATION
OCALA CAVERNS WEST	ARTIFICIAL TUNNEL	QUARRY	OBSCURED BY VEGETATION
PEACE SIGN	NA	TOPOGRAPHIC LOW	CLEARLY VISIBLE
QUARTER	NA	QUARRY	CLEARLY VISIBLE
RATTLESNAKE	CRAWL	SINKHOLE	OBSCURED BY VEGETATION
REUFF'S	STOOP OR DUCK WALK	QUARRY	CLEARLY VISIBLE
SICK BAT	TIGHT SQUEEZE	SINKHOLE	CLEARLY VISIBLE
SNEAK	TIGHT SQUEEZE	QUARRY	OBSCURED BY VEGETATION
THORNTON'S	STOOP OR DUCK WALK	FLOODPLAIN	OBSCURED BY VEGETATION
TRAIL 10 BAT	STOOP OR DUCK WALK	SINKHOLE	CLEARLY VISIBLE
TURPENTINE	NA	SINKHOLE	CLEARLY VISIBLE
VANDAL	STOOP OR DUCK WALK	SINKHOLE	CLEARLY VISIBLE
WERNER	NA	SINKHOLE	OBSCURED BY ROCKS

Appendix E: (Continued)

Name	Ent_modification	Ent_minimum_size	Entrance_Drop_Depth
JACKPOT	NONE	SQUEEZE	0
JEEP	NONE	STOOP	0
JENNING'S	NONE	CRAWL	7
LEGEND	ROAD CONSTRUCTION	SQUEEZE	2
MAYNARD'S	NONE	CRAWL	10
OCALA CAVERNS EAST	ARTIFICIAL ENTRANCE	WALK	0
OCALA CAVERNS WEST	ARTIFICIAL ENTRANCE	WALK	0
PEACE SIGN	GATED	VERTICAL DROP	2
QUARTER	WIDENED	VERTICAL DROP	2
RATTLESNAKE	QUARRY	CRAWL	0
REUFF'S	QUARRY	STOOP	0
SICK BAT	WIDENED	SQUEEZE	0
SNEAK	QUARRY	SQUEEZE	0
THORNTON'S	NONE	STOOP	0
TRAIL 10 BAT	WIDENED	CRAWL	0
TURPENTINE	NONE	VERTICAL DROP	4
VANDAL	NONE	STOOP	5
WERNER	QUARRY	SQUEEZE	3

Appendix E: (Continued)

Name	Entrance_Notes	Passage_Orientation
JACKPOT	TIGHT ENTRANCE	NE-SW
JEEP	EASILY ACCESSIBLE IF LOCATION IS KNOWN	NE-SW
JENNING'S	LARGE PIT DROP, CAVE HAS GATE, BUT NEVER LOCKED. MANAGED BY MIKE GORDON OF FSS. OWNED BY SCC	NE-SW & NW-SE
LEGEND	NA	NW-SE
MAYNARD'S	IRON LADDER INSTALLED AT ONE OF THE VERTICAL ENTRANCES	NW-SE
OCALA CAVERNS EAST	ARTIFICIAL HORIZONTAL ENTRANCE, NATURAL ENTRANCE WIDENED	NE-SW
OCALA CAVERNS WEST	ARTIFICIAL CAVE ENTRANCE, NATURAL VERTICAL ENTRANCE BLOCKED AND HORIZONTAL ENTRANCE DUG OPEN	NE-SW
PEACE SIGN	GATE IS NEVER LOCKED	NW-SE
QUARTER	2M DROP PIT	NE-SW
RATTLESNAKE	ENTRANCE IS LARGE BREAKDOWN DEBRIS SLIDE, UNSAFE	NE-SW, NW-SE, N-S, & E-W
REUFF'S	ENTRANCE EXPOSED IN QUARRY WALL	NE-SW
SICK BAT	NA	NW-SE
SNEAK	ENTRANCE COVERED BY ROCKS AND VEGETATION	NE-SW & NW-SE
THORNTON'S	MULTIPLE ENTRANCES, KARST WINDOWS/SKYLIGHTS ABUNDANT	NE-SW & NW-SE
TRAIL 10 BAT	ENTIRE CAVE AREA IS FENCED, GATED, AND LOCKED	NW-SE
TURPENTINE	CHIMNEY CLIMB DOWN	NW-SE
VANDAL	VERTICAL ENTRANCE REPRESENTS UNROOFED PORTION OF CAVE	NE-SW, NW-SE, N-S, & E-W
WERNER	ENTRANCE WAS WIDENED, CAVE LOCATED IN QUARRY	NE-SW, NW-SE, N-S, & E-W

Appendix E: (Continued)

Name	Passage_Types	Passage_Min_Sizes
JACKPOT	ENLARGED FISSURE, BREAKDOWN	SQUEEZE, CRAWL, STOOP, WALK
JEEP	ENLARGED FISSURE	STOOP, WALK
JENNING'S	ENLARGED FISSURE	CRAWL, STOOP, WALK
LEGEND	BREAKDOWN, ENLARGED FISSURE	SQUEEZE, CRAWL, STOOP, WALK
MAYNARD'S	BREAKDOWN, LARGE SOLUTION CHAMBER	CRAWL, STOOP, WALK
OCALA CAVERNS EAST	ARTIFICIAL TUNNEL, ENLARGED FISSURE, PHREATIC	SQUEEZE, CRAWL, STOOP, WALK
OCALA CAVERNS WEST	ARTIFICIAL TUNNEL, ENLARGED FISSURE	CRAWL, STOOP, WALK
PEACE SIGN	BREAKDOWN, PHREATIC TUBES, ENLARGED FISSURES	SQUEEZE, CRAWL, STOOP, WALK
QUARTER	BREAKDOWN	SQUEEZE, CRAWL, STOOP
RATTLESNAKE	BREAKDOWN	SQUEEZE, CRAWL
REUFF'S	BREAKDOWN	STOOP, WALK
SICK BAT	BREAKDOWN	SQUEEZE, CRAWL, STOOP, WALK
SNEAK	ENLARGED FISSURE, PLUS-SIGN	SQUEEZE, CRAWL, STOOP, WALK
THORNTON'S	ENLARGED FISSURE, PHREATIC TUBES	CRAWL, STOOP, SWIM
TRAIL 10 BAT	ENLARGED FISSURE, BREAKDOWN	STOOP, CRAWL, WALK
TURPENTINE	PHREATIC, BREAKDOWN, ENLARGED FISSURE	CRAWL, STOOP, WALK
VANDAL	BREAKDOWN, ENLARGED FISSURE	SQUEEZE, CRAWL, STOOP, WALK
WERNER	BREAKDOWN, SEDIMENT, PHREATIC, ENLARGED FISSURE	SQUEEZE, CRAWL, STOOP, WALK

Appendix E: (Continued)

Name	Passage_Hydrology	Passage_Floor
JACKPOT	DRIPS, SEEPS, AQUIFER	SEDIMENT, BREAKDOWN
JEEP	NA	SEDIMENT
JENNING'S	DRIPS, POOL	BREAKDOWN, SEDIMENT
LEGEND	INTERMITTENT STREAM DURING RAIN, DRIPS, SEEPS	SEDIMENT, BREAKDOWN
MAYNARD'S	SEEPING, DRIPPING	SEDIMENT, CLAY
OCALA CAVERNS EAST	AQUIFER	SEDIMENT, BREAKDOWN
OCALA CAVERNS WEST	INTERMITTENT STREAM WASH IN FROM SURFACE	SEDIMENT, BREAKDOWN
PEACE SIGN	NA	SEDIMENT, BREAKDOWN
QUARTER	NA	BREAKDOWN, SEDIMENT
RATTLESNAKE	NA	BREAKDOWN, SEDIMENT
REUFF'S	NA	SEDIMENT, BREAKDOWN
SICK BAT	NA	SEDIMENT, BREAKDOWN
SNEAK	AQUIFER POOLS, DEEP AQUIFER CONNECTION	SEDIMENT, BREAKDOWN
THORNTON'S	DRIPS, POOL, AQUIFER, CAVE ACTS AS ESTEVELLE	SEDIMENT, SMALL BREAKDOWN, WATER, GUANO, CLAY
TRAIL 10 BAT	A2:DRIP	SEDIMENT, BREAKDOWN
TURPENTINE	INTERMITTENT STREAM, POOLED, AQUIFER	SEDIMENT, BREAKDOWN
VANDAL	NA	SEDIMENT, BREAKDOWN
WERNER	POOLED, INTERMITTENT STREAM, AQUIFER	BREAKDOWN, SEDIMENT, GUANO

Appendix E: (Continued)

Name	Passage_Hazards	Passage_Notes	Tites_Mites_Columns_Condition
JACKPOT	TIGHT, TECHNICAL PASSAGES; STEEP DROP	NA	NA
JEEP	NA	NA	NA
JENNING'S	NA	SEASONAL POOL: A11	NA
LEGEND	UNSTABLE BREAKDNW	NA	A3,5,8:DEPOSITING
MAYNARD'S	LOOSE, SPLIPPERY ROCK, STEEP ROCK, VERTICAL SHAFT/PIT	NA	A3,6,7:DEPOSITING
OCALA CAVERNS EAST	NA	NA	NA
OCALA CAVERNS WEST	NA	NA	NA
PEACE SIGN	NA	NA	DAMAGED, REMOVED, DRY:A0-A6
QUARTER	UNSTABLE BREAKDOWN	NA	NA
RATTLESNAKE	UNSTABLE CEILING BREAKDOWN	COLLAPSED BREAKDOWN SINKHOLE	NA
REUFF'S	LOOSE BREAKDOWN, BRITTLE WALLS	NA	NA
SICK BAT	TOO TIGHT	NA	A1,2:REMOVED
SNEAK	NA	NA	NA
THORNTON'S	EAR-DIP PASSAGES, DEEP PITS INTO AQUIFER	DIAMOND PATTERN PASSAGES	B14-16:DEPOSITING
TRAIL 10 BAT	MOLD ON GUANO:A2	NA	A2-THREE SODA STRAWS-DRY
TURPENTINE	CAVE FLOODS DURING RAIN EVENTS	NA	NA
VANDAL	TOO TIGHT	NA	A3,6:REMOVED
WERNER	GUANO, UNSTABLE BREAKDOWN, FLOODING	CAVE FLOODS DURING RAIN EVENTS	NA

Appendix E: (Continued)

Name	Drapery_Condition	Helictites_Condition	Rimstone_Condition	Popcorn_Condition
JACKPOT	NA	NA	NA	NA
JEEP	NA	NA	NA	NA
JENNING'S	NA	NA	NA	NA
LEGEND	A3,5,8:DEPOSITING	NA	A5:DEPOSITING	NA
MAYNARD'S	A3,6,7:DEPOSITING	NA	A3:DEPOSITING	NA
OCALA CAVERNS EAST	NA	NA	NA	NA
OCALA CAVERNS WEST	NA	NA	NA	NA
PEACE SIGN	DAMAGED, REMOVED:A0,1	NA	NA	NA
QUARTER	NA	NA	NA	NA
RATTLESNAKE	NA	NA	NA	NA
REUFF'S	NA	NA	NA	NA
SICK BAT	NA	NA	NA	NA
SNEAK	NA	NA	NA	NA
THORNTON'S	NA	NA	NA	NA
TRAIL 10 BAT	A2-DRY	NA	NA	NA
TURPENTINE	NA	NA	NA	NA
VANDAL	A3,6:REMOVED	NA	NA	NA
WERNER	NA	NA	NA	NA

Appendix E: (Continued)

Name	Flowstone_Condition	Spar_Condition	Calcite_Coating_Condition	Calcite_Rafts
JACKPOT	NA	NA	NA	NA
JEEP	NA	NA	NA	NA
JENNING'S	NA	NA	NA	NA
LEGEND	A5,8:DEPOSITING; A8:DAMAGED	NA	NA	NA
MAYNARD'S	A3,6,7:DEPOSITING	NA	NA	NA
OCALA CAVERNS EAST	NA	NA	NA	NA
OCALA CAVERNS WEST	NA	NA	NA	NA
PEACE SIGN	DAMAGED:A0,1,5	NA	GREY:A0,1	NA
QUARTER	NA	NA	NA	NA
RATTLESNAKE	NA	NA	NA	NA
REUFF'S	NA	NA	NA	NA
SICK BAT	A2:DAMAGED;DRY	NA	NA	NA
SNEAK	NA	NA	NA	A4,5,10
THORNTON'S	NA	NA	NA	NA
TRAIL 10 BAT	A2-DRY	NA	NA	NA
TURPENTINE	NA	NA	NA	NA
VANDAL	A3,6:REMOVED	NA	NA	NA
WERNER	NA	NA	NA	NA

Appendix E: (Continued)

Name	Scallops	Anastomosen	Sediments	Sediments_Notes
JACKPOT	WIDESPREAD	NA	LAYERED ORGANICS AND SAND	GOOD FOR CORE, BUT IN TIGHT SPACE
JEEP	A3	NA	A0-3	LAYERED SEDIMENTS, POSSIBLE FOR SEDIMENT CORE
JENNING'S	A1-11	NA	LAYERED, FINE LAMINAE, MIXED ORGANICS AND SAND	GOOD FOR CORE
LEGEND	NA	NA	LAYERED	SEDIMENT GOOD FOR CORE
MAYNARD'S	NA	NA	LAYERED ORGANICS AND SAND	GREAT LAYERED SEDIMENTS, GOOD FOR CORE
OCALA CAVERNS EAST	A1-5	NA	COMPACTED CLAY	NOT GOOD FOR CORE
OCALA CAVERNS WEST	A2,3,4	NA	VARVED CLAY, HEAVILY COMPACTED	CORE POSSIBLE, BUT IN TIGHT LOCATION
PEACE SIGN	NA	NA	UNSORTED	HIGH COMPACTION WASH-IN FROM SURFACE, NOT GOOD FOR CORE
QUARTER	NA	NA	NA	NA
RATTLESNAKE	NA	NA	UNSORTED	NOT GOOD FOR CORE
REUFF'S	NA	NA	LAYERED	LAYERED SEDIMENTS, BUT NO ROOM FOR SEDIMENT CORE
SICK BAT	NA	NA	UNSORTED	HIGH COMPACTION, NOT GOOD FOR CORE
SNEAK	A1-11	NA	UNSORTED	NOT GOOD FOR CORE
THORNTON'S	NA	NA	LAYERED CLAY AND ORGANIC MATTER	SEDIMENT IS CLAYEY, BUT GOOD PLACE FOR SEDIMENT CORE
TRAIL 10 BAT	NA	NA	LAYERED, UNSORTED	NA
TURPENTINE	NA	NA	LAYERED ORGANICS	GOOD FOR SEDIMENT CORE
VANDAL	NA	NA	UNSORTED	COMPACTED SEDIMENT, NOT GOOD FOR CORE
WERNER	CC4	NA	LAYERED, VARVED CLAYS; UNSORTED SANDS	GOOD FOR SEDIMENT CORE IN VARVED CLAYS AREAS

Appendix E: (Continued)

Name	Fossils	Bones
JACKPOT	UNIQUE FISH FOSSIL CURRENTLY BEING ANALYZED BY SPECIALIST	BOBCAT
JEEP	NA	NA
JENNING'S	NA	NA
LEGEND	A3:ARTICULATED SPINE OF UNKNOWN MAMMAL	A1,2:COW, DEER
MAYNARD'S	NA	HUMAN SKULL
OCALA CAVERNS EAST	NA	NA
OCALA CAVERNS WEST	NA	NA
PEACE SIGN	NA	NA
QUARTER	NA	NA
RATTLESNAKE	NA	NA
REUFF'S	NA	NA
SICK BAT	NA	NA
SNEAK	NA	NA
THORNTON'S	FOSSILIZED TURTLE SHELL IN CEILING:A4	NA
TRAIL 10 BAT	NA	NA
TURPENTINE	UNIDENTOFIED VERTIBRAE	WHOLE TURTLE SHELLS
VANDAL	NA	NA
WERNER	NA	SNAKE SKELETON

Appendix E: (Continued)

Name	Geologic Strata	Other Geologic Strata	Geologic Notes
JACKPOT	OCALA LIMESTONE (EOCENE)	NA	NA
JEEP	OCALA LIMESTONE (EOCENE)	NA	POSSIBLE PALEO-SPRING NEAR STATION A3
JENNING'S	OCALA LIMESTONE (EOCENE)	NA	FISSURE CONTOLLED PASSAGES
LEGEND	OCALA LIMESTONE (EOCENE)	NA	NA
MAYNARD'S	OCALA LIMESTONE (EOCENE)	NA	GREAT BEDDING STRUCTURES AT A3
OCALA CAVERNS EAST	OCALA LIMESTONE (EOCENE)	NA	NA
OCALA CAVERNS WEST	OCALA LIMESTONE (EOCENE)	NA	NICE FISSURE FEATURE WITH SCALLOPS, BUT HEAVILY DISTURBED
PEACE SIGN	SUWANNEE LIMESTONE (OLIGOCENE)	NA	NA
QUARTER	OCALA LIMESTONE (EOCENE)	NA	CAVE CONSISTS ENTIRELY OF BREAKDOWN
RATTLESNAKE	OCALA LIMESTONE (EOCENE)	NA	CAVE CONSISTS ENTIRELY OF BREAKDOWN
REUFF'S	OCALA LIMESTONE (EOCENE)	NA	NA
SICK BAT	SUWANNEE LIMESTONE (OLIGOCENE)	NA	NA
SNEAK	OCALA LIMESTONE (EOCENE)	NA	GREAT PLUS-SIGN FISSURE PASSAGE, INTERSECTING FISSURES
THORNTON'S	OCALA LIMESTONE (EOCENE)	NA	MINERALIZED FLAKES(ORGANIC DRAPERY):B14; GREAT FISSURE AND BEDDING PLANE FEATURES; DIAMOND PATTERN PASSAGES
TRAIL 10 BAT	OCALA LIMESTONE (EOCENE)	NA	A1-GREAT BEDDING PLANE FEATURE
TURPENTINE	TAMPA MEMBER (ARCADIA FORMATION)(UPPER OLIGOCENE-LOWER MIOCENE)	SUWANNEE LIMESTONE (OLIGOCENE)	NA
VANDAL	SUWANNEE LIMESTONE (OLIGOCENE)	NA	NA
WERNER	OCALA LIMESTONE (EOCENE)	NA	GOOD CROSSBEDDING:C9

Appendix E: (Continued)

Name	Biological_Vertebrates	Invertebrates	Mold_Bacteria
JACKPOT	NA	CAVE CRAYFISH, SPIDERS, CAVE CRICKETS, FROGS	NA
JEEP	NA	NA	NA
JENNING'S	EASTERN PIPISTRELLE; SOUTHEASTERN BAT	SPIDERS, FROGS, BLACK SNAKE	NA
LEGEND	NA	ROACHES, FROGS, CRICKETS	NA
MAYNARD'S	NA	SPIDERS, CRICKETS	NA
OCALA CAVERNS EAST	NA	SPIDERS, CAVE CRICKETS, CAVE CRAYFISH (2)	A4: MOLD ON HUMAN WASTE
OCALA CAVERNS WEST	NA	NA	NA
PEACE SIGN	NA	NA	NA
QUARTER	NA	CAVE CRICKETS; FROGS; SPIDERS	NA
RATTLESNAKE	NA	NA	NA
REUFF'S	NA	SMALL FROGS:A3	NA
SICK BAT	NA	SPIDERS, CAVE CRICKETS, FROGS	NA
SNEAK	BLIND MINNOW FISH, BROWN CRAYFISH, ALBINO CRAYFISH	NA	NA
THORNTON'S	SOUTHEASTERN BAT:E9-10, A19,E12	LEOPARD FROG:E8; LARGE CAT FISH:B9	MOLD ON GUANO:E9-10, A19,E12
TRAIL 10 BAT	A2-SOUTHEASTERN BAT	A0-SPIDERS, BROWN CRICKETS	A2-MOLD ON GUANO
TURPENTINE	MICE	CAVE SHRIMP; CAVE CRAYFISH; FROGS, CRICKETS, SPIDERS	NA
VANDAL	NA	SPIDERS, CRICKETS, FROGS	MOLD ON HUMAN WASTE
WERNER	BLACK BUZZARD, SOUTHEASTERN BAT	CAVE CRICKETS, SOUTHEASTERN BAT TICK, BLIND CRAYFISH	MOLD ON GUANO

Appendix E: (Continued)

Name	Roots	Roost_Stains	Guano_Piles	Biological_Notes
JACKPOT	A0-1	NA	NA	NA
JEEP	A0	NA	NA	NA
JENNING'S	A10	A9,10	NA	KNOWN SOUTHEASTERN BAT AND PIPISTRELLE HABITAT, BUT VACANT LAST FEW YEARS
LEGEND	A0	NA	NA	NA
MAYNARD'S	A1	A3	NA	ROOST STAINS FOUND AT A3, BUT NO BATS
OCALA CAVERNS EAST	NA	NA	NA	2 DIFFERENT CAVE CRAYFISH FOUND
OCALA CAVERNS WEST	NA	NA	NA	NA
PEACE SIGN	NA	NA	NA	NA
QUARTER	A1,3	NA	NA	NA
RATTLESNAKE	A0,1,5	NA	NA	NA
REUFF'S	A4-6	NA	NA	NA
SICK BAT	A1	NA	NA	NA
SNEAK	A0,1	NA	NA	NA
THORNTON'S	EVERYWHERE LG & SMALL	E9-10, A19,E12	E9-10, A19,E12	NA
TRAIL 10 BAT	A0,0A	A1,2	A2	CAVE IS HABITAT FOR SOUTHEASTERN BAT
TURPENTINE	A1-5	NA	NA	NA
VANDAL	A3	NA	NA	NA
WERNER	A4-A15	B15, C1, B17, C5, B11	B15, C1, B17, C5	ESTIMATED SE BAT POPULATION OF 10,000 DURING PATERNITY SEASON

Appendix E: (Continued)

Name	Artifacts_Historical	Artifacts_Modern	Cultural_Notes
JACKPOT	NA	NA	NA
JEEP	NA	NA	NA
JENNING'S	NA	NA	LEGEND SAYS CAVE WAS ONCE USED TO HIDE SLAVES DURING CIVIL WAR, BUT NO EVIDENCE FOUND TO SUPPORT THIS
LEGEND	NA	NA	NA
MAYNARD'S	NA	NA	EXCAVATED IN 1960'S FOR HUMAN REMAINS WHEN SKULL WAS FOUND
OCALA CAVERNS EAST	NA	LIGHT FIXTURES FOUND THROUGHOUT CAVE FROM 1960'S	NA
OCALA CAVERNS WEST	NA	LIGHT FIXTURES FOUND THROUGHOUT CAVE FROM 1960'S	NA
PEACE SIGN	NA	NA	ARCH SITE LISTED IN FLORIDA MASTER SITE FILE
QUARTER	NA	NA	NA
RATTLESNAKE	NA	NA	NA
REUFF'S	NA	NA	NA
SICK BAT	NA	NA	ARCH SITE LISTED IN FLORIDA MASTER SITE FILE
SNEAK	NA	NA	NA
THORNTON'S	NA	NA	NA
TRAIL 10 BAT	NA	NA	NA
TURPENTINE	NA	TURPENTINE POTS FOUND WIDESPREAD THROUGHOUT CAVE	TURPENTINE POTS WASH IN FROM SURFACE. REMNANTS FROM WHEN TURPENTINE WAS MINED IN FOREST ABOVE CAVE, NEEDS ANALYSIS FROM SPECIALIST
VANDAL	NA	NA	ARCH SITE LISTED IN FLORIDA MASTER SITE FILE
WERNER	NA	NA	NA

Appendix E: (Continued)

Name	Scientific_Potential_Areas_Notes	Special_Interest_Areas_Notes
JACKPOT	NA	NA
JEEP	NA	NA
JENNING'S	SEDIMENT CORE COLLECTIONS SITE, WATER COLLECTION SITE DRIPPING FROM PENDANT	NA
LEGEND	SPELEOTHEM WATER COLLECTION SITE, SEDIMENT CORE COLLECTION SITE	NA
MAYNARD'S	SEDIMENT CORES, SPELEOTHEM COLLECTION	UNIQUE GEOLOGICAL BEDDING STRUCTURES
OCALA CAVERNS EAST	AQUIFER, BIOTA, HISTORIC CAVE STUDY	NA
OCALA CAVERNS WEST	HISTORIC CAVE STUDY	NA
PEACE SIGN	NA	NA
QUARTER	NA	NA
RATTLESNAKE	NA	NA
REUFF'S	NA	NA
SICK BAT	NA	NA
SNEAK	BIOTA, AQUIFER WATER	NA
THORNTON'S	MINERALIZED "CORN FLAKES" BEING ANALYZED IN NEW MEXICO, BIOTA, AQUIFER STUDY	FLOOR-ROOF FISSURE:A24A; CAVE ACTS AS ESTEVELLE BETWEEN WITHLACOOCHEE RIVER AND GUM SLOUGH
TRAIL 10 BAT	BIOTA STUDY	NA
TURPENTINE	AQUIFER, BIOTA, SEDIMENT STUDIES	NA
VANDAL	NA	NA
WERNER	BIOTA STUDY	NA

Appendix E: (Continued)

Name	SI_Biota	SI_Hydrology	SI_Speleothems	SI_Mineralogy	SI_Paleontology	SI_Cultural	SI_Score
JACKPOT	3	3	0	1	3	0	0.56
JEEP	0	0	0	0	1	0	0.05
JENNING'S	3	3	0	1	2	0	0.50
LEGEND	2	3	3	1	2	0	0.61
MAYNARD'S	1	3	2	1	1	0	0.44
OCALA CAVERNS EAST	3	3	0	0	1	0	0.33
OCALA CAVERNS WEST	0	3	0	0	1	0	0.16
PEACE SIGN	0	1	0	0	0	3	0.22
QUARTER	0	2	0	0	1	0	0.11
RATTLESNAKE	0	3	0	0	1	0	0.16
REUFF'S	1	0	0	0	1	0	0.06
SICK BAT	1	1	0	0	1	3	0.28
SNEAK	3	3	0	0	2	0	0.44
THORNTON'S	3	3	1	2	2	0	0.61
TRAIL 10 BAT	3	1	1	1	1	0	0.33
TURPENTINE	3	3	1	2	3	1	0.72
VANDAL	1	1	0	0	1	3	0.28
WERNER	3	3	0	2	3	0	0.61

Appendix E: (Continued)

Name	DI_Speleothems	DI_Graffiti	DI_Trash	DI_Floor_Dist	DI_Cultural	DI_CC
JACKPOT	NA	0	0	1	NA	0
JEEP	NA	2	1	3	NA	0
JENNING'S	NA	3	2	3	NA	0
LEGEND	1	2	2	2	NA	0
MAYNARD'S	1	1	1	2	NA	0
OCALA CAVERNS EAST	NA	1	3	3	NA	1
OCALA CAVERNS WEST	NA	3	3	3	NA	1
PEACE SIGN	3	3	3	3	NA	0
QUARTER	NA	0	0	3	NA	0
RATTLESNAKE	NA	1	2	3	NA	0
REUFF'S	NA	0	0	1	NA	0
SICK BAT	3	3	3	3	NA	0
SNEAK	NA	0	0	1	NA	0
THORNTON'S	NA	0	1	1	NA	1
TRAIL 10 BAT	2	0	1	2	NA	0
TURPENTINE	0	0	0	1	1	0
VANDAL	3	3	3	3	NA	0
WERNER	NA	0	1	2	NA	0

Appendix E: (Continued)

Name	DI_Desiccation	DI_Sedimentation	DI_Biota_Pop_Den	DI_Biota_Spec_Rich	DI_Fossils
JACKPOT	NA	NA	LD	LD	0
JEEP	NA	2	LD	LD	3
JENNING'S	NA	3	LD	LD	2
LEGEND	0	2	LD	LD	2
MAYNARD'S	0	3	LD	LD	2
OCALA CAVERNS EAST	NA	3	LD	LD	3
OCALA CAVERNS WEST	NA	3	LD	LD	3
PEACE SIGN	0	3	LD	LD	3
QUARTER	NA	1	LD	LD	3
RATTLESNAKE	NA	3	LD	LD	3
REUFF'S	NA	1	LD	LD	0
SICK BAT	0	3	LD	LD	3
SNEAK	NA	1	LD	LD	0
THORNTON'S	NA	NA	LD	LD	0
TRAIL 10 BAT	0	3	LD	LD	2
TURPENTINE	0	NA	LD	LD	0
VANDAL	0	3	LD	LD	3
WERNER	NA	3	LD	LD	1

Appendix E: (Continued)

Name	DI_Deforestation	DI_Urbanization	DI_Agriculture	DI_Score
JACKPOT	0	1	1	0.11
JEEP	0	1	0	0.39
JENNING'S	0	2	1	0.53
LEGEND	0	1	3	0.44
MAYNARD'S	0	1	3	0.42
OCALA CAVERNS EAST	0	3	1	0.63
OCALA CAVERNS WEST	0	3	1	0.70
PEACE SIGN	0	1	1	0.56
QUARTER	0	1	2	0.37
RATTLESNAKE	1	1	0	0.53
REUFF'S	3	1	2	0.37
SICK BAT	0	1	1	0.56
SNEAK	1	1	2	0.30
THORNTON'S	0	1	3	0.26
TRAIL 10 BAT	0	1	0	0.31
TURPENTINE	0	1	3	0.17
VANDAL	0	1	1	0.56
WERNER	1	1	0	0.37

Appendix F: Cave Inventory Form

Appendix F: Cave Inventory Form

Cave Name	Inventory Date	Cave Inventory ID	Personnel			
Twp.	**Rge.**	**Sec.**	**¼ ¼ Sec.**	**GPS Lat.**	**GPS Long.**	**Elev (m)**

Cave Ownership / Management Notes
Entrance

Topographic position	sinkhole	hillside	quarry	
Visibility	Clearly visible	Obscured by vegetation	Behind rocks	

Modification	none	widened	artificial entrance	gated	
Minimum size	squeeze	Crawl	Stoop	Walk	Vert. drop (m)

Equipment needed:
Entrance Notes:
Passage

Appendix F: (Continued)

<table>
<tr><td colspan="2">Type</td><td colspan="6"></td></tr>
<tr><td colspan="2">Min. size</td><td colspan="6"></td></tr>
<tr><td colspan="2">Water</td><td colspan="6"></td></tr>
<tr><td colspan="2">Floor</td><td colspan="6"></td></tr>
<tr><td colspan="2">Hazards</td><td colspan="6"></td></tr>
<tr><td colspan="8">Passage Notes:</td></tr>
<tr><td colspan="8">Geologic Features</td></tr>
<tr><td colspan="8">Geologic Strata:</td></tr>
<tr><td colspan="8">Calcite Deposits: Enter following code for each survey station for state of deposits: (∀) Depositing; (ϕ) Dry; (⊕) Corroding; (δ) Damaged; (*) Removed</td></tr>
<tr><td colspan="2">tites/mites/columns</td><td>drapery</td><td>helictites</td><td>rimstone</td><td>popcorn</td><td colspan="2">aragonite needles</td></tr>
<tr><td colspan="2">flowstone</td><td>spar</td><td colspan="4">calcite coating</td><td></td></tr>
<tr><td>Misc</td><td>Ripple marks/scallops</td><td colspan="3">Anastomosen</td><td colspan="3"></td></tr>
</table>

Appendix F: (Continued)

Sediments	
Fossils	list locations:
Bones	list locations:
Geologic Notes:	
Biological (list specimen / photographs included)	
Vertebrates:	
Invertebrates:	
Mold-bacteria (location):	
Roots (location):	
Roost stains (location):	
Guano Piles (location):	
Biological Notes:	
Cultural (list and describe)	

Appendix F: (Continued)

Artifacts (historical)
Artifacts (modern)
Vandalism (historical)
Vandalism (modern)
Commercialization (historical)
Commercialization (modern)
Cultural Notes:

Sensitivity Index					
Biota	Hydrology	Speleothems	Mineralogy	Paleontology	Cultural

Disturbance Index				
Trash	Speleothems(% damaged / broken)	Graffiti	Floor Dist.	Dest. cultural artifacts (%)

Appendix F: (Continued)

Condensation Corrosion	Desiccation	Cave sedimentation	Biota-pop. density (% decline)	Biota-species richness (% decline)

Dest. of fossils	Deforestation (% w/in 1 km buffer)	Agriculture (% w/in 1 km buffer)	Urbanization (% w/in 1 km buffer)

Human Impact Notes:
Special Interest Areas
Unique geological cross-sections:
Exceptional decorations:

Appendix F: (Continued)

Very fragile area:
Area of potential scientific research:
Closed; no access:
Other interest areas notes:

Appendix G: Photographs of Vandalism within BRC

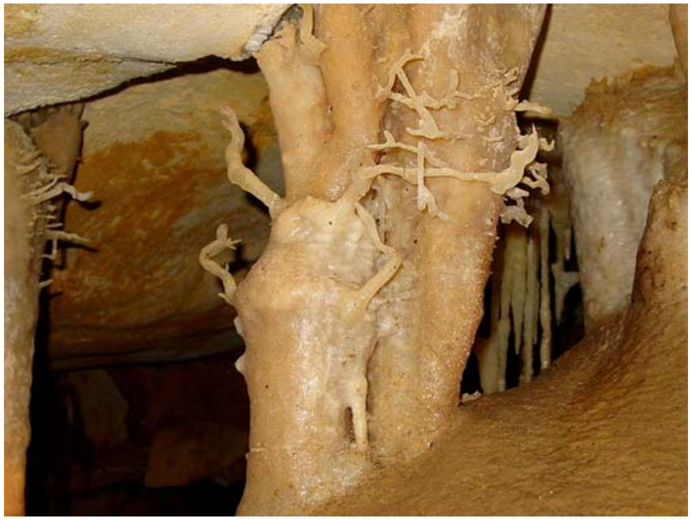
Appendix G: Photographs of Vandalism within BRC

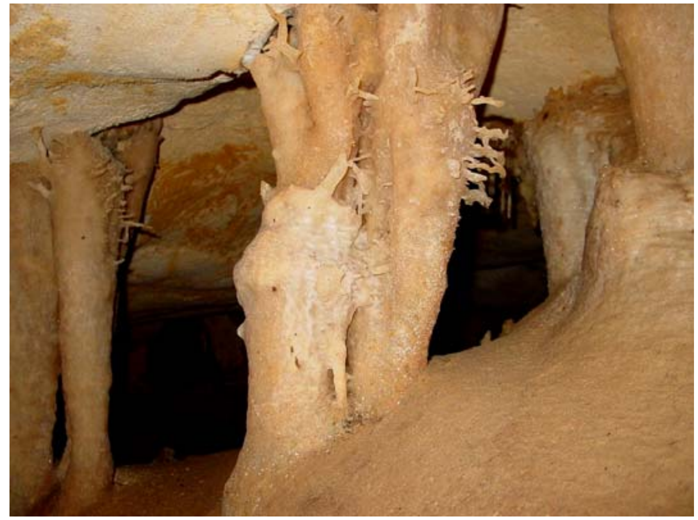
All before photos in this Appendix are courtesy of Tom Turner. All after pictures were taken by an anonymous, concerned caver.

The “Claw” helictite formation on night of cave discovery.

The “Claw” helictite formation after vandalism.

Appendix G: (Continued)

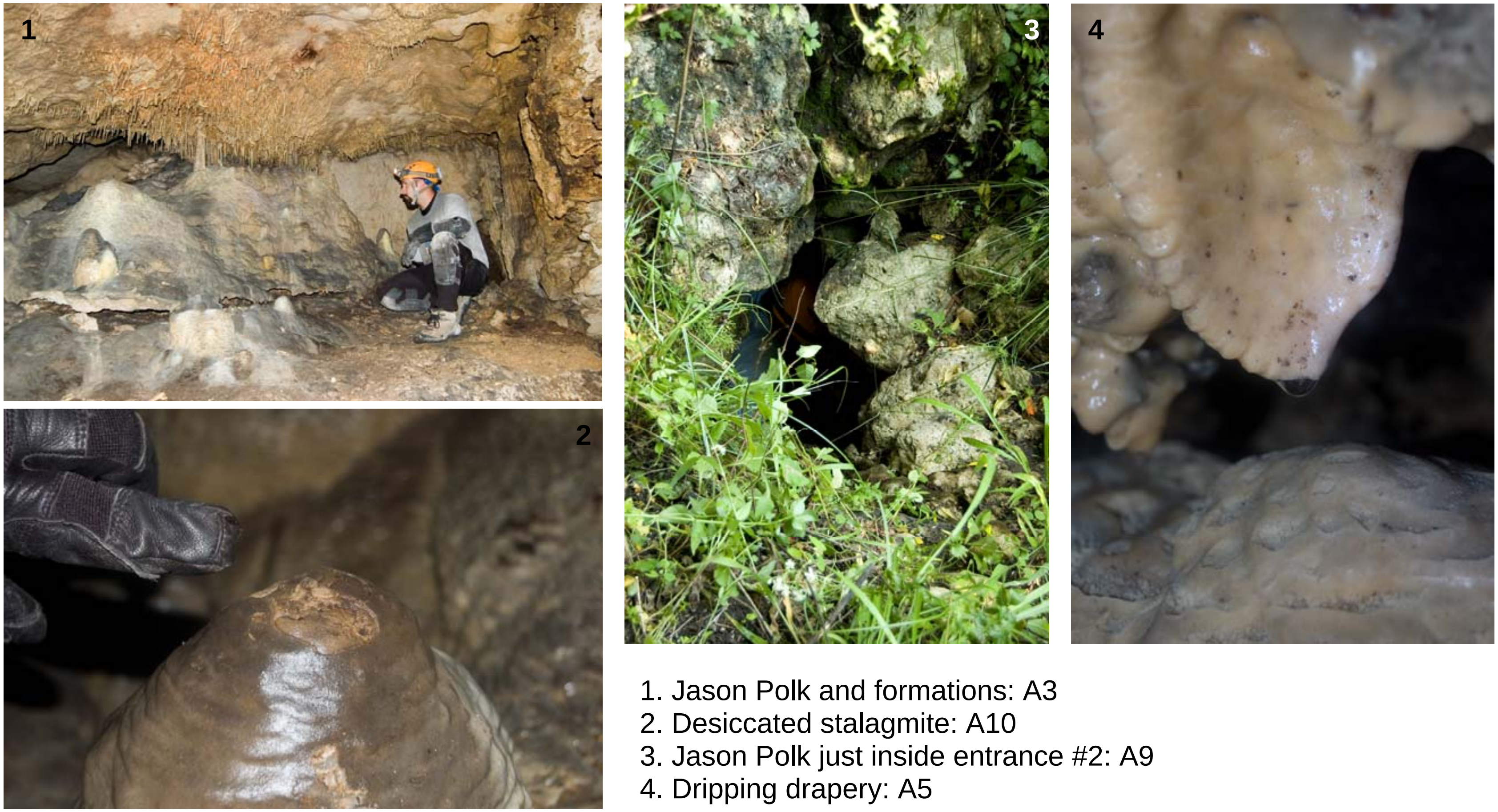

"Medusa" helictite formation on night of cave discovery.


"Medusa" helictite formation after vandalism.

Appendix H: Cave Inventory Photographs

Appendix H: Cave Inventory Photographs

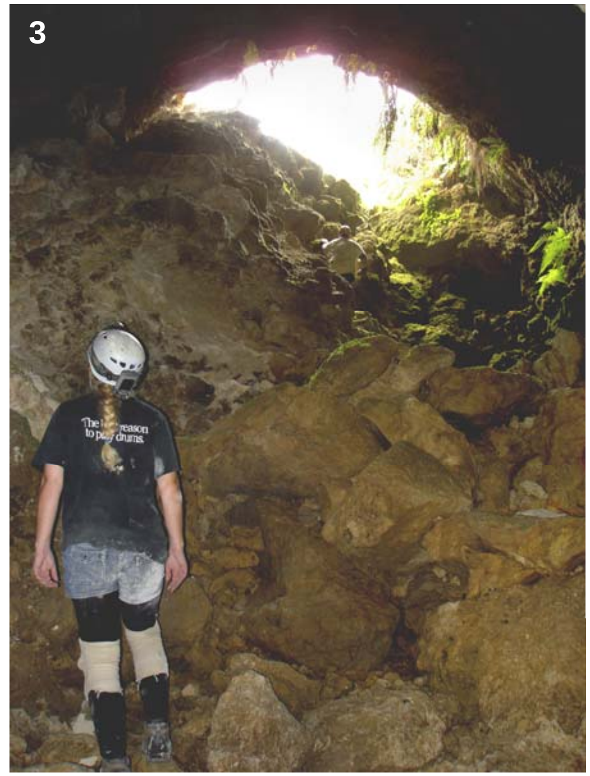
Belleview Formation Cave, Marion County, Florida



1. Jason Polk and formations: A3
2. Desiccated stalagmite: A10
3. Jason Polk just inside entrance #2: A9
4. Dripping drapery: A5

Appendix H: (Continued)

Big Mouth Cave, Citrus County, Florida



1. Robert Brooks at entrance: A1
2. Lee Florea just inside entrance: A1
3. Sonja Wescomb and Jason Polk: A2

Appendix H: (Continued)

Blowing Hole Cave, Citrus County, Florida

1. Grant Harley and Jason Polk, Railroad Tunnel Passage: A2-B1

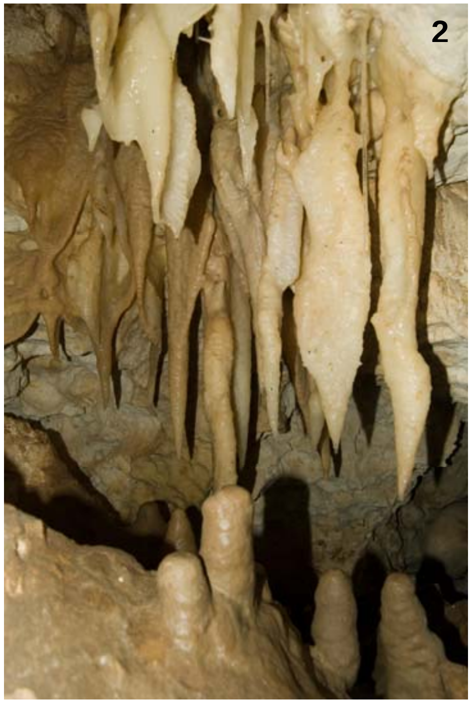
2. Popcorn: D2B

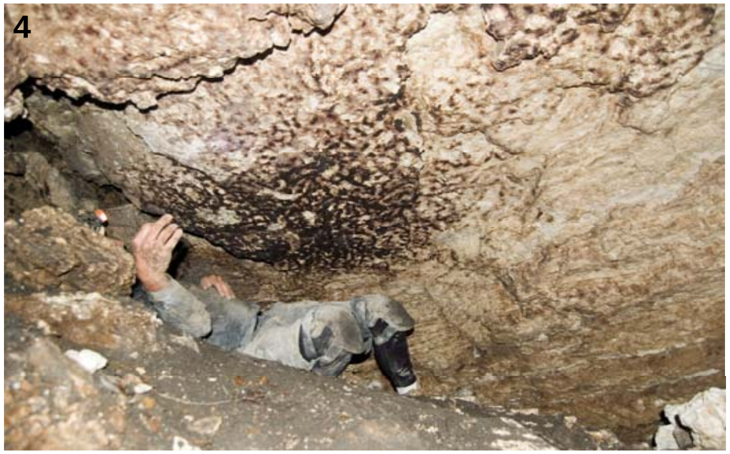
3. Graffiti on flowstone: D5

4. Greenhouse frogs below entrance pit: E1

Appendix H: (Continued)

Bottle Cap Cave, Citrus County, Florida

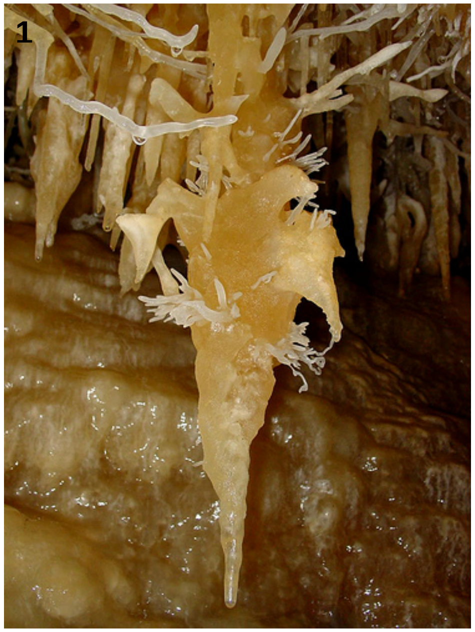




1. ~ 2m entrance pit to Bottle Cap Cave: A0
2. Stalagmites, stalactites, and soda straws: A17
3. Soda straws and helictites: A17A
4. Tom Turner underneath the bat roost stain: A2

Appendix H: (Continued)

BRC Cave, Hernando County, Florida



1. Indescribable formations: Helictites growing out of a stalactite: E6 (photo: Tom Turner
2. Translucent, carrot-like stalactites, helictites, soda straws, drapery, and stalagmites: BU8 (photo: Tom Turner)
3. “Helictimus II” in the Brewery Room (photo: Bruce Brewer)
4. Heart-shaped geode in ceiling: B16

Appendix H: (Continued)

Briar Cave, Marion County, Florida

1. Fissure passage, aquifer, near Lake Room, lower level: A4

2. Countless soda straws, Endless Room, upper level: A11

3. Robert Brooks kneels beside the clear waters of the Florida Aquifer System; nearly 13 m deep: A4 (photo: Tom Turner)

4. Jason Polk stands in from of flagging tape used to protect speleothems: A14

Appendix H: (Continued)

Dog Drop Cave, Citrus County, Florida

1. Jason Polk descends into entrance pit: A0

2. Passage near B1 (Jason Polk)

3. Jason Polk surveying near A1

4. Jason Polk standing: A2

Appendix H: (Continued)

Fallen Oak Cave, Citrus County, Florida

1. Jason Polk looking up from the sinkhole near A1

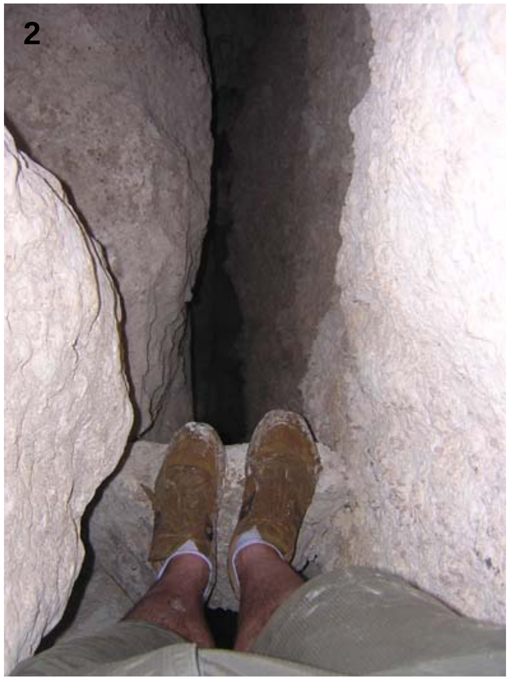
2. Jason Polk stands beside the tight, horizontal entrance near A1

3. Unidentified bone found near A2

4. Dipping bedding structures near A0

Appendix H: (Continued)

Finch's Cave, Marion County, Florida



1. Jason Polk at the entrance sink
2. Deep crevasse ~ 7m: A11
3. Calcite rafts in pool: A17Y
4. Spongework with unidentified mineralization

Appendix H: (Continued)

Football Cave, Citrus County, Florida

1. Formations: A10
2. Jason Polk watches as Robert Brooks descends into entrance
3. Tom Turner in tall breakdown chamber: A13
4. Tom Turner and graffiti: A11

Appendix H: (Continued)

Girl Scout Cave, Citrus County, Florida

1. Graffiti: A3

2. Trash and organic debris: A2

3. Snake in wall: A3

4. Jason Polk stands at the entrance to Girl Scout Cave: A0

Appendix H: (Continued)

Goat Mummy Cave, Citrus County, Florida

1


2


3


4


1. Speleothem; photo looking SW: A5

2. Condensation corrosion: A6 (Jason Polk)

3. SE bat roost: A4

4. Monica Exner and Jason Polk exit the cave: A1

Appendix H: (Continued)

Heroine Cave, Marion County, Florida

1. Monica Exner descends into entrance: A0

2. Jason Polk by trash: A1-A3

3. Grant Harley and Monica Exner in the entrance sink; note the entrance symbol: A0 (Jason Polk)

4. Jason Polk by trash: A3

Indigo Cave, Citrus County, Florida

1. Jason Polk at entrance: A0

2. Close-up of entrance: A0

Appendix H: (Continued)

Jackpot Cave, Citrus County, Florida

Jackpot entrance: A0

Appendix H: (Continued)

Jeep Cave, Citrus County, Florida

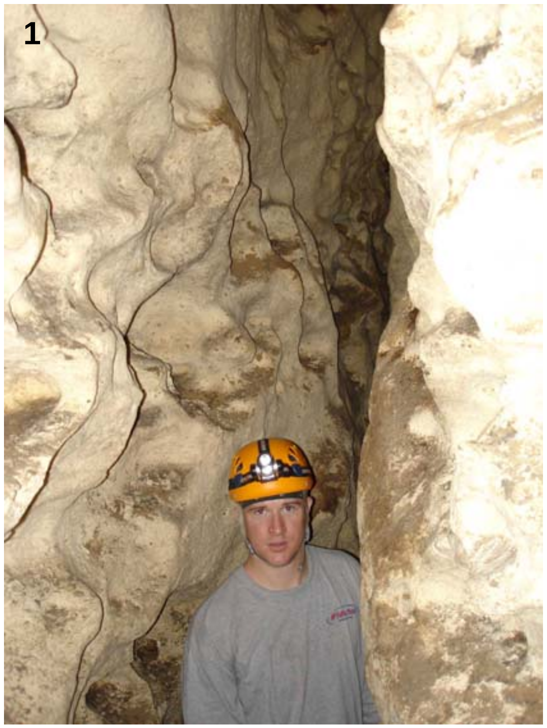
1. Jason Polk at the entrance: A0A

2. Jason Polk near graffiti: A0-A1. Historic graffiti was recently (2007) found underneath modern graffiti on this wall.

3. Close-up of graffiti: A0-A1

Appendix H: (Continued)

Jenning's Cave, Citrus County, Florida



1. Grant Harley in fissure-passage: near A10 (Jason Polk)

2. Fossiliferous Ocala Limestone: A6

3. Spongework: A4

4. Grant Harley at broken gate: near A2 (Jason Polk)

Crumbling Rock Cave, Citrus County, Florida

1. Lance Elder entrance gate: A1

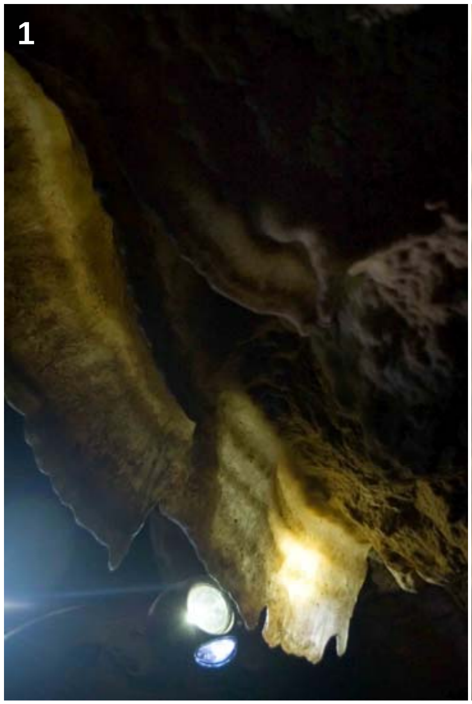
2. shrimp-like invertebrate found near A5. *Crogonyx Hobbsi*? (Tom Turner)

3. Robert Brooks in Lake Room: A5 (Tom Turner)

4. Caver near Lake Room: A5 (tom Turner

Appendix H: (Continued)

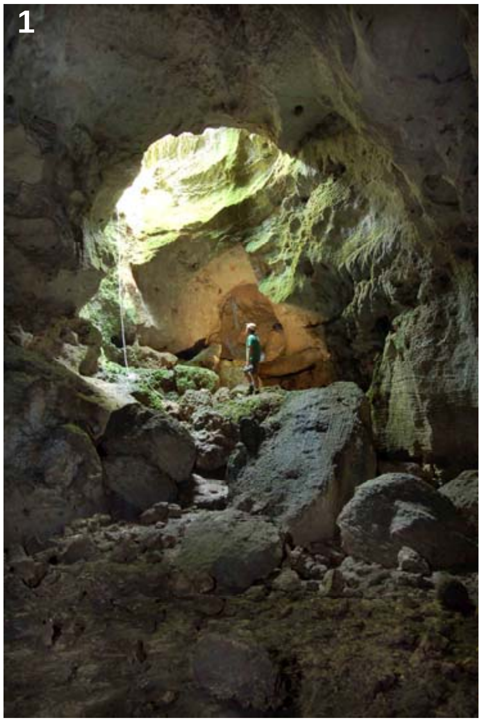
Legend Cave, Citrus County, Florida

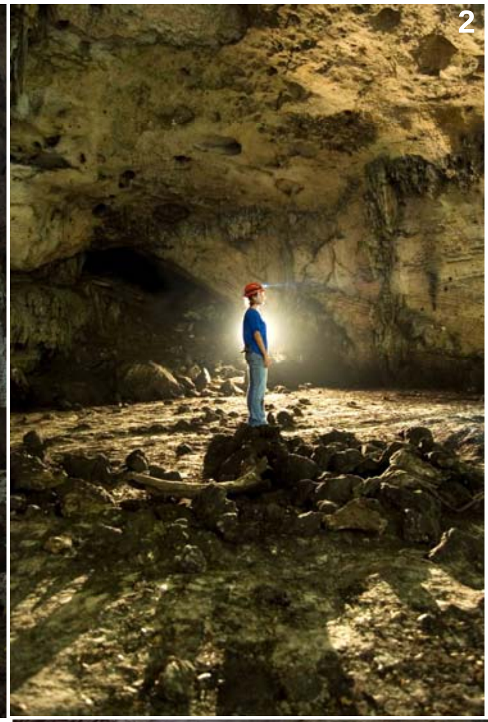


1. Curtain: A9
2. Articulated vertebrate: A3
3. Soda straw drip: A9
4. Grant Harley exits entrance: A0 (Jason Polk)

Appendix H: (Continued)

Maynard's Cave, Citrus County, Florida

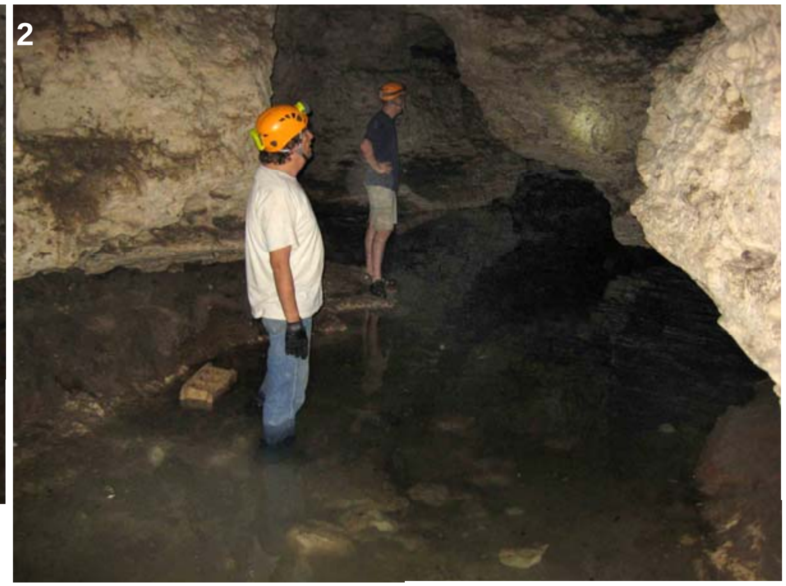




1. Dan Straley at window entrance:A2
2. Lindsey Hodges in Grand Chamber: A3
3. Tom Turner on rope: A2
4. Panoramic of Grand Chamber: A4 looking towards A1

Appendix H: (Continued)

Ocala Caverns East, Marion County, Florida



1. Large troglobitic crayfish ~ 4 in. long: A3
2. Bob Brinkmann and Grant Harley: A3 (Jason Polk)
3. Jason Polk at aquifer connection: A2
4. Smaller troglobitic crayfish ~2 in. long: A1

Appendix H: (Continued)

Ocala Caverns West, Marion County, Florida

1


2


3


4


1. Jason Polk descends into artificial entrance opened when cave was commercial: A1
2. Monica Exner and Jason Polk in graffiti-filled, fissure controlled passage: A3
3. Original light-bulb from mid-21st century
4. Monica Exner and Jason Polk exiting cave; notice stairs: A1-A2

Appendix H: (Continued)

Peace Sign Cave, Citrus County, Florida

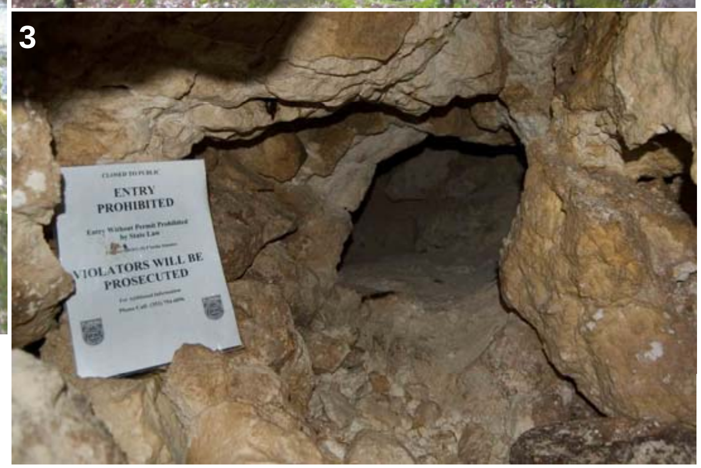
1. Broken speleothems and graffiti: A3

2. Modern fire pit: A2

3. Jason Polk near graffiti: A5

Appendix H: (Continued)

Quarter Cave, Citrus County, Florida



1. Jason Polk at entrance: A0

2. Bob Brinkmann supervises as Grant Harley places a “Do Not Enter” sign from the landowner at the cave entrance: A0 (Jason Polk)

3. Example of sign near A2

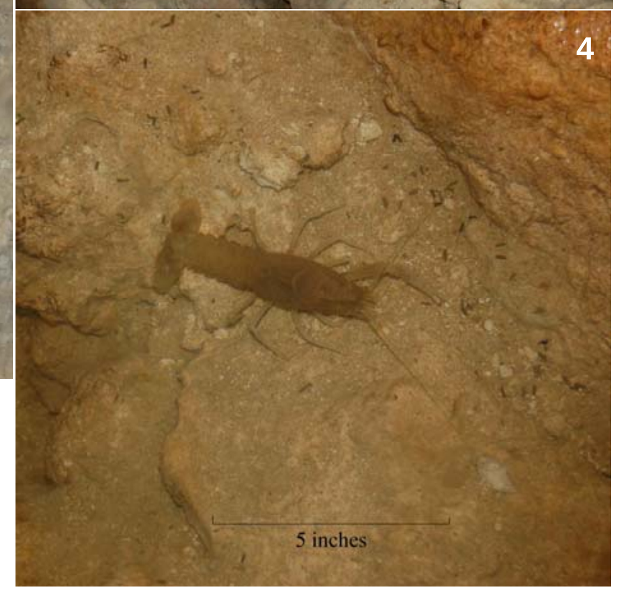
Appendix H: (Continued)

Reuff's Cave, Hernando County, Florida

1. Carl Reich climbs up quarry wall to entrance: A0 (Jason Polk)
2. Treehouse frog: A3
3. Breakdown passage; note orange flagging tape of station A3

Appendix H: (Continued)

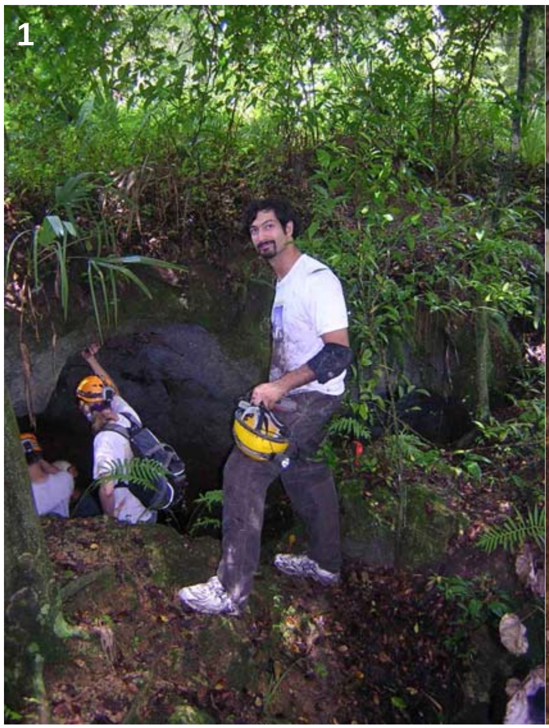
Sneak Cave, Marion County, Florida



1. Entrance squeeze: A0
2. Blind minnow and crayfish (inside circle): A4
3. Jason Polk in plus-sign passage: A8
4. Large crayfish: A4

Appendix H: (Continued)

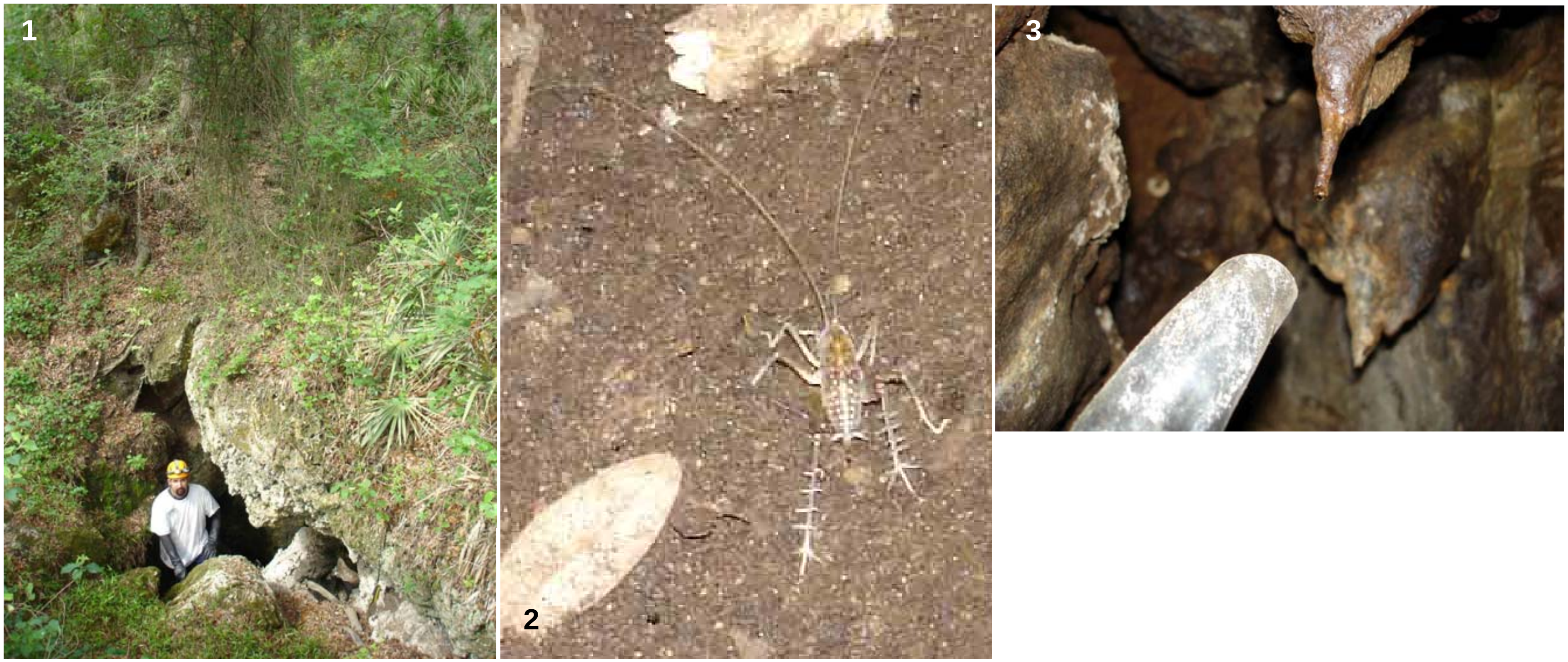
Thornton’s Cave, Sumter County, Florida



1. Dan Doctor at Tangerine entrance: A0 (Jason Polk)
2. “Don King” fungus growing on animal dung: A15 (Dan Doctor)
3. Deep Pool near A2 (Tom Turner)

Appendix H: (Continued)

Trail 10 Cave, Citrus County, Florida



1. Jason Polk in entrance: A0
2. Cave cricket: A2
3. Soda straw with active drip; not finger for scale: A3

Appendix H: (Continued)

Turpentine Cave, Citrus County, Florida

1. Tom Turner in chimney-down entrance: A0
2. Justin Marks in climb-down passage: A4 (Tom Turner)
3. Grant Harley in water-table passage: A11 (Jason Polk)

Appendix H: (Continued)

Hitchhiker Cave, Marion County, Florida

1. Jason Polk at large entrance: A0

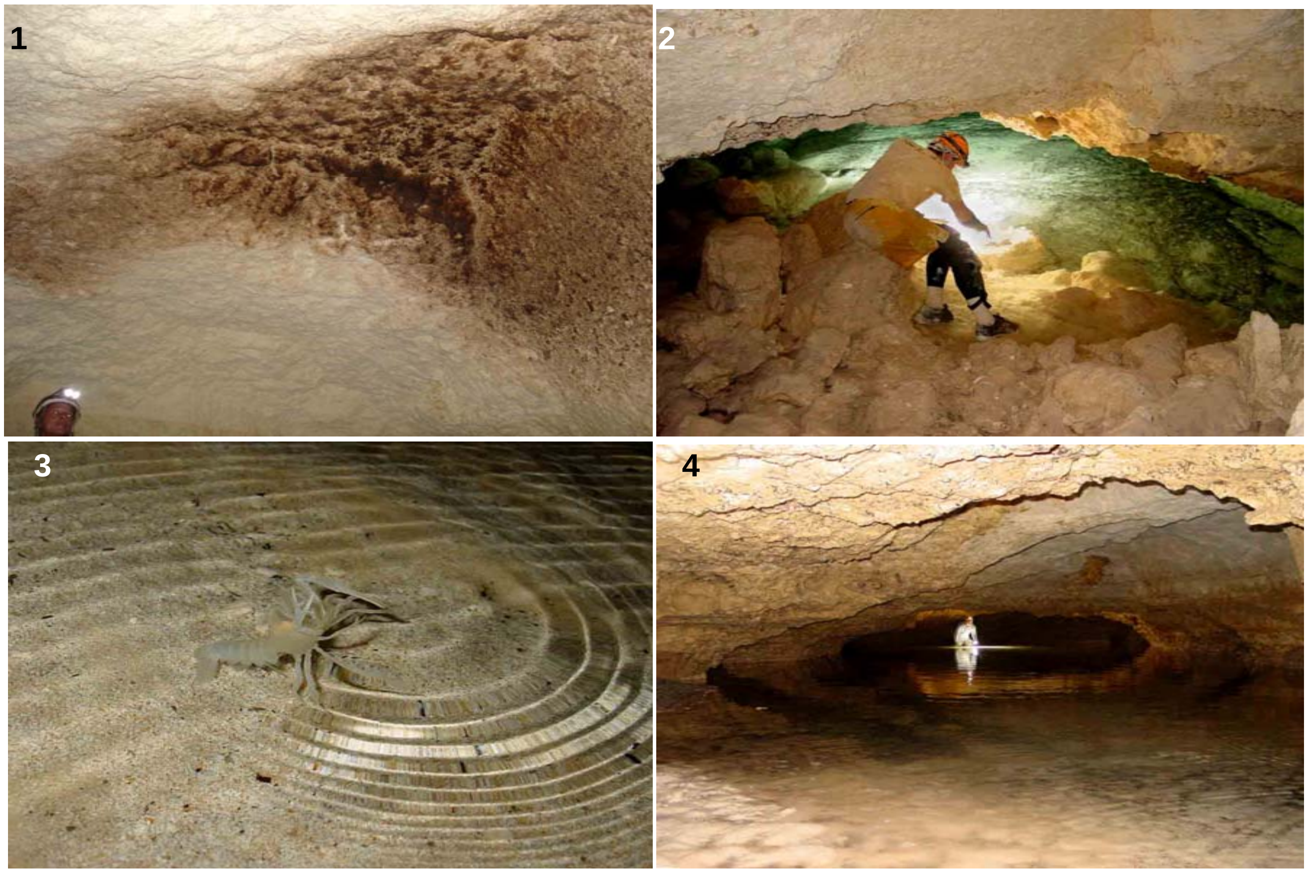
2. Graffiti: A2

3. Jason Polk looking at graffiti on flowstone: A3

4. Mattress near A1

Appendix H: (Continued)

Werner Cave, Citrus County, Florida



1. Tom Turner underneath bat roost stain: B15

2. Lee Florea collects an aquifer sample: B20 (Tom Turner)

3. Troglobitic crayfish: BA1 (Tom Turner)

4. Robert Brooks in water-table passage: view west from station BA1 (Tom Turner)

Appendix H: (Continued)

Holy Oak Cave, Citrus County, Florida

1. Monica Exner just inside entrance: A0-A1

2. Colleen Werner descends into entrance: A0

3. Graffiti: A1

Appendix H: (Continued)

Morris Cave, Citrus County, Florida

1. Robert Brooks stands at a pool before cave was filled in by sediment from surface erosion: near A4 (Tom Turner)

2. Tom Turner stands in virtually the same location after hurricanes caused sediment to wash into cave: near A4 (Tom Turner)

Appendix H: (Continued)

Vandal Cave, Citrus County, Florida

1. Grant Harley looks up window feature out of collapsed portion of cave: near A1

2. Grant Harley at entrance #1: A0

3. Jason Polk squeezes through tight passage: A8

Appendix H: (Continued)

Sick Bat Cave, Citrus County, Florida

1. Water droplets collect on the ceiling: A5

2. Eastern pipistrelle bat: A3

3. Trash buried in sediment: A1

About the Author

Grant Harley was raised in Lakeland, Florida. He received his bachelors in environmental geography at University of South Florida –Tampa in December of 2005. In January of 2006, he started working on his Master's degree at University of South Florida (USF) in the Department of Geography. Since starting graduate work at USF, Grant has been actively involved in the USF Karst Research Group. This group is a student-run organization that involves graduate students and faculty from four departments focused on karst research. To learn more about this active group, please visit their website at www.karst.usf.edu.

This thesis represents the end to Grant's Master's program. Grant has been a caver for over 5 years and has explored the underground in Belize, New Mexico, Florida, Texas, Indiana, Missouri, and Tennessee. Following graduation with a Masters degree in Environmental Geography from the University of South Florida December of 2006, Grant plans on pursuing his Ph.D. degree and using the field of human-environmental impact assessment in caves as a means of continuing his love of venturing underground. When he isn't hard at work on projects at the University, or exploring caves, Grant can be found involved with his other passion as a photographer for Beyond the Mist Photography. To learn more about the business, visit www.beyondthemistphotography.com.