BATS AND CAVES OF THE NORTHWESTERN HIGHLAND RIM OF TENNESSEE

JAMES RALPH HELTSLEY

August 13, 1965

To the Graduate Council:

I am submitting a thesis written by James Ralph Heltsley entitled "Bats and Caves of the Northwestern Highland Rim of Tennessee." I recommend that it be accepted for eight quarter hours credit in partial fulfillment of the requirements for the degree of Master of Arts with a major in Biology.

David Snyder
Major Professor

We have read this thesis and
recommend its acceptance:

Hackell C. Phillips

Tollie B Burns

accepted for the Council:
Dean of the Graduate School

H W Woodward

BATS AND CAVES OF THE NORTHWESTERN HIGHLAND RIM OF TENNESSEE

An Abstract of a Thesis

Presented to

the Graduate Council of

Austin Peay State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

---

by

James Ralph Heltsley

August 1965

BATS AND CAVES OF THE NORTHWESTERN HIGHLAND RIM OF TENNESSEE

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David H. Snyder Thesis Supervisor

ABSTRACT

The purpose of this study was to determine the number of bat-inhabitable caves in the area, the number and species of bats present in these caves, their species associations and sex ratios, the sites of nursery colonies, and the nature, extent and phenology of the movements of the bats.

Over a fourteen month period 4,627 bats of six species from twenty-six caves were collected either by mist netting, a Constantine trap or from hibernation, and were wing banded. Bats were taken from Montgomery, Stewart, and Cheatham Counties in Tennessee and from Christian County in Kentucky. The species found were Myotis grisescens, Myotis lucifugus, Myotis sodalis, Myotis keenii, Pipistrellus subflavus and Eptesicus fuscus. M. grisescens was the most abundant bat in both winter and summer and it was always in close association with four or more other species, except during the parturition period. M. lucifugus and M. sodalis occurred in larger numbers during the winter than in summer and both were most abundant in caves where M. grisescens was found. M. keenii was found in larger numbers during summer and was always found in association with one or more other species of bats. P. subflavus was found more abundantly

in winter, and in more caves than any other bat during both seasons. E. fuscus was found in small colonies in five caves in winter and one in summer.

Of the 3,106 bats banded during the winter, 1,814 (58%) were males. During the summer, of 1,521 bats banded, 482 (32%) were males.

M. grisescens was the only species that produced usable information on movements. The movement from the hibernal site to the dispersal or nursery site was generally south. Fifty-four (almost 2%) of the M. grisescens banded were recaptured. The maximum distance between banding and recovery site was forty-three miles. One nursery colony was discovered, containing an estimated 800 M. grisescens.

Bellamy and Tobacco Port Caves harbored most of the area bats (92% of the total winter population; 91% of the summer population was in Bellamy alone).

Original, detailed maps were drafted of all the caves investigated during the study.

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BATS AND CAVES OF THE NORTHWESTERN HIGHLAND RIM OF TENNESSEE

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ACKNOWLEDGMENTS

I wish to express my appreciation to Mr. David H. Snyder for the many hours of help rendered and for the guidance during the study. I wish to thank all the cave owners for the privilege of investigating their caves, especially Mr. R. F. Allen, owner of Bellamy Cave, and Mr. J. J. Kingins, owner of Tobacco Port Cave. Austin Peay State College students Mildred Bateman, Marie Scudder, Tom Williams, Don Hammer and George Murphy and Clarksville High School students Don Harker and Joe Pardue gave of their time and interest to help in the banding and investigation of many of the area caves. Without their help many of the undertakings would not have been possible. To my wife I am indebted for the many long hours that she gave freely, helping in every way to make this study successful. I sincerely appreciate the assistance given by Dr. William Ellis, Dr. Ellis Burns, Dr. Haskell Phillips, Mr. Wallace Snyder and Mr. Floyd Brown in the constructive criticism of the writing of this thesis.

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CHAPTER I

INTRODUCTION

The underlying limestone of the Northwestern Highland Rim of Tennessee is honeycombed with many caverns which, when exposed at the surface, have made us aware of their existence. Man is not the only animal cognizant of these caves, for many animals use the caves during their daily activities either as a retreat or a home. Although it is generally known that bats inhabit these caverns, there are many questions pertaining to these secretive nocturnal animals in this area that are left unanswered.

Statement of the Problem

The purpose of this study was to obtain some data which might help to answer, in part or in full, these questions:

1. How many bat inhabitable caves were there in the study area, and where were they located?
2. What was the extent and ecological nature of each cave?
3. What species of bats were normally found in the area caves in summer and in winter?
4. What were the species associations for the winter and summer populations, in what numbers was each species found, and what were the sex ratios of the several species during the different seasons?
5. In which caves were summer nursery colonies located?
6. What were the approximate dates of entrance into and emergence from hibernation?

7. What was the nature and extent of the spring emigration and immigration of the cave bats?

Importance of the Study

As the above list implies, this study was mainly descriptive in nature, not experimental. Such a study is prerequisite for any more detailed and specific problem, descriptive or experimental, that may be done in relation to the area caves and their bat inhabitants in the future.

As man's leisure time increases, more people are turning to cave exploration as a means of recreation. The mistreatment of the caves and their fauna by these would-be "spelunkers" is increasingly apparent in disfigured caverns and disappearing cave faunas. It is hoped that this study will enable the general public better to appreciate bats and their cave habitats.

Study as a Whole

Chapter II is concerned with a description of the study area concerning such aspects as physiography, climate, geology, vegetative cover, cave fauna, and ecology. Also included is a set of detailed maps, with descriptions for each cave.

Chapter III is concerned with the methods and materials used in the study. This chapter explains how the bats were collected, banded, and how the data was recorded for each bat. A brief history of banding, an explanation of the lengths of seasons and the effects of disturbance due to banding are also included.

Chapter IV deals with the species associations. A literature review of the species associations that reportedly occur here is accompanied by the report of the species associations that were found in the study.

Chapter V is concerned with the sex ratios of the bats in the study area. A review of the literature on sex ratios found in similar studies is accompanied by the data pertaining to sex ratios collected from the study area during the winter and summer.

Chapter VI is concerned with the movements of bats and includes a review of related literature and a report of the bats recaptured after having been banded previously at a different location.

Chapter VII contains the summary and conclusions derived from the data collected.

CHAPTER II

THE STUDY AREA

This cave rich area in the deciduous woodlands of the eastern half of the United States is biotically, climatically and geologically similar to the adjacent portions of Missouri, Kentucky and Arkansas, all of which belong to the Carolinian area of the Austral Life-Zone (Orr, 1961).

This study was conducted in Montgomery, Stewart, and Cheatham counties in Tennessee, and Christian County, Kentucky. Most of the work was concentrated in Montgomery County (Plate 1).

Literature Review

Even though the uniqueness of their faunas has long been recognized, few biological studies have been conducted in the caves of northwest Tennessee. The earliest interest seems to have been for commercial, rather than biological, reasons.

Barr (1961) states that:

> Cave fills contain significant percentages of nitrates, probably in the form of niter, nitrocalcite, and nitromagnesite. During the early history of Tennessee, cave fills were an important source of nitrate for the manufacture of gunpowder. The earth was leached for several days in large wooden vats or barrels. The resulting liquor was treated with wood ashes and boiled in large iron kettles to obtain saltpeter. An anonymous author writing in the Medical Repository in 1805 stated that Tennessee abounded in saltpeter caves to such a degree that the price of gunpowder in Nashville was only 1 dollar for 3 pounds!

PLATE 1. Study Area, Showing Locations of the Caves Investigated

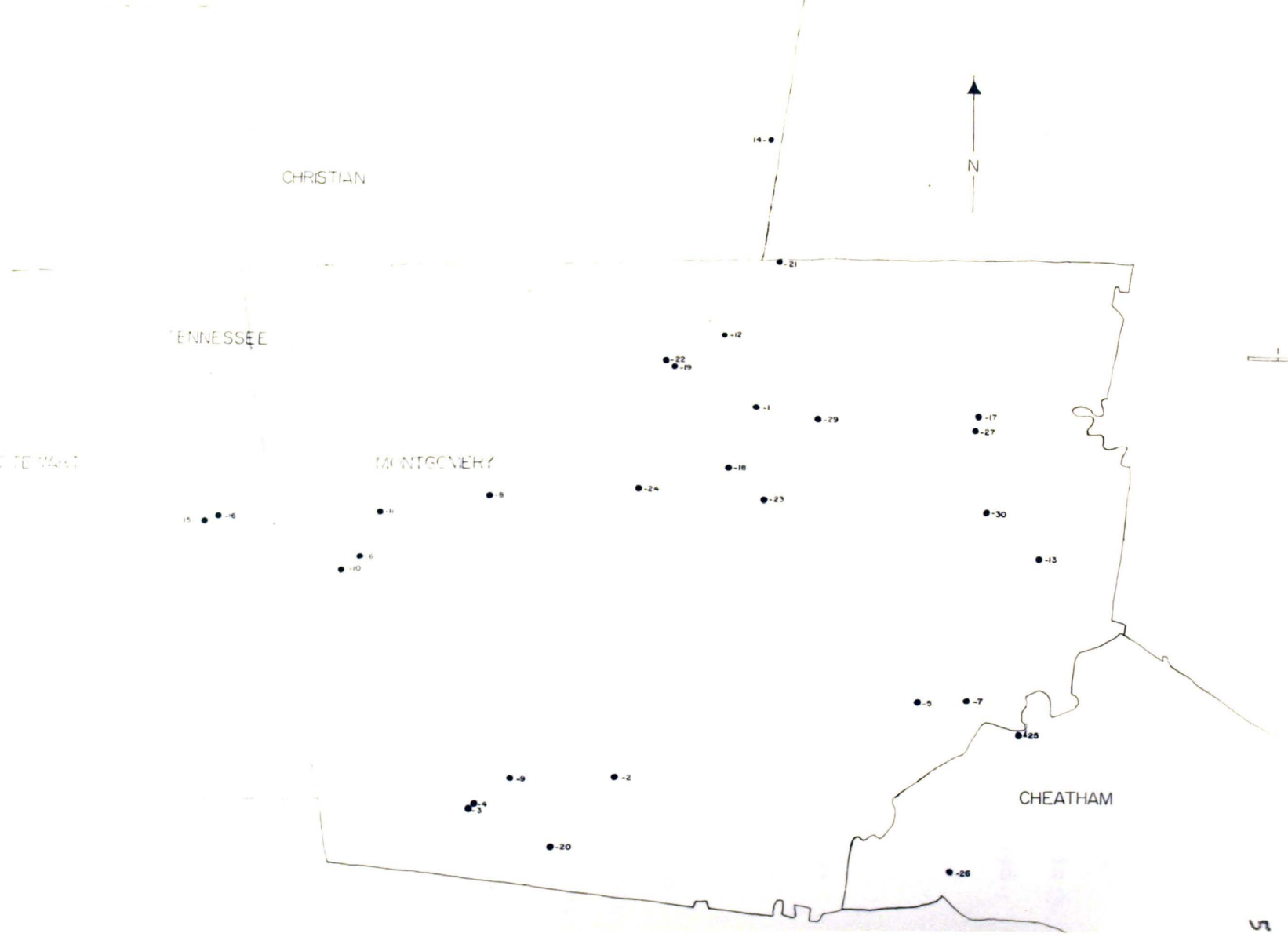


PLATE 1. Study Area, Showing Locations of the Caves Investigated

During the War of 1812 and especially during the Civil War, certain Tennessee caves were scenes of great activity (Faust, 1955, as quoted by Barr, 1961). Evidence of digging, and deteriorated nitrate hoppers, indicate that such activities were carried on in Bellamy Cave and in Cooper Creek Cave, both of which are involved in the present study.

Physiography, Geology, Climate, and Vegetative Association

The greater part of the study area falls within the northwestern section of the Highland Rim of Tennessee, adjacent to the Kentucky border. It is covered with red soils and white chert formed by the weathering of St. Louis and Warsaw Limestones, which underlie the greater portion of the study area. The area represents only a small portion of the Highland Rim, which completely surrounds the Central Basin, centered on Nashville. The caves of this area are developed in the St. Louis and Warsaw Limestones. The St. Louis Limestone consists of dark-colored beds of varying lithology which overlie the coarse-grained, light-colored, massive Warsaw Limestone and underlie the light-colored, highly oolitic Ste. Genevieve Limestone (Marcher, 1962). This formation, as described by Stafford (1869), is of Mississippian age.

The origin of the area caves is explained by Davis' two cycle theory (1930, quoted by Barr, 1961) which states that caves formed deep below the land surface and water table during the first cycle and were drained and exposed during the second cycle. Bretz (1956)

adds a third cycle that accounts for the red clay fills that occur in many of the area caves. This cycle, occurring between the two cycles proposed by Davis, consists of the deposition of fine red clay while the caverns were still below the water table. He lists two possible sources of this clay: it is either washed in from surface water or is released from the limestone upon its dissolution by the ground water.

The following information relevant to climate was obtained from Visher (1954) and Miller (1962). The mean annual precipitation at Clarksville, in the center of the study area, is forty-eight inches, and is fairly evenly distributed throughout the year. There is about ten inches of snow annually. The streams are lowest in late summer and fall (October) and are highest in winter (March). There are about fifty-five days of thunderstorms occurring annually. The coldest part of the year begins between November twenty-fifth and December first. The first killing frost occurs about October eighth and the last killing frost around April seventh. The average depth of frost penetration is three to four inches. The hottest period occurs between May eighth and October fifth. There are about 1,500 hours with a temperature above eighty degrees Fahrenheit.

The zoogeographic region is suited for agriculture (Stafford, 1869) and consists mostly of oak-hickory climax communities. For the population as a whole, oak and hickories represent approximately fifty per cent of the total basal area and thirty-five per cent of the total density (Duncan, 1965). Duncan (1965) found that there is

a codominance of several species that include white oak (Quercus alba), red oak (Quercus rubra), southern red oak (Quercus falcata), tulip poplar (Liriodendron tulipifera), and mockernut hickory (Carya tomentosa).

Cave Biota

From 1953 to 1959, Thomas Barr of Nashville, Tennessee, spent many hours exploring and collecting animal specimens from Tennessee caves. Barr's (1961) book, CAVES OF TENNESSEE, is the only extensive work pertaining to the cave biota of this area. Listed below are some of the animals found by Barr which can also be found in the area caves: eyeless crayfish (Orconectes pellucidus), harvestmen (Phalangodes armata),ablind millipede (Pseudotremia sp.), springtails (Pseudosinella espana) (Sinella barri) (S. cavernarum), a bristletail (Plusiocampa jonesi), cave cricket (Ceuthophilus sp.), a blind carabid beetle (Pseudanophthalmus pubescens), Small Blindfish (Typhlichthys subterraneus), Cave Salamander (Eurycea lucifuga), Long-tailed Salamander (Eurycea longicauda longicauds), Zig-zag Salamander (Plethodon dorsalis dorsalis), Slimy Salamander (Plethodon glutinosus), Northern Red Salamander (Pseudotriton ruber ruber), Pickeral Frog (Rana palustris), Bullfrog (Rana catesbeiana), Eastern Phoebe (Sayornis phoebe), Allegheny Wood Rat (Neotoma magister) White-footed Mouse (Peromyscus leucopus), Red Fox (Vulpes fulva), and Gray Fox (Urocyon cinereoargenteus). In addition I have observed tracks and other signs of Raccoon (Procyon lotor), opossum (Didelphis

Marsupialis) and Feral house cats (Felis Catus).

Cave Climatology

The interior of most caves is characterized by a relatively constant temperature, by a high relative humidity, and by total darkness. The temperature in an ideal cave is equivalent to the average annual surface temperature of the region in which the cave is located (Barr, 1961). In the study area this is fifty-six to fifty-nine degrees Fahrenheit. Observations by Barr (1961) have disclosed, however, that air currents and streams entering the cave from the exterior can profoundly modify this ideal temperature. Larger caves with small entrances frequently suck air in or blow gusts of air out. The inward movement of air occurs in summer and the outward movement in winter. These air movements usually are explained on the basis of density gradients between the surface air and the cave air, but atmospheric pressure changes and the number and location of openings to the cave almost certainly are involved.

The relative humidity of most caves in this study area is 95-100 per cent, but in dry, dusty caves it may drop as low as 79 per cent. Terrestrial cave animals generally are found only where the humidity is 98-100 per cent. As the result of these high relative humidities the rate of evaporation is known to be quite low in comparison with surface rates.

Area caves are driest in September and October and are wetter and damper through the winter and spring. Cave streams may become

rushing torrents a short time after heavy rains, and the amount of water dripping from the ceiling noticeably increases.

Cave Location, Visitation, and Familiarization

Preliminary work began in May, 1964, and work was continued during all seasons through July, 1965. During the study, 149 cave visits were made to collect and band bats and to map the caves (Table I).

Three caves were examined at least once for bat populations, while the remaining twenty-nine caves were visited from two to ten times each.

Caves were located by referring to Barr's (1961) list, consulting with persons active in cave exploration, and talking with landowners in the immediate vicinity. An appeal for cave and bat information over the radio and via the newspapers received very little response.

Each cave was thoroughly explored during the first visit to estimate the number of bats present. It was soon apparent that most caves were used by bats, but some much more than others. Subsequent visits were made to caves which contained significant numbers of bats during any season.

Thirty-two of the area caves were visited during the winter and with the exceptions of Kennedy, Glover's, and Jeff Pace Caves all were rechecked the following summer.

The Area Caves

Area caves generally have spacious entrances which provide

TABLE I

VISITS TO AREA CAVES, MONTHLY

Month	No. of visits
May 1964	4
June 1964	6
September 1964	6
October 1964	3
November 1964	3
January 1965	14
February 1965	16
March 1965	31
April 1965	16
May 1965	20
June 1965	20
July 1965	10
Total for 12 months	149 visits

easy access. However, some have very deep vertical joints while others have very tight squeeze-way entrances. The only literature relating to the area caves is Barr's CAVES OF TENNESSEE (1961). He lists ten of the 32 caves that were found in the area studied.

In each cave description the following information has been included: (1) name, (2) location, (3) owner, (4) nearest post office, and (5) physical description and account. Symbols used on the cave maps appear on Plate 2. These symbols are as proposed by The Missouri Speleological Survey, 1959.

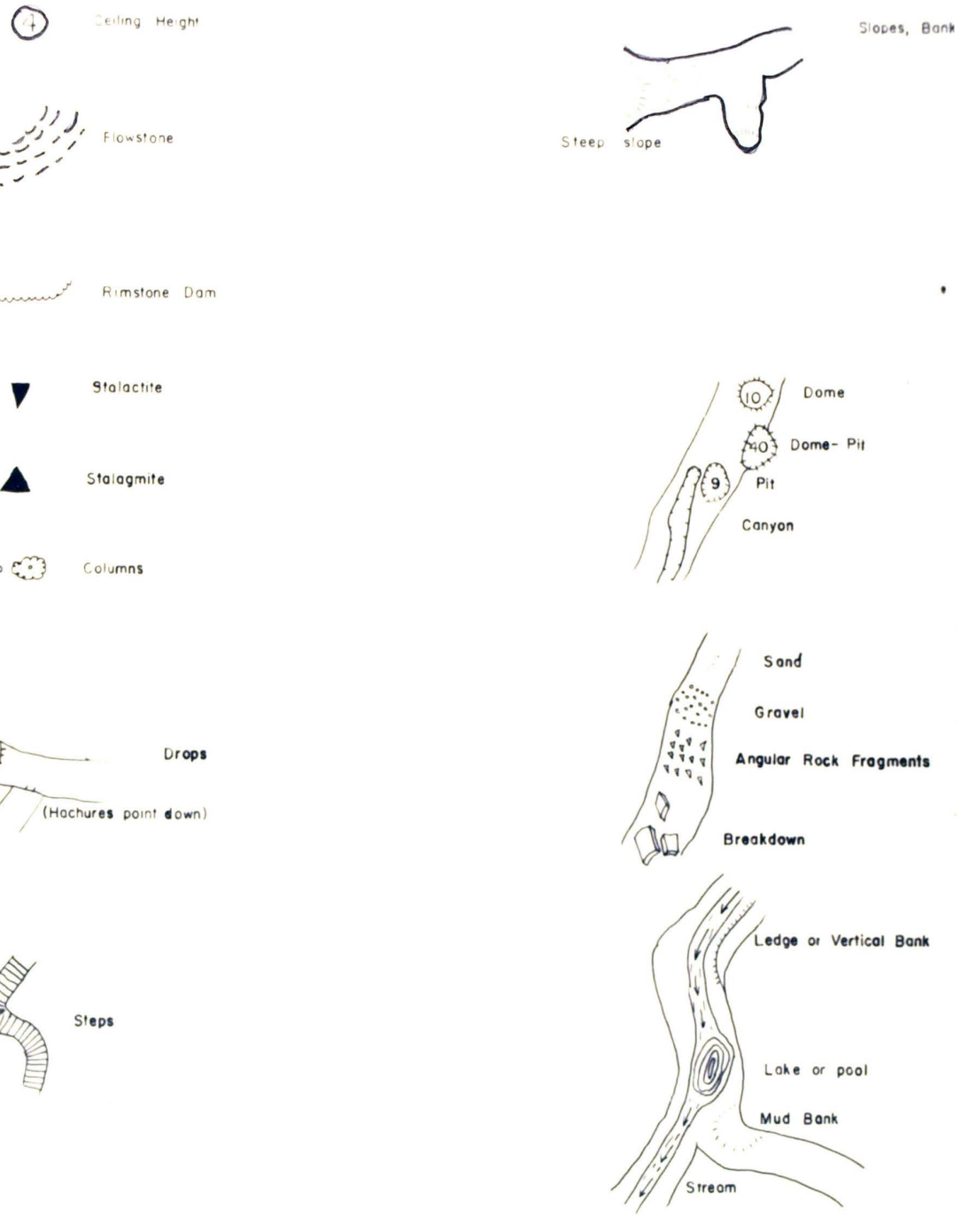


PLATE 2. Legend of Map Symbols Used

CAVE NAME: Austin Peay State College Cave

LATITUDE: 36° 34' 06" N.; LONGITUDE: 87° 20' 14" W.

OWNER: Austin Peay State College

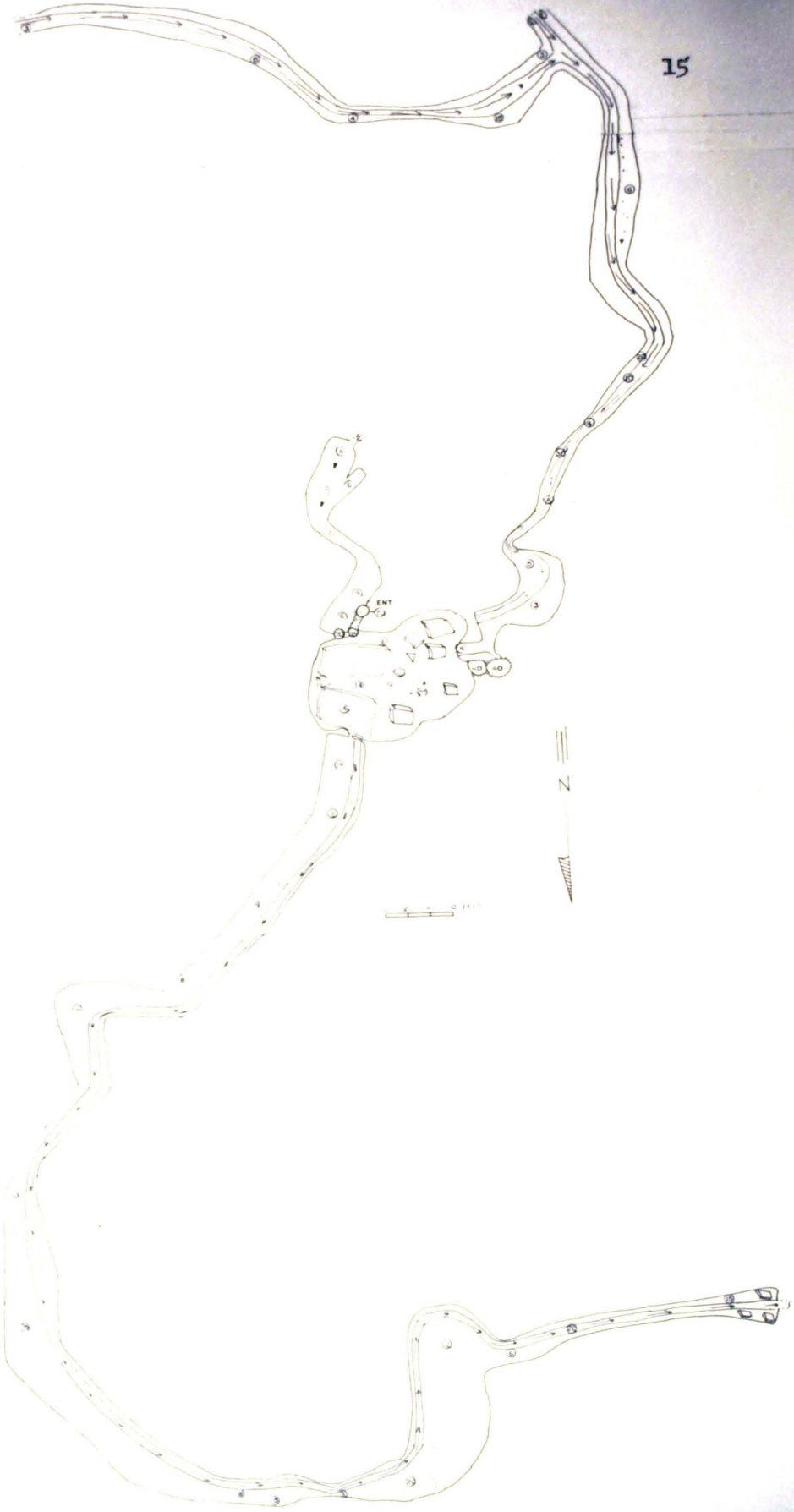
LOCATION: A. P. S. C. Cave is 7/10 mile east of Big West Fork Creek, 700 feet south of Austin Peay Recreation Area Access and 1 and 1/20 miles south of Needmore School at an elevation of 510 feet.

QUADRANGLE: Clarksville, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The entrance is in a small cluster of deciduous trees and is protected by a woven wire fence. This cave is accessible only by a long rope or similar device. The deep, vertical entrance drops nearly straight down for seventy feet, encounters a forty-five degree slope for fifty feet, and then drops straight down another twenty-five feet to a large room. Three passages that lead from this room were investigated and mapped. Throughout the cave there is evidence of breakdown in the form of large limestone slabs. A stream courses along the north and west passages and in this stream Small Blindfish (Typhlichthys subterraneus) and a blind crayfish (Orconectes pellucidus) may be found. The large room has been the site of a moonshine still as is evidenced by the broken jugs, the decaying wooden barrels and the rusty barrel hoops.

PLATE 3. Austin Peay State College Cave (Opposite)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CAVE NAME: Baggett's Cave

LATITUDE: 36° 23' 6" N.; LONGITUDE: 87° 25' 13" W.

OWNER: Herbert Baggett

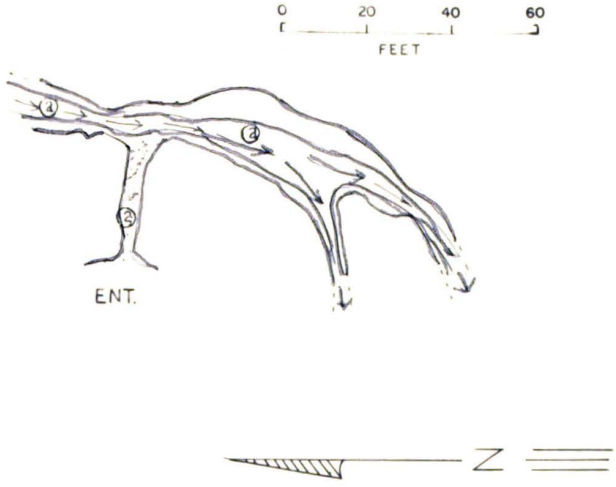
LOCATION: The entrance is 200 feet north of Highway 13 and 1/2 mile east of Spike Baggett Hollow Road at an elevation of 600 feet.

QUADRANGLE: Palmyra, Tennessee

NEAREST POST OFFICE: Cunningham, Tennessee

DESCRIPTION AND ACCOUNT: A permanent spring emanates from this cave on the east slope of the hill. The greatest ceiling height is two feet.

PLATE 4. Baggett's Cave (Opposite)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CAVE NAME: Ballinger's Cave

LATITUDE: 36° 22' 12" N.; LONGITUDE: 87° 30' 18" W.

OWNER: John Dan Allen

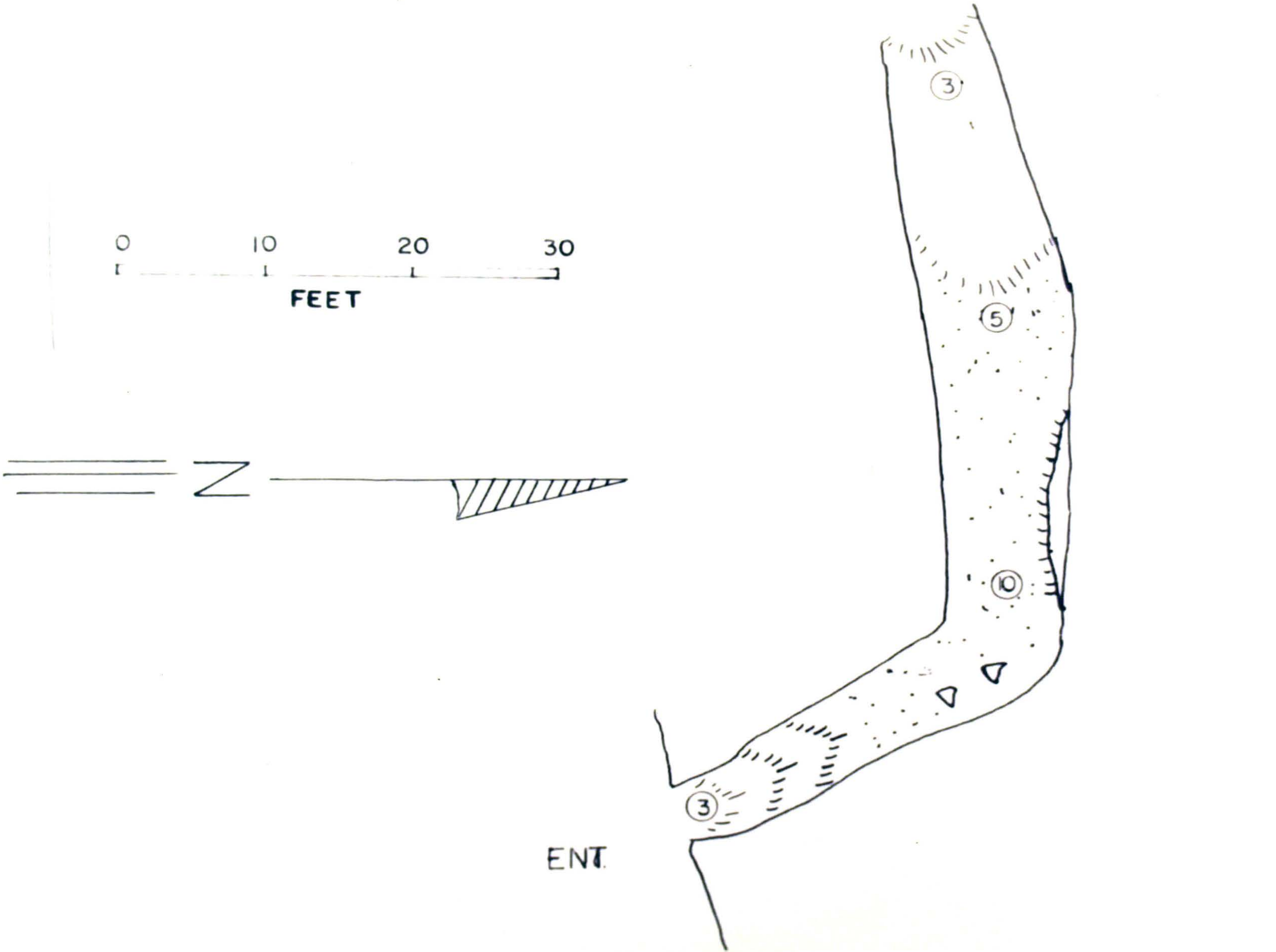
LOCATION: The cave is 2,000 feet west of East Fork Creek on the north side of the hollow at an elevation of 500 feet. The hollow is approached from the east by wading the creek or by walking across a swinging bridge.

QUADRANGLE: Erin, Tennessee

NEAREST POST OFFICE: Cunningham, Tennessee

DESCRIPTION AND ACCOUNT: This cave has a small opening located directly across the hollow from a small spring. The three foot entrance opens to a height of ten feet farther back in the cave and then the passage begins to become smaller again. Cave crickets (Hadenoecus subterraneus) and cave salamanders (Eurycea lucifuga) can be found.

PLATE 5. Ballinger's Cave (Opposite)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ENT.

CAVE NAME: Ballinger's Other Cave

LATITUDE: 36° 22' 20" N.; LONGITUDE: 87° 30' 08" W.

OWNER: John Dan Allen

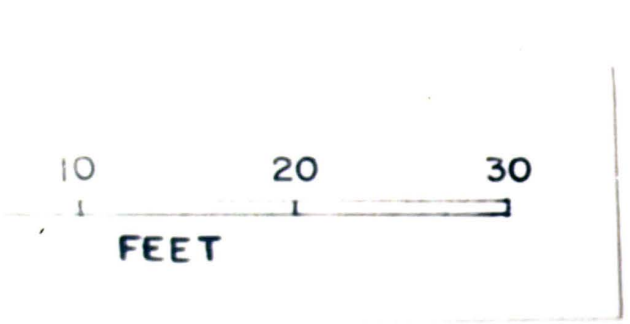
LOCATION: The entrance is thirty feet from the west bank of East Fork Creek at an elevation of 470 feet.

QUADRANGLE: Erin, Tennessee

NEAREST POST OFFICE: Cunningham, Tennessee

DESCRIPTION AND ACCOUNT: Some bat droppings were found on the floor but no bats were collected at any time. The floor is usually moist from seeping water and is covered with small pebbles and larger rocks.

PLATE 6. Ballinger's Other Cave (Opposite)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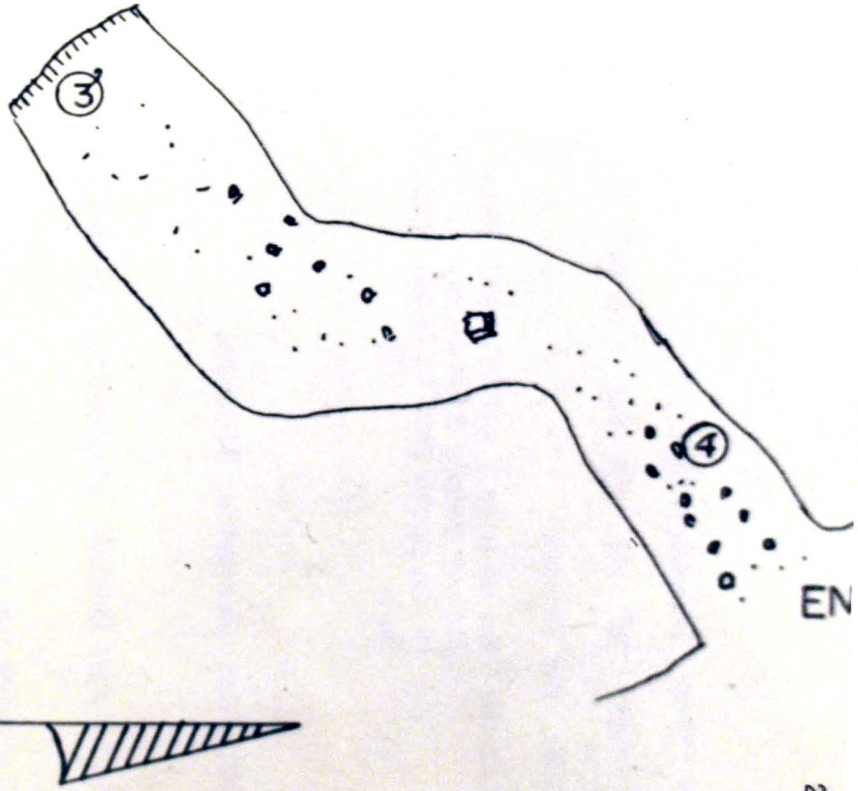
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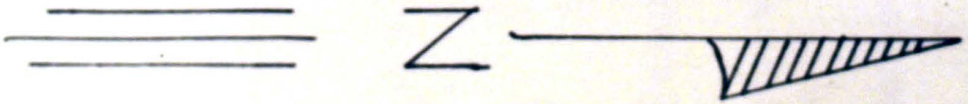


CAVE NAME: Bearden's Cave

LATITUDE: 36° 25' 25" N.; LONGITUDE: 87° 14' 43" W.

OWNER: Pat Bearden

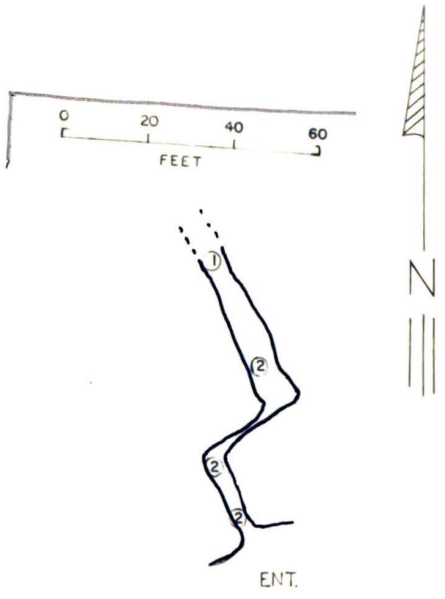
LOCATION: The cave is 1 and 2/10 mile south and slightly east of Hickory Point, 2 miles west of the Ashland City Road, on the north bank of Brush Creek at an elevation of 410 feet.

QUADRANGLE: Henrietta, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: Two red foxes were flushed from this small cave when it was investigated in January of 1965.

PLATE 7. Bearden's Cave (Opposite)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ENT.

CAVE NAME: Bellamy Cave

LATITUDE: 36° 29' 39" N.; LONGITUDE: 87° 34' 14" W.

OWNER: R. F. Allen

LOCATION: The cave mouth is 1 and 3/10 mile north-northwest of Stringtown and 8/10 mile west of Wylie Chapel, on the west side of a hollow, 300 yards north of the Blooming Groove Creek Road, at an elevation of 600 feet (Barr, 1961).

QUADRANGLE: Erin, Tennessee

NEAREST POST OFFICE: Woodlawn, Tennessee

DESCRIPTION AND ACCOUNT: Barr (1961) states that: "This cave is named for Dr. Peter F. Bellamy, who once lived near it. During the Civil War the cave was intensively mined for nitrate. The rotted remains of several old niter hoppers can be seen in both branches. The mouth is in a depression on the side of the hollow and is fifteen feet wide and eight feet high. A steep slope leads down to the floor of the cave. The main gallery trends north and south from the entrance, averages thirty-five feet wide, and is fourteen to forty-five feet high. A small stream flows through the lower levels. The north fork is accessible through two small passages to the right of the entrance. The south fork splits into three levels near the end.

Near the mouth is a twenty-five-foot pit, "Hell's Hole." In August 1883, William Morrow, a brother-in-law of Bellamy's, shot a Negro named Dick Overton and threw his body into the pit. The skeleton was discovered eight months later by Deputy Sheriff Taylor, and Morrow was hanged June 19, 1885."

A map of this cave may be found in the book Caves of Tennessee by Thomas C. Barr, Jr.

CAVE NAME: Blue Spring Cave

LATITUDE: 36° 25' 25" N.; LONGITUDE: 87° 12' 59" W.

OWNER: George Murff

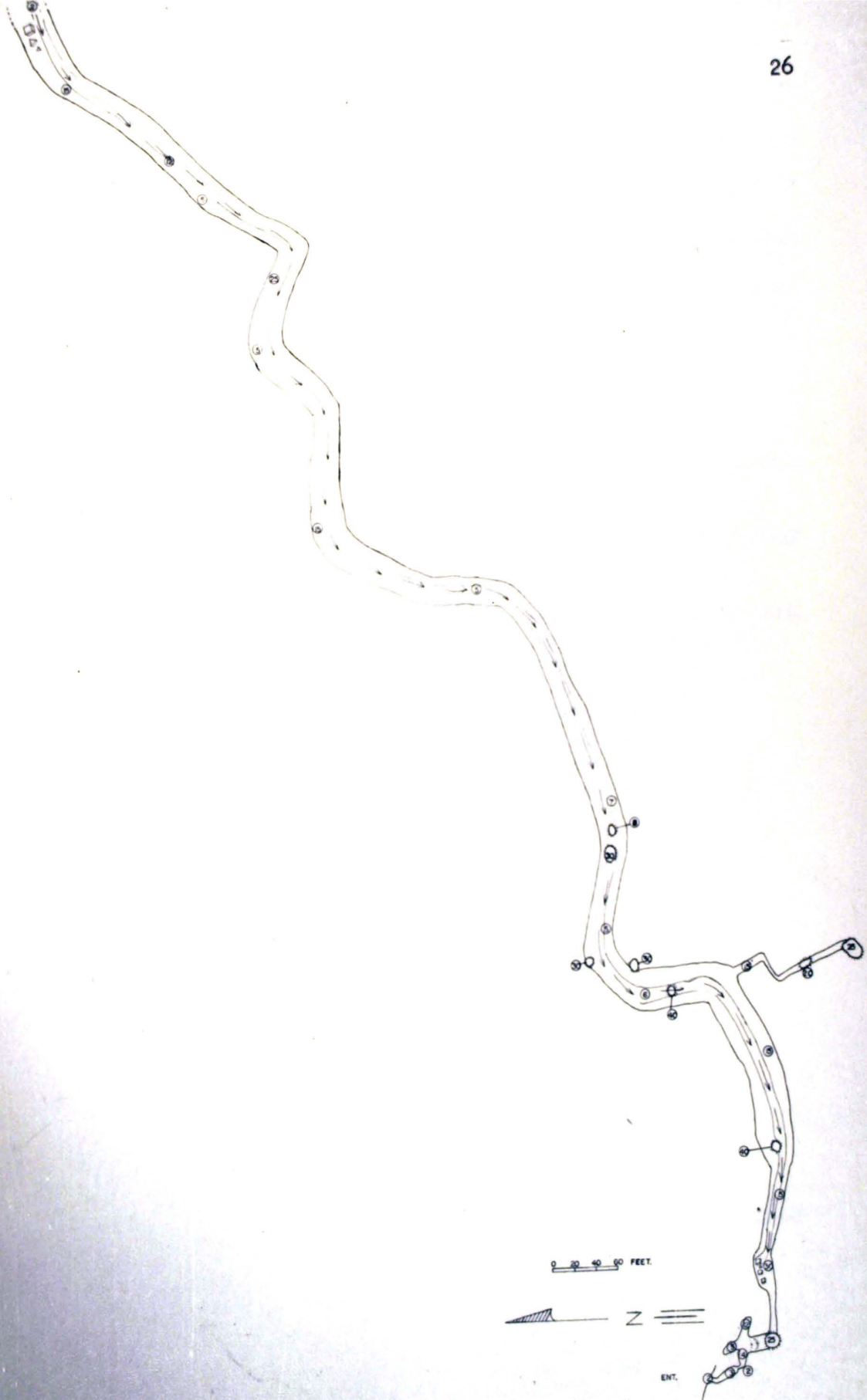
LOCATION: The cave is 325 feet south of Brush Creek and 225 feet west of the Ashland City Road at an elevation of 530 feet.

QUADRANGLE: Henrietta, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The entrance is a two foot vertical squeeze-way that progresses back to a passage that contains a small, clear stream. The stream runs the length of the cave. Only one side passage from the main passage was discovered and this had water flowing from it during wet weather. The cave is very muddy and contains very few formations. West of the entrance, at the base of a large limestone bluff, is a pool of water that empties into Brush Creek. This pool is believed to be fed by the cave stream.

PLATE 8. Blue Spring Cave (Opposite)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ENT.

CAVE NAME: Bone Cave

LATITUDE: 36° 31' 30" N.; LONGITUDE: 87° 29' 39" W.

OWNER: Smith Wall

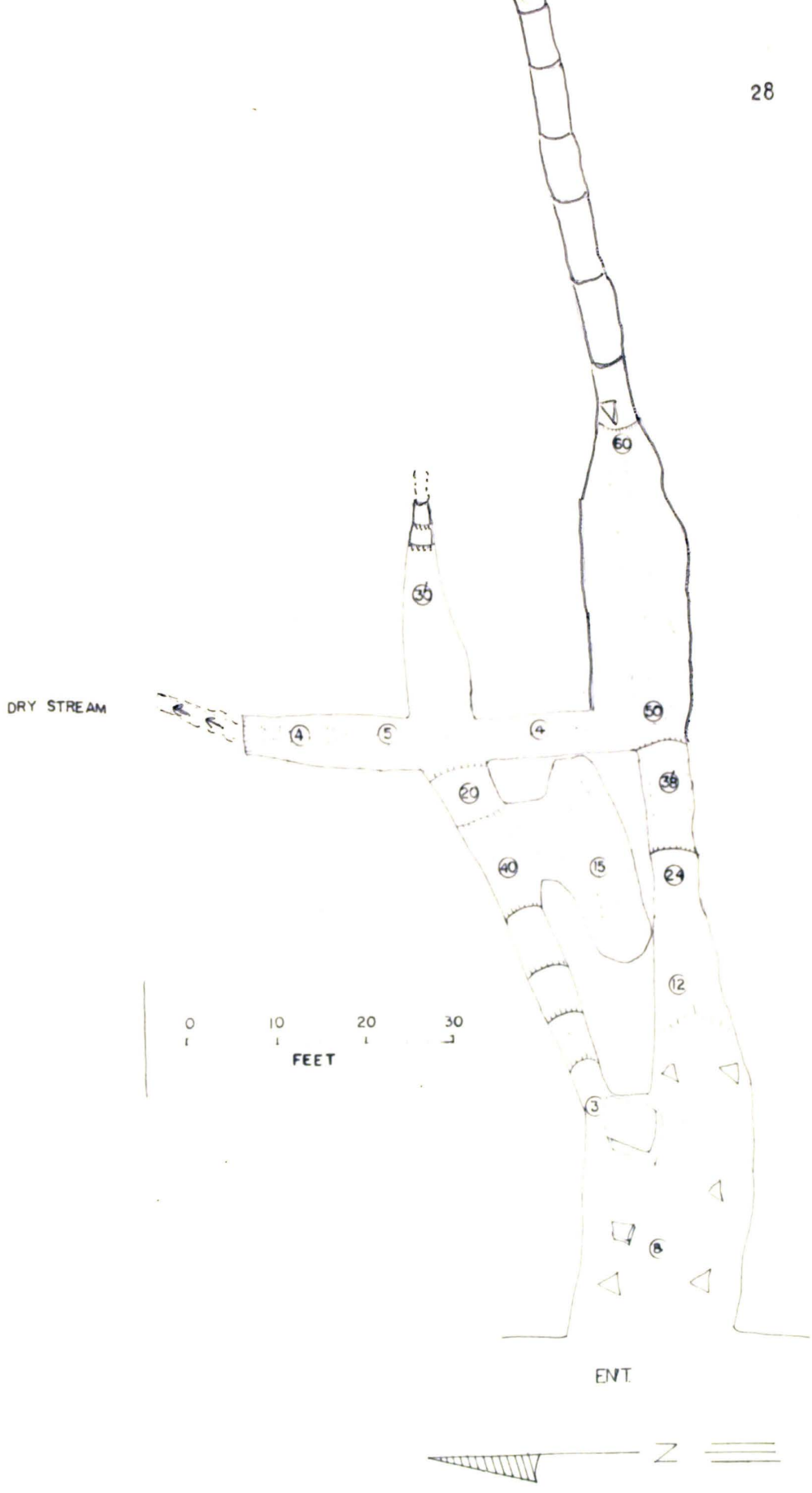
LOCATION: The cave is 1 and 5/10 mile south of Woodlawn School, in a large sink 100 yards east of the Dry Branch Road, at an elevation of 534 feet (Barr, 1961).

QUADRANGLE: New Providence, Tennessee

NEAREST POST OFFICE: Woodlawn, Tennessee

DESCRIPTION AND ACCOUNT: The eight by twenty foot (width) entrance of Bone Cave splits into two parallel fissures. The fissure on the right is sixty feet high and was found to have flood-water debris on the walls to within ten feet of the ceiling. The left fissure is twenty feet from the right and reaches about forty feet in height. The entrance slopes sharply down to the floor and near the rear the floor slopes gradually upward.

PLATE 9. Bone Cave (Opposite)


DRY STREAM
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CAVE NAME: Burney Cave

LATITUDE: 36° 23' 6" N.; LONGITUDE: 87° 28' 57" W.

OWNER: James Cook

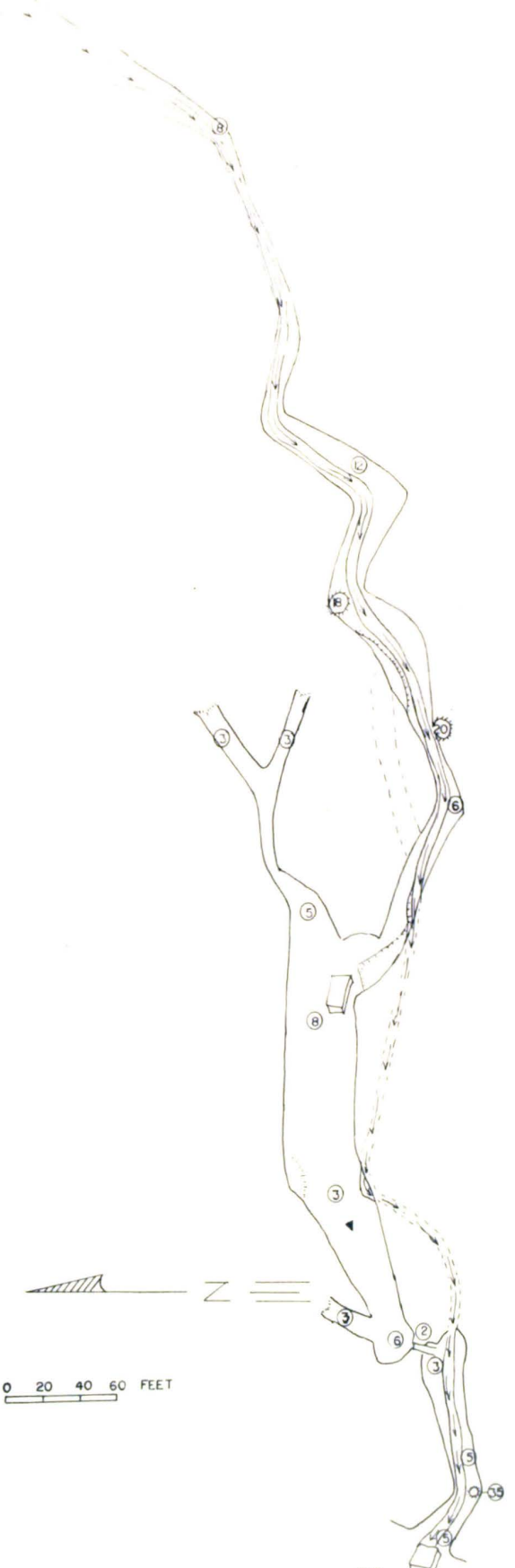
LOCATION: The cave is 2,325 feet east of the Shiloh road, and 1 and 1/4 miles west of the Old Clarksville-Waverly Road at an elevation of 505 feet.

QUADRANGLE: Palmyra, Tennessee

NEAREST POST OFFICE: Cunningham, Tennessee

DESCRIPTION AND ACCOUNT: Burney Creek emanates from the entrance that is five feet high and twenty-two feet wide. One hundred feet from the entrance the ceiling is only three feet high and one must pass through a tight vertical squeezeway on the north side before the main part of the cave can be explored. The cave has had a lot of visitors as is evidenced by the tracks in the mud, the broken formations, the piles of used carbide, and the writing on the walls. A roaring little waterfall near the terminus adds to the beauty of the cave.

PLATE 10. Burney Cave (Opposite)


0 20 40 60 FEET

CAVE NAME: Coleman Cave

LATITUDE: 36° 29' 20" N.; LONGITUDE: 87° 34' 55" W.

OWNER: Wayne Price

LOCATION: Coleman Cave is 1 and 5/10 miles northwest of Stringtown, on the right side of Pacco Branch or Eldirige Creek, at an elevation of 420 feet.

QUADRANGLE: Erin, Tennessee

NEAREST POST OFFICE: Woodlawn, Tennessee

DESCRIPTION AND ACCOUNT: Coleman Cave has three entrances, about 75 feet apart, all opening at the base of the west wall of the valley. About 150 feet from the south entrance is a large stalactite known as the "Beefheart." Farther back near the rear of the south entrance there are some guano deposits, but no bats were collected from above the deposits. The central passage is connected to both the north and south passages. The owner has a hay rack in the south passage near the entrance and has an ideal shelter for his cattle in both winter and summer. The north passage gets progressively smaller near the rear and may be entered at the back through a sink opening into a field.

A map of this cave may be found in the book Caves of Tennessee by Thomas Barr, Jr.

CAVE NAME: Cooper Creek Cave or Foster's Cave

LATITUDE: 36° 31' 04" N.; LONGITUDE: 87° 33' 35" W.

OWNER: O. T. Barnett

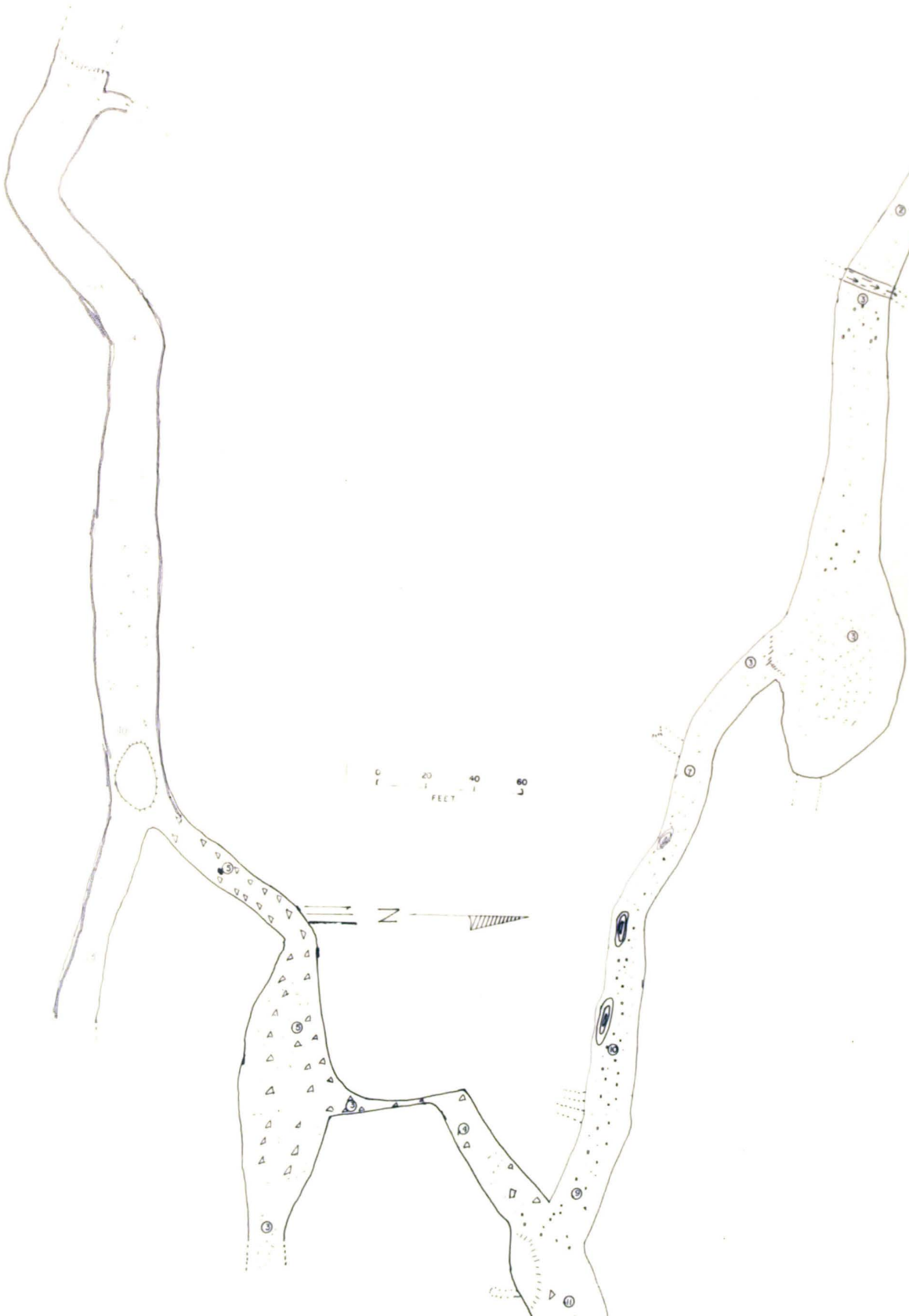
LOCATION: This cave is 1 and 4/10 miles south of Highway 79, 100 yards west of Cooper Creek and 100 yards east of the Cooper Creek Road, at an elevation of 440 feet (Barr, 1961).

QUADRANGLE: Woodlawn, Tennessee

NEAREST POST OFFICE: Woodlawn, Tennessee

DESCRIPTION AND ACCOUNT: The entrance is thirty-five feet wide and eleven feet high and is located at the base of a limestone bluff one hundred feet high. The cave forks into two passages fifty feet from the mouth. The right passage proceeds northwest for 440 feet and lowers to a one foot ceiling at this point. The left passage runs southwest for fifty feet then south for forty more feet. This portion must be crawled through to reach the left part of the cave. Then the cave runs southwest for 420 feet. All along this passage there has been intensive digging for saltpeter as is evidenced by the holes and piles of dirt. Near the rear of each passage is a wet-weather stream that connects the two passages.

PLATE 11. Cooper Creek Cave or Foster's Cave (Opposite)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CAVE NAME: Dragstrip Cave

LATITUDE: 36° 36' 17" N.; LONGITUDE: 87° 21' 25" W.

OWNER: Clyde Kennedy

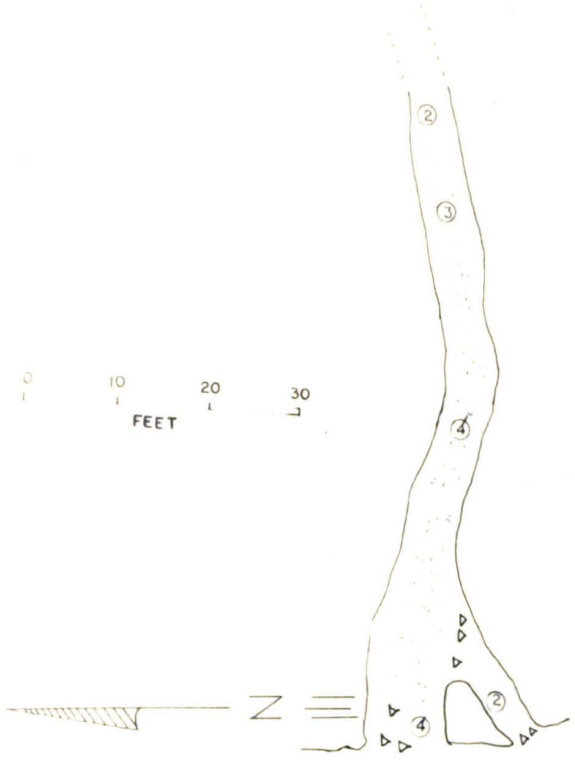
LOCATION: Dragstrip Cave is 700 feet west and slightly south of the Clarksville Dragway and thirty feet from the crest of a sixty foot limestone bluff that faces west at an elevation of 500 feet.

QUADRANGLE: Clarksville, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: This cave can be approached by climbing down the bluff until a path that runs along the bluff is reached. The owner had goats that used this path and also must have stayed around the cave. Earlier the cave was used for camping and there is still camping equipment lying around. This is one of the driest caves in the study area.

PLATE 12. Dragstrip Cave (Opposite)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ENT.

CAVE NAME: Durham Cave

LATITUDE: 36° 30' 30" N.; LONGITUDE: 87° 10' 26" W.

OWNER: Jesse R. Durham

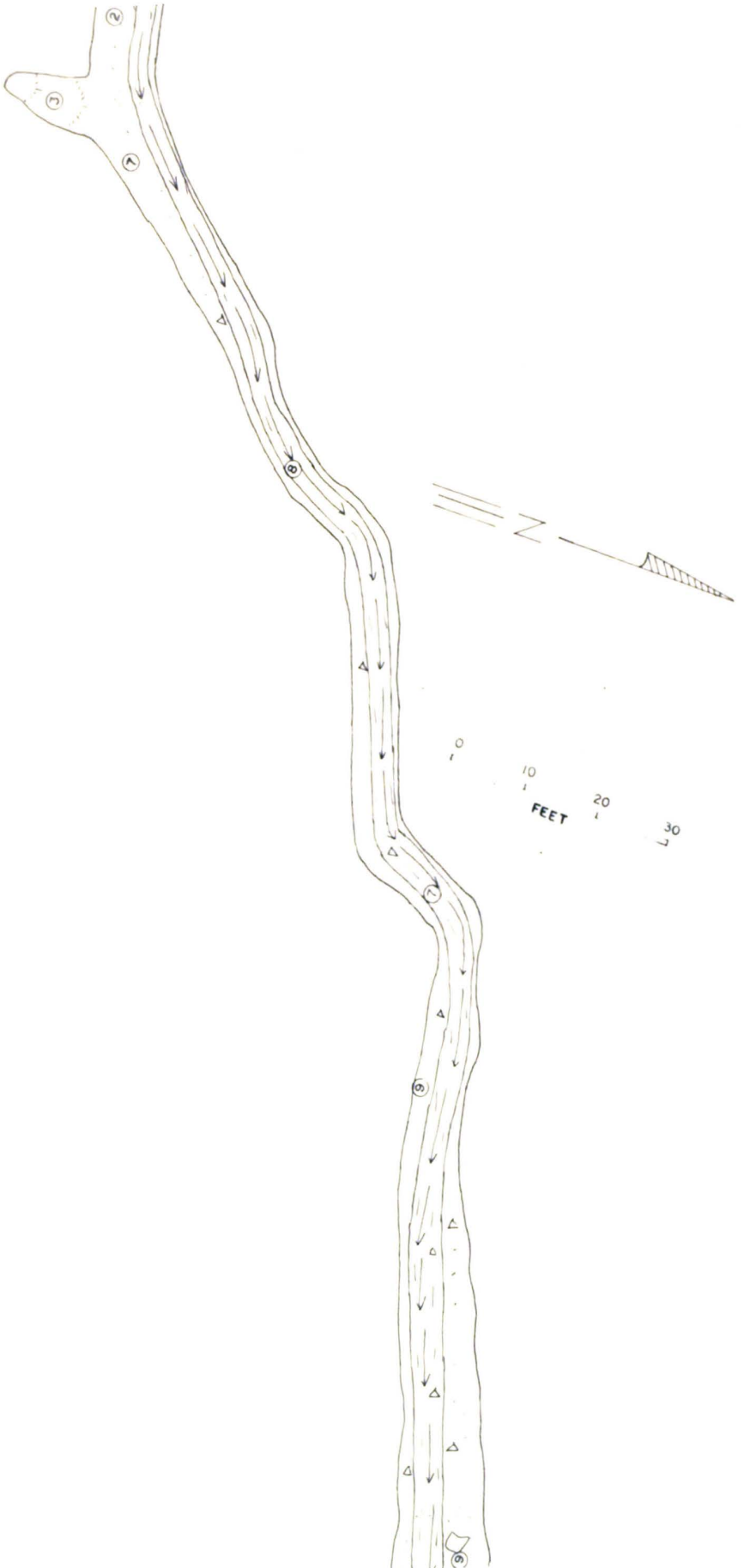
LOCATION: Durham Cave is 2 and 6/10 miles east of Sango, on the west side of Coon Creek, 200 feet north of the Trough Spring Road, at an elevation of 450 feet (Barr, 1961).

QUADRANGLE: Sango, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: Durham Cave is a small wet weather stream cavern, well known because it is the site of frequent picnics.

PLATE 13. Durham Cave (Opposite)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CAVE NAME: Glover's Cave

LATITUDE: 36° 42' 14" N.; LONGITUDE: 87° 19' 48" W.

OWNER: R. D. and Robert Glover

LOCATION: Glover's Cave is 5 miles west of Trenton, Kentucky in southeast Christian County, just west of the Todd County line, 3 miles north of the Tennessee State line and 50 yards east of the West Fork Creek at an elevation of 500 feet.

QUADRANGLE: Hammacksville, Kentucky-Tennessee

NEAREST POST OFFICE: Trenton, Kentucky

DESCRIPTION AND ACCOUNT: The cave has two entrances; a main entrance, thirty-one feet wide, and a smaller entrance 540 feet north of the main one. During wet weather a small stream flows from the small entrance. The main entrance opens into a large area 152 feet long and seventy-two feet wide. The cave extends from the main entrance northeast for several miles. Vietzen (1956) gives an interesting account of the history of the cave.

39

CAVE NAME: Grizzard Cave

LATITUDE: 36° 30' 43" N.; LONGITUDE: 87° 39' 43" W.

OWNER: Jake Grizzard

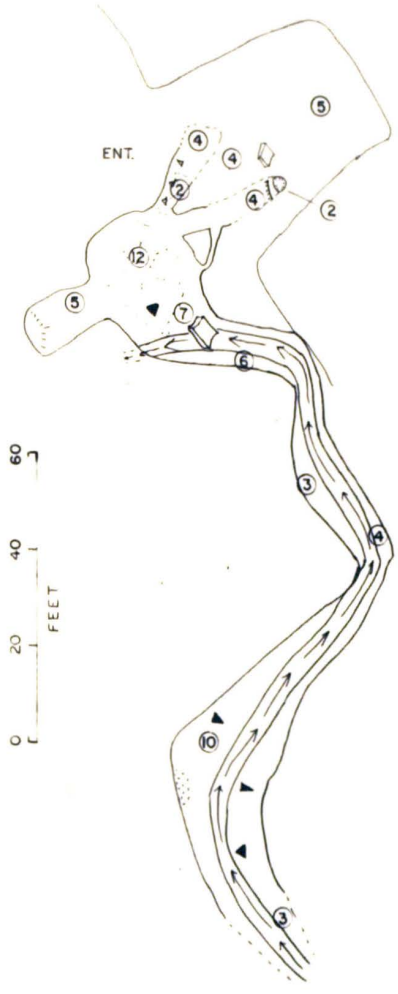
LOCATION: The cave is 3/4 mile east of Indian Mound Road and 110 feet north of Cross Creek Road at an elevation of 455 feet.

QUADRANGLE: Indian Mound, Tennessee

NEAREST POST OFFICE: Indian Mound, Tennessee

DESCRIPTION AND ACCOUNT: The entrance of the cave is fifty feet wide and four feet high. On the right side a few feet from the mouth is a small hole two feet in diameter. This leads to the main portion of the cave, where there is a small stream with flowstone and other formations.

PLATE 14. Grizzard Cave (Opposite)


ENT.
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60
FEET
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CAVE NAME: Kates' Cave

LATITUDE: 36° 30' 48" N.; LONGITUDE: 87° 39' 02" W.

OWNER: Nathan Kates

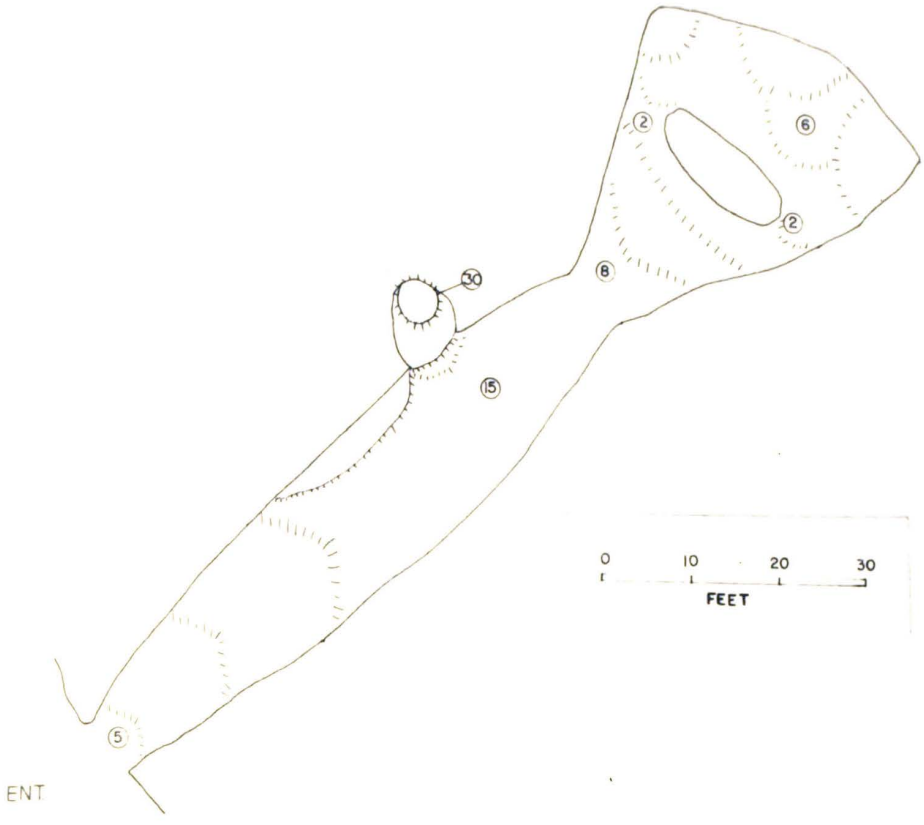
LOCATION: Kates' Cave is 1 and 3/10 miles east of Indian Mound Road and ninety feet north of Cross Creek Road at an elevation of 500 feet.

QUADRANGLE: Indian Mound, Tennessee

NEAREST POST OFFICE: Indian Mound, Tennessee

DESCRIPTION AND ACCOUNT: This cave has an entrance five feet high and six feet wide from which slopes a passage northwest. Seventy feet back the floor slopes up and the cave forks into two passages which reconnect.

PLATE 15. Kates' Cave (Opposite)


2
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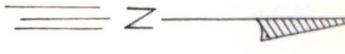
FEET


N

CAVE NAME: Killebrew Cave

LATITUDE: 36° 33' 54" N.; LONGITUDE: 87° 12' 32" W.

OWNER: Riggs Hayes

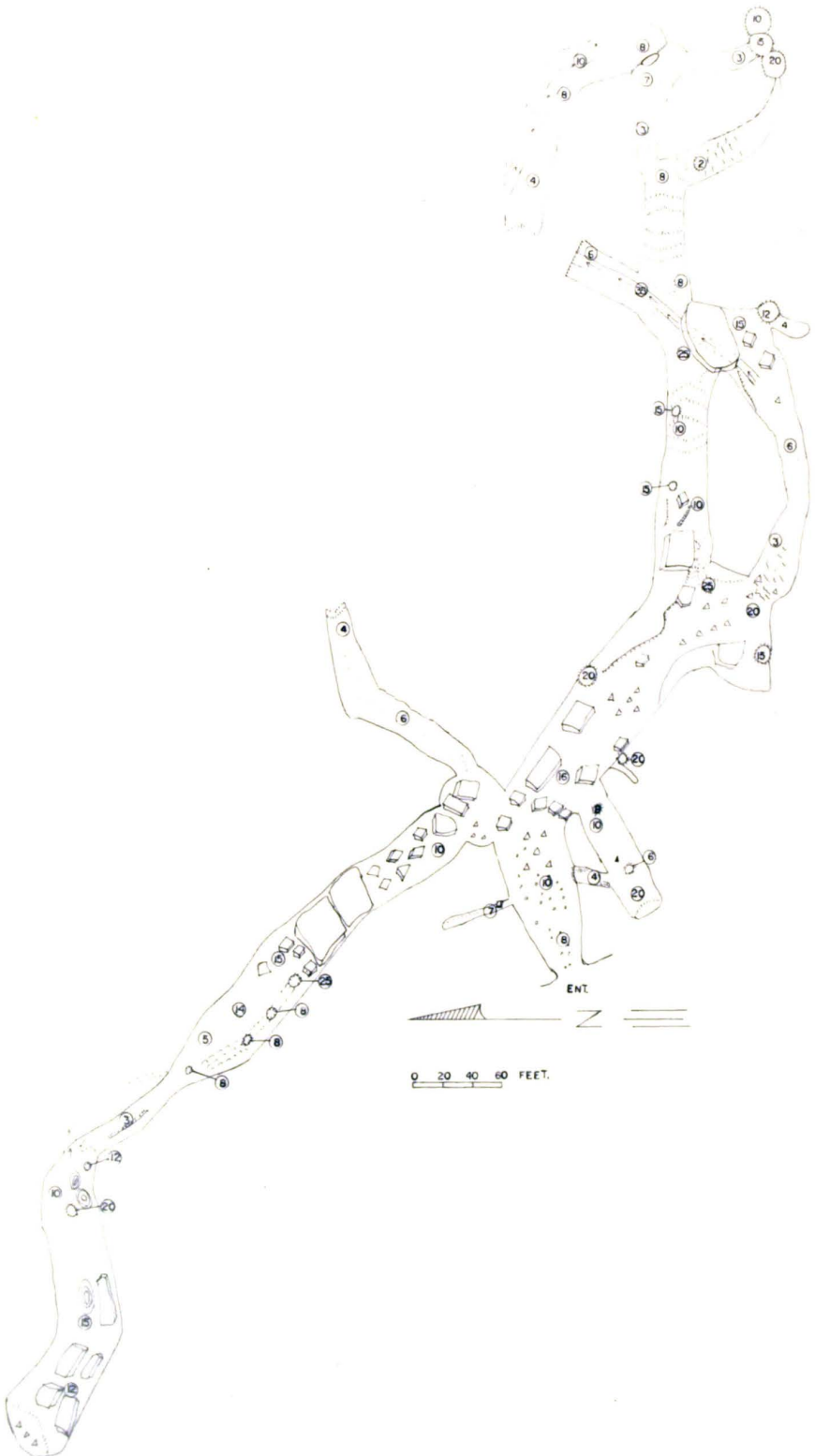
LOCATION: Killebrew Cave is in the Rossview Community, a mile east and slightly north of Whites Chapel, 800 feet south of the Rossview Road, and half a mile north of Red River, at an elevation of 460 feet. (Barr, 1961).

QUADRANGLE: Sango, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The cave opens in the bottom of a wooded sink that contains some decaying logs, old farm machinery, and assorted junk. The cave is characterized by a great deal of breakdown, considerable moisture, and large clay fills. The investigator found two dead foxes in the cave about 100 feet from the entrance, plus two human skeletons. The streams in this cave are wet weather streams only.

PLATE 16. Killebrew Cave (Opposite)


ENT.
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0 20 40 60 FEET.

CAVE NAME: Kraft Street Quarry

LATITUDE: 36° 32' 34" N.; LONGITUDE: 87° 21' 16" W.

OWNER: Taylor Moore

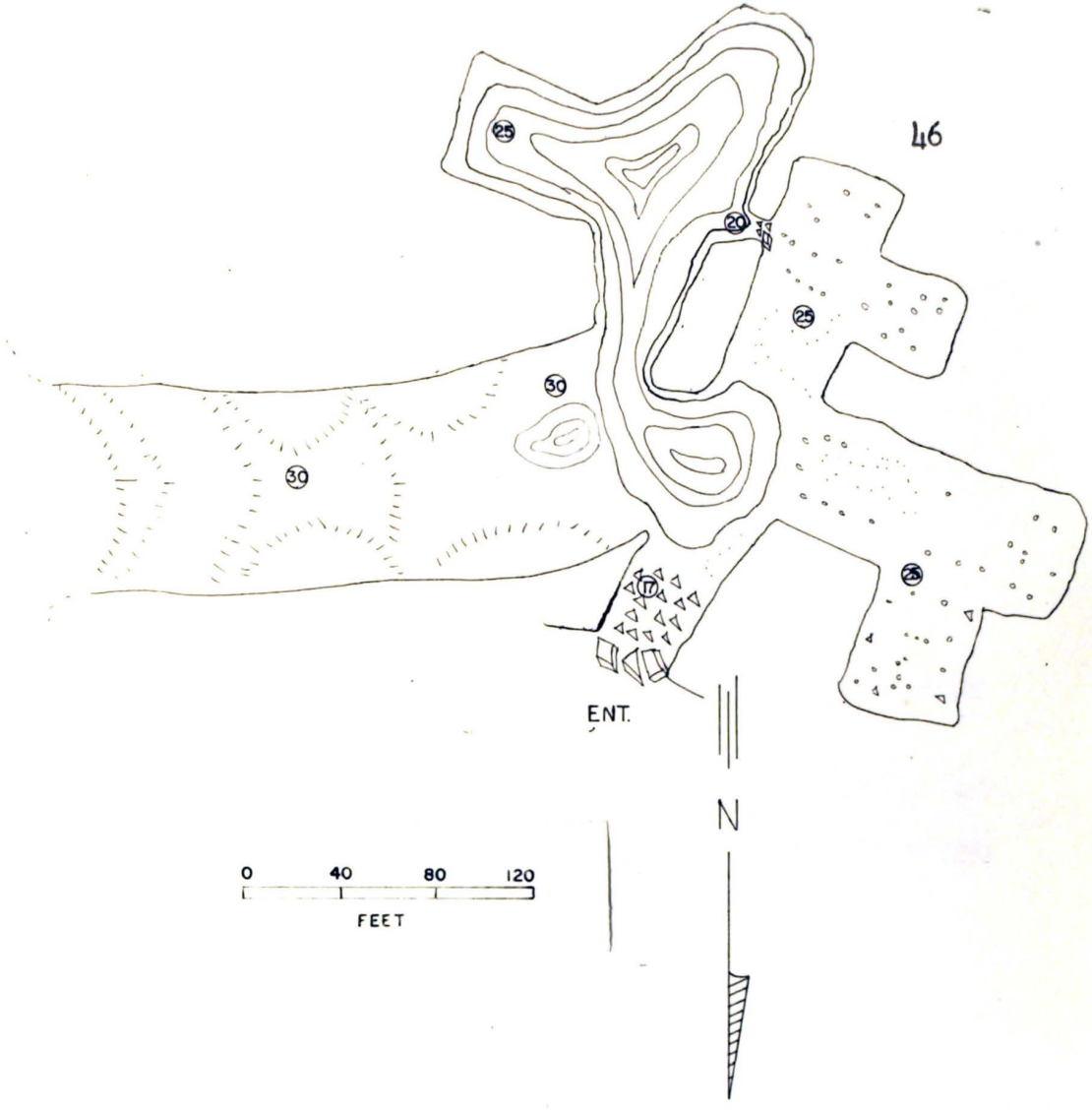
LOCATION: Two hundred feet south of Red River, 1,000 feet east of Tennessee Central Railroad and 600 feet north of Kraft Street at an elevation of 400 feet.

QUADRANGLE: Clarksville, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The large entrance is located on the south end of a quarry depression that has had a great deal of limestone removed from it. Part of the cave floor is covered with water that was found to get as cold as forty-five degrees F. The ceiling has fallen in recently in spots which is probably the reason the quarry is no longer used. The Big Brown Bat (Eptesicus fuscus) was the only bat found in this cave.

PLATE 17. Kraft Street Quarry Cave (Opposite)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FEET

CAVE NAME: Little West Fork Creek Cave

LATITUDE: 36° 35' 25" N.; LONGITUDE: 87° 23' 05" W.

OWNER: Murphy Chester

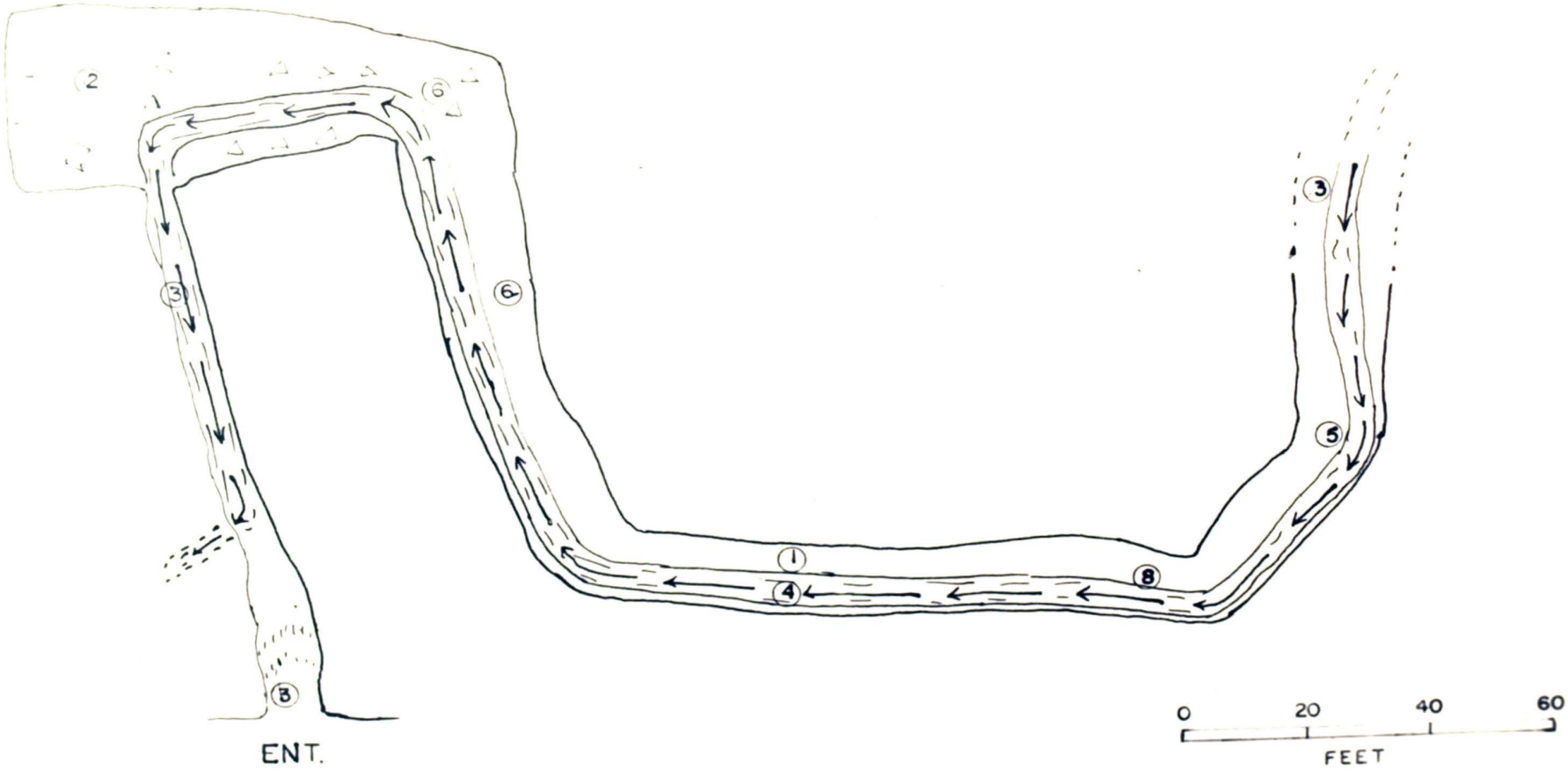
LOCATION: The cave is 3/10 mile east of Peacher's Mill Road on the south side of Little West Fork Creek at an elevation of 400 feet.

QUADRANGLE: New Providence, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The cave may be approached from the creek by swimming or by boat or by walking along the bank. The entrance is three feet high by six feet wide. From the entrance a slope leads down to a small stream that runs into Little West Fork Creek at another opening. Ninety feet from the entrance the cave opens into a larger space that is twelve feet high. The floor in this part is covered with broken rocks and mud.

PLATE 18. Little West Fork Creek Cave (Opposite)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FEET
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CAVE NAME: McWhorter's Cave

LATITUDE: 36° 21' 01" N.; LONGITUDE: 87° 27' 27" W.

OWNER: Luther McWhorter

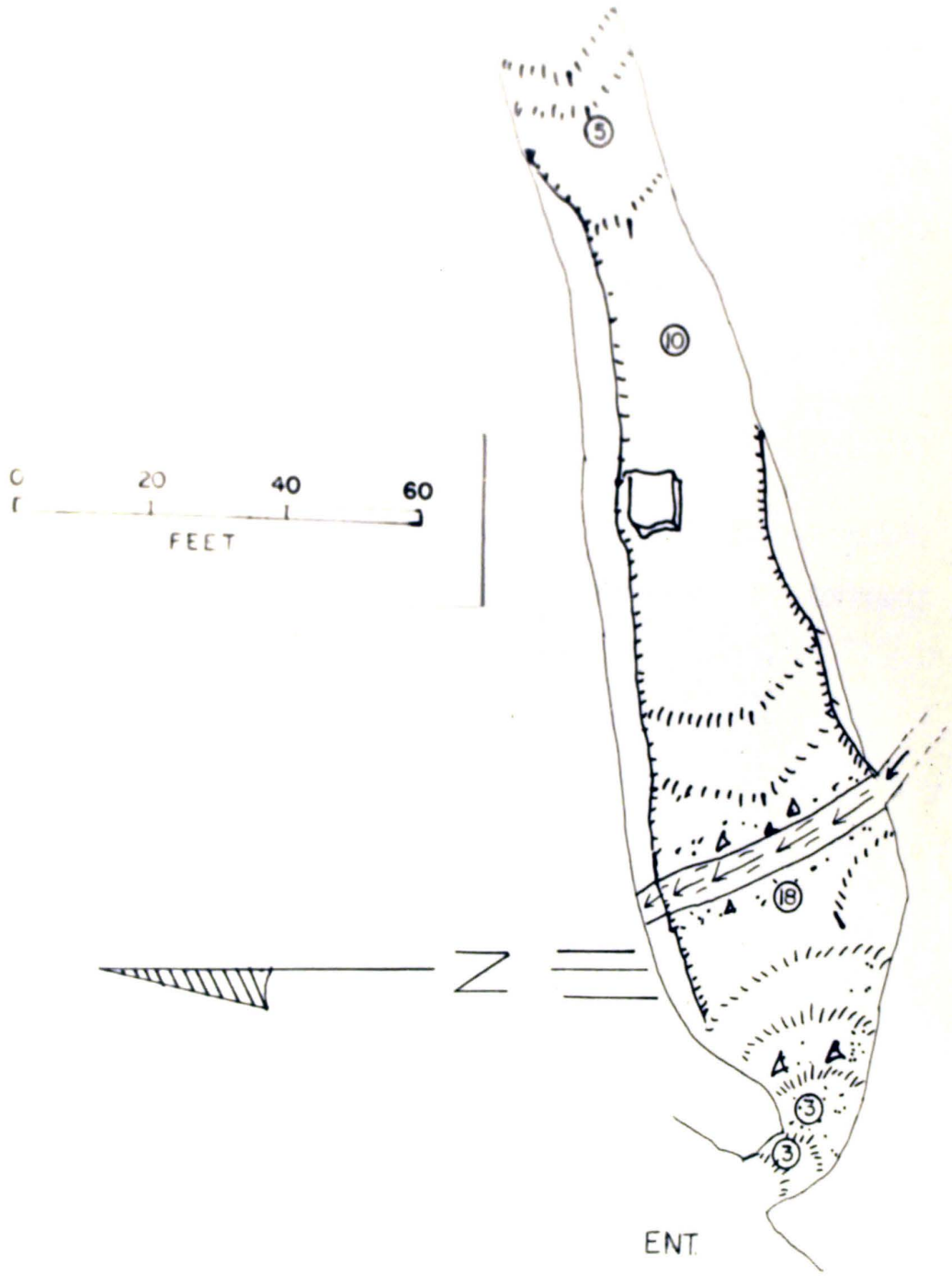
LOCATION: The cave is 1,200 feet east of Bryant Hollow Road on the south slope across from the McWhorter house.

QUADRANGLE: Slayden, Tennessee

NEAREST POST OFFICE: Cunningham, Tennessee

DESCRIPTION AND ACCOUNT: McWhorter's Cave has a small entrance that opens on the east side of a wooded sink. There is a small wet weather stream in the cave flowing from south to north. The cave becomes impassable at a clay fill, but it seems possible that beyond this the cave again becomes passable.

PLATE 19. McWhorter's Cave (Opposite)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CAVE NAME: Meriwether Cave

LATITUDE: 36° 38' 28" N.; LONGITUDE: 87° 19' 35" W.

OWNER: H. T. Meriwether

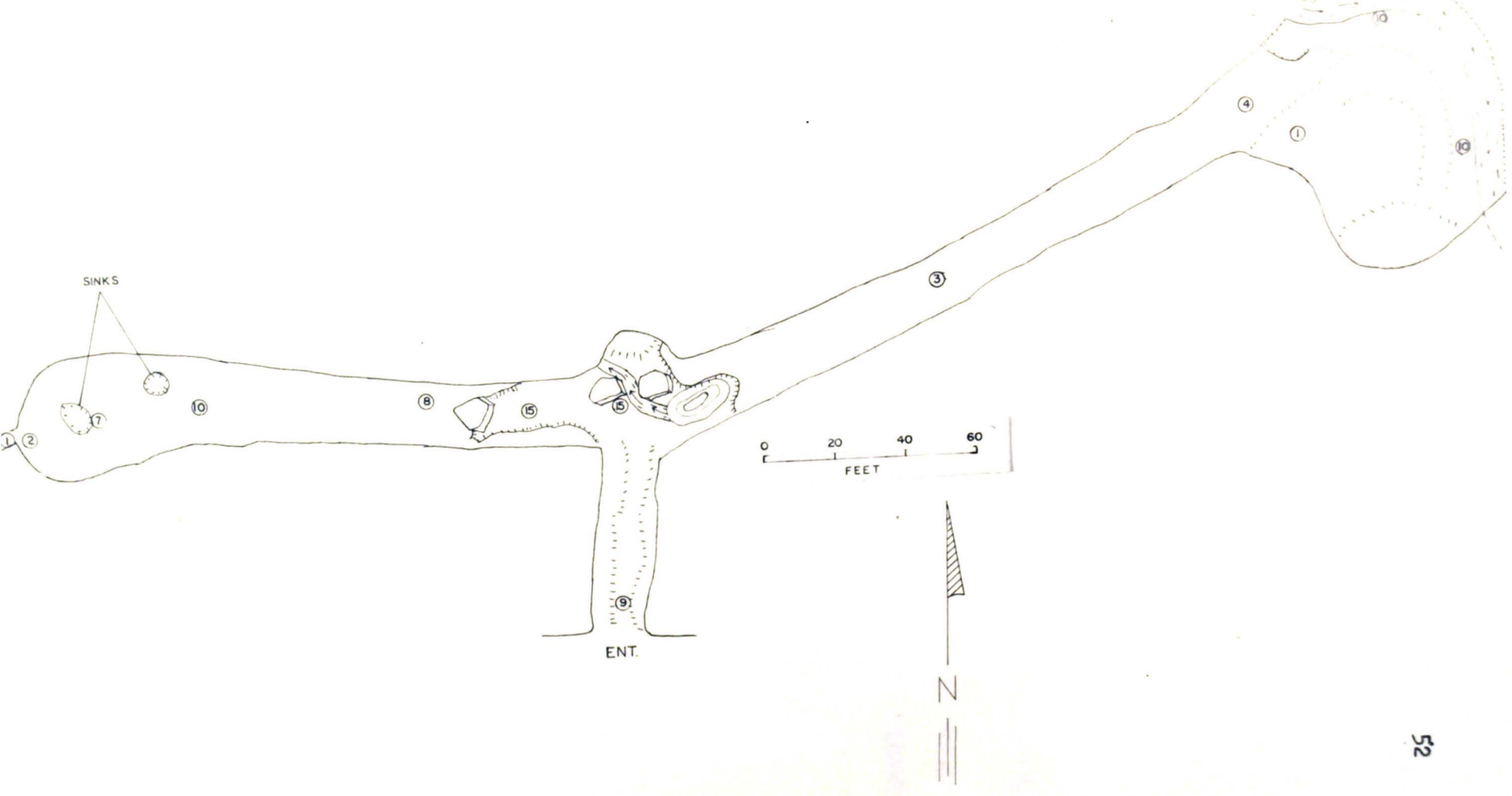
LOCATION: Meriwether Cave is west of the Trenton Highway and 1 and 1/10 mile north of Peacher's Mill Road at an elevation of 450 feet.

QUADRANGLE: Hammacksville, Kentucky-Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The cave mouth is nine feet high and sixteen feet wide, opening beneath a limestone outcropping at the base of a wooded sink. From the entrance the cave leads south and seventy feet from the mouth it forms a T, one fork going west and the other going northeast. At the center of the T a small stream appears and flows northwest and disappears under a limestone ledge. A small catfish and several crayfish were found in the water. During heavy rains the cave floods all the way to the ceiling, as indicated by the mud and debris.

PLATE 20. Meriwether Cave (Opposite)


SINKS
ENT.
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CAVE NAME: Peacher's Mill Road Cave

LATITUDE: 36° 35' 28" N.; LONGITUDE: 87° 23' 26" W.

OWNER: Mack Clardy

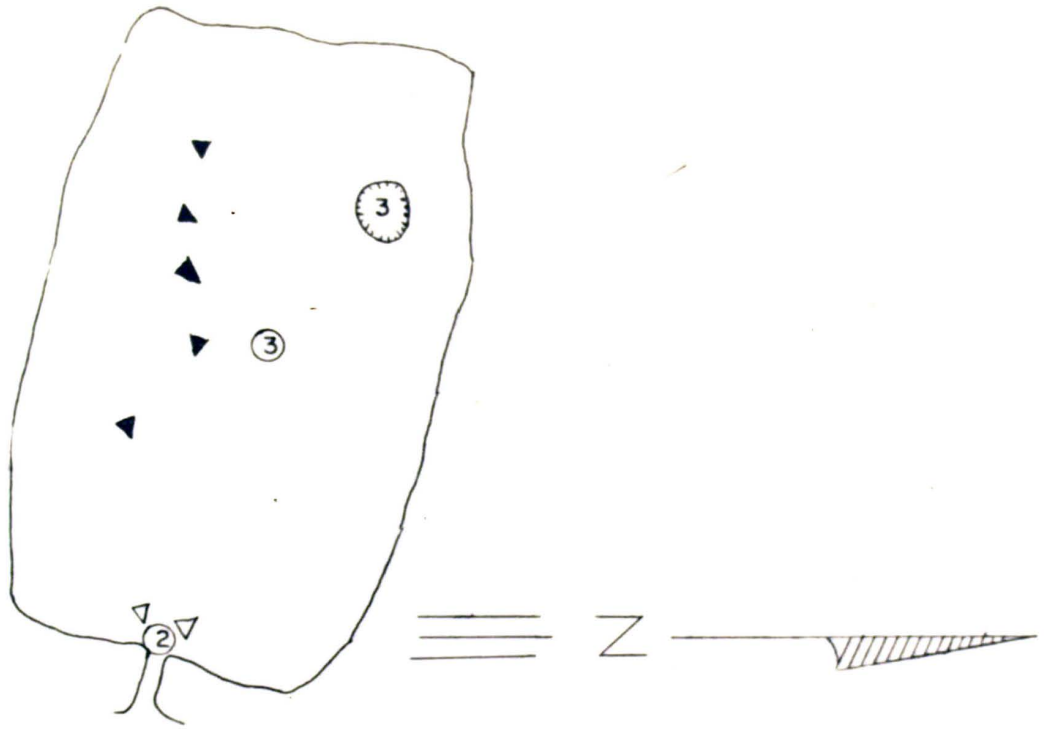
LOCATION: The cave is 100 years south of the Little West Fork Creek Bridge and ten yards west of Peacher's Mill Road at an elevation of 420 feet.

QUADRANGLE: New Providence, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: This small cave was opened up when a roadcut for Peacher's Mill Road was made. The small entrance is two feet high and two feet wide. There are many formations and a lot of moisture. No bats were found in the cave.

PLATE 21. Peacher's Mill Road Cave (Opposite)



10 20 30
FEET

CAVE NAME: Porter's Bluff Cave

LATITUDE: 36° 31' 37" N.; LONGITUDE: 87° 20' 03" W.

OWNER: Louis Gauchat

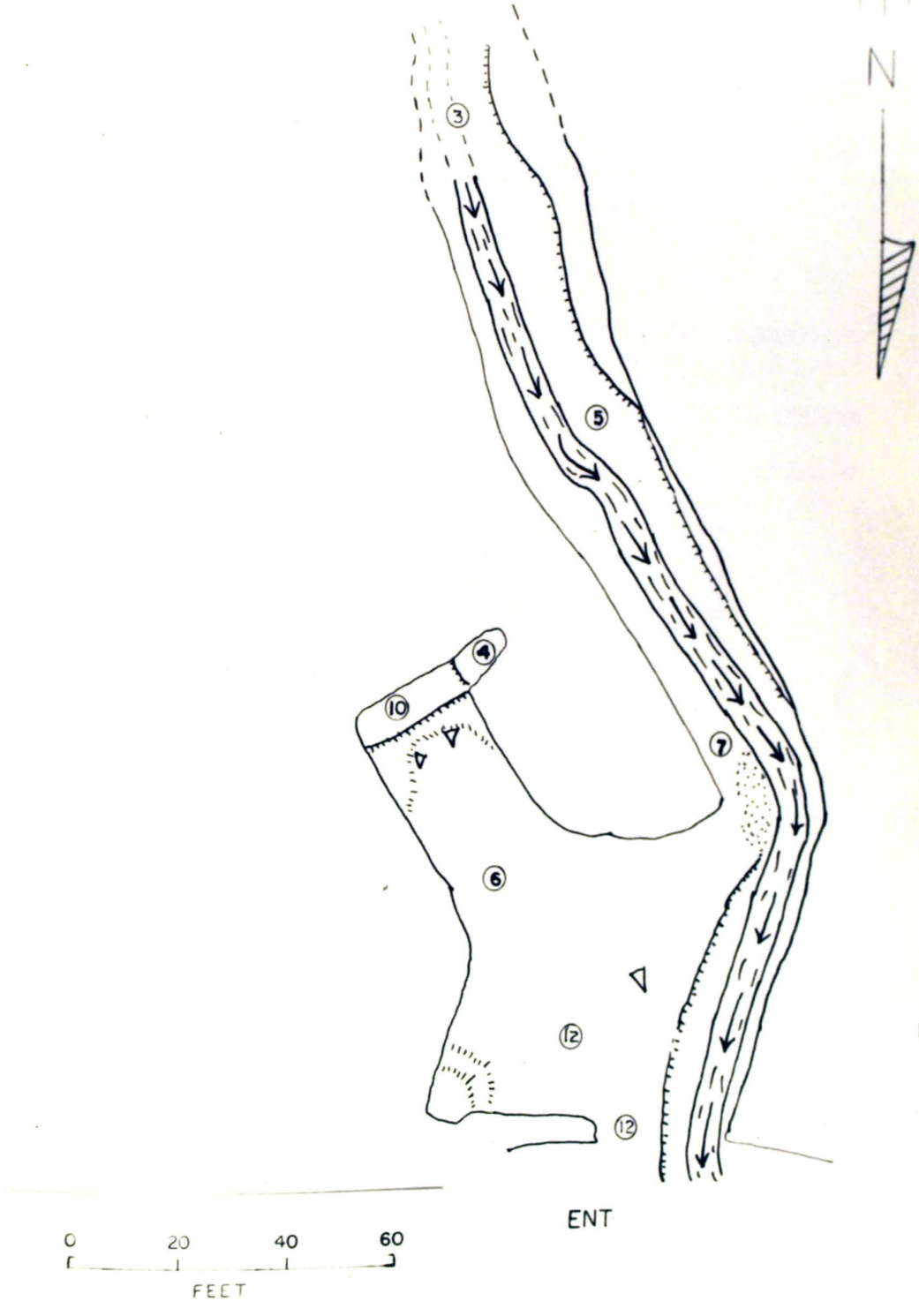
LOCATION: The cave is 2,250 feet north of Madison Street in Clarksville and 150 feet south of Red River at an elevation of 400 feet. The entrance faces north at the base of a limestone bluff 30 feet high.

QUADRANGLE: Clarksville, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The mouth is twelve feet high and twenty-two feet wide. A small stream flows from the cave and empties into Red River. The cave may have been an Indian site due to its nearness to the river and the size of the entrance. Three small concrete dams have been built in the cave and apparently sewage is piped into the stream from the houses on the bluff above.

PLATE 22. Porter's Bluff Cave (Opposite)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40
60
FEET

CAVE NAME: Red Bluff Cave

LATITUDE: 36° 31' 47" N.; LONGITUDE: 87° 24' 35" W.

OWNER: A. J. Darnell

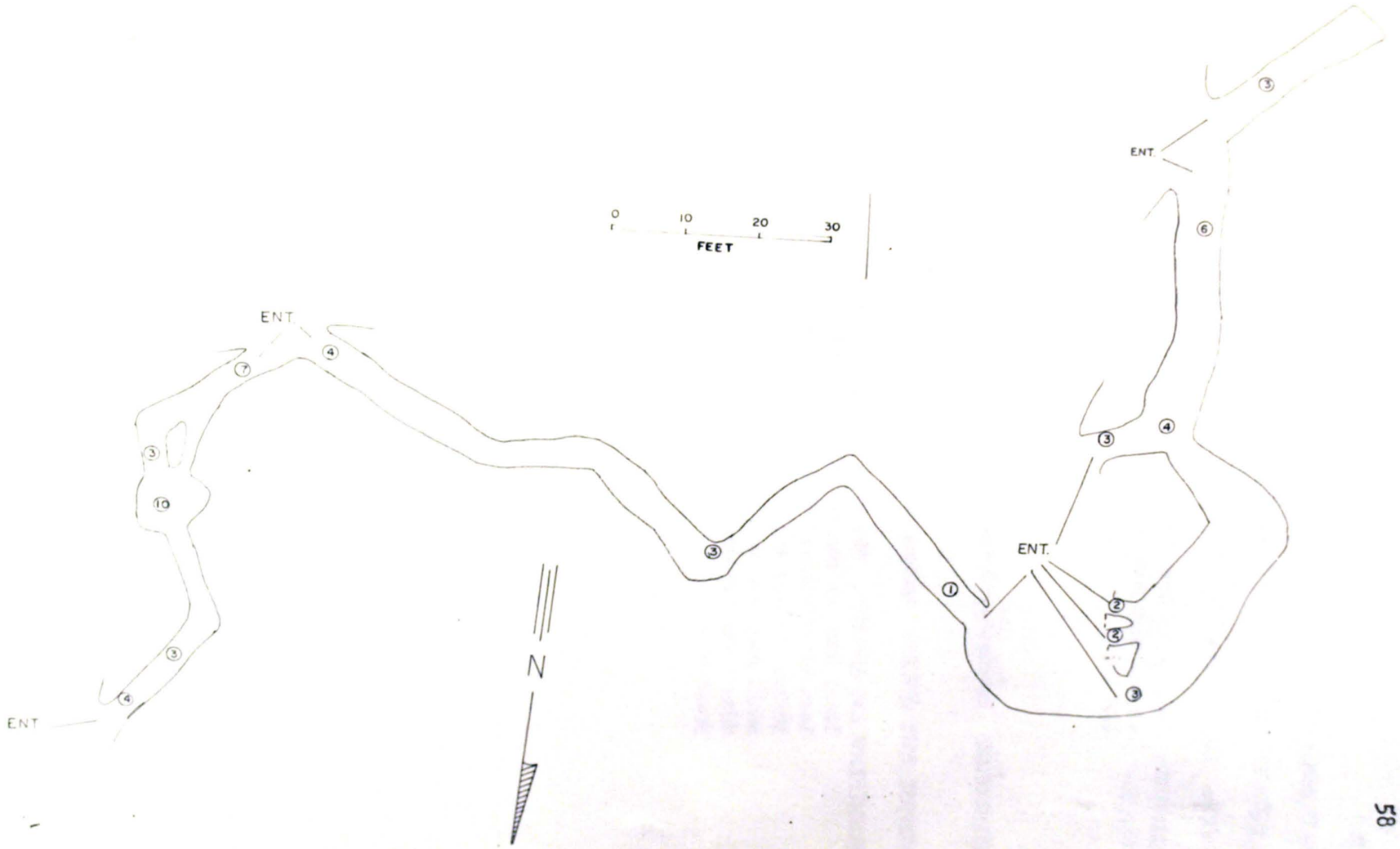
LOCATION: Red Bluff Cave overlooks the north bank of the Cumberland River and is 1 and 9/20 mile south of State Highway 79 at an elevation of 500 feet.

QUADRANGLE: New Providence, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The caverns are fifty feet above the river and forty feet below the top of the bluff. The bluff here is catacombed with small passages, all of which are so shallow or near the outside that there is little temperature difference between the inside and the outside. This should have been an excellent place for Indians because of the proximity of the river below and the high vantage point afforded here.

PLATE 23. Red Bluff Cave (Opposite)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4
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2
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3

CAVE NAME: Ringtail Cave

LATITUDE: 36° 24' 20" N.; LONGITUDE: 87° 11' 01" W.

OWNER: Elton Watts

LOCATION: This small cave is 1 and 1/10 miles east of Henrietta on the west bank of Half Pone Creek at an elevation of 450 feet.

QUADRANGLE: Henrietta, Tennessee

NEAREST POST OFFICE: Ashland City, Tennessee

DESCRIPTION AND ACCOUNT: The cave is called Ringtail Cave by the local hunters due to the number of raccoons that have been taken there. When it was visited in the spring a Turkey Vulture was disturbed and seemed to fill the small entrance as it made its escape. Below the small dome a few bat droppings were seen but no bats were present.

PLATE 24. Ringtail Cave (Opposite)


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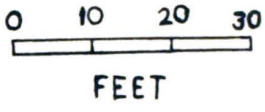

0 10 20 30
FEET

CAVE NAME: Saltpeter Cave

LATITUDE: 36° 20' 13" N.; LONGITUDE: 87° 13' 33" W.

OWNER: Atlas Justice

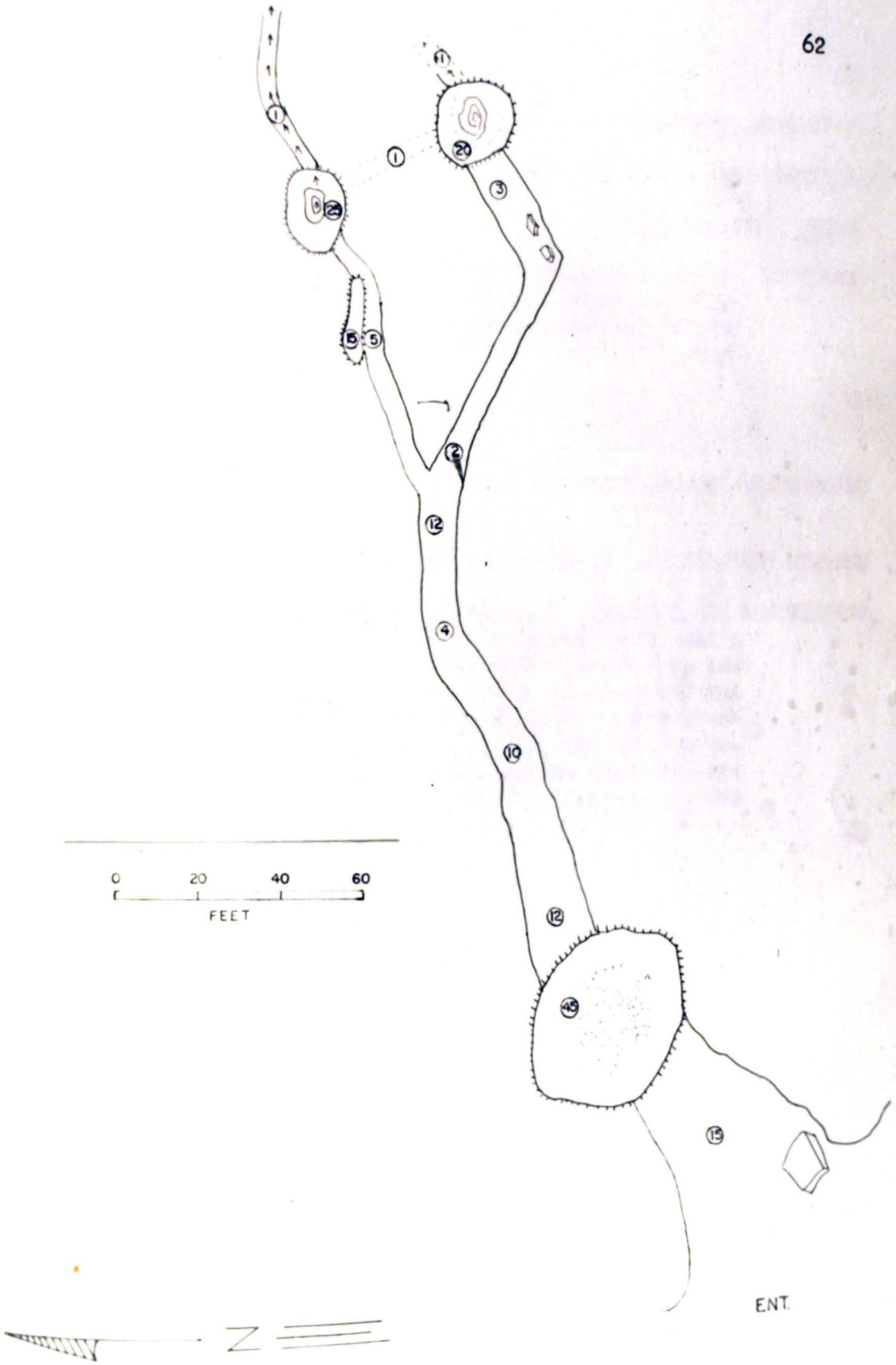
LOCATION: The cave is 1.5 miles southwest of Neptune, in the north wall of the valley of the Cumberland River, just north of the Tennessee Central Railroad tracks, at an elevation of 480 feet (Barr, 1961).

QUADRANGLE: Cheatham Dam, Tennessee

NEAREST POST OFFICE: Neptune, Tennessee

DESCRIPTION AND ACCOUNT: The Neptune Saltpeter Cave mouth is sixteen feet high and forty-five feet wide. The entrance faces west. Sixty feet from the entrance a large domed room, forty-five feet high and fifty feet in diameter serves as the site for a nursery colony of Myotis grisescens. Northeast of the domed room the cave progresses to a fork that has two passages. Each passage ends in a small domed room and the two domes are connected by a very low-ceilinged crawlway.

PLATE 25. Saltpeter Cave (Opposite)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CAVE NAME: Silvey Cave

LATITUDE: 36° 33' 26" N.; LONGITUDE: 87° 12' 40" W.

OWNER: Mike Silvey

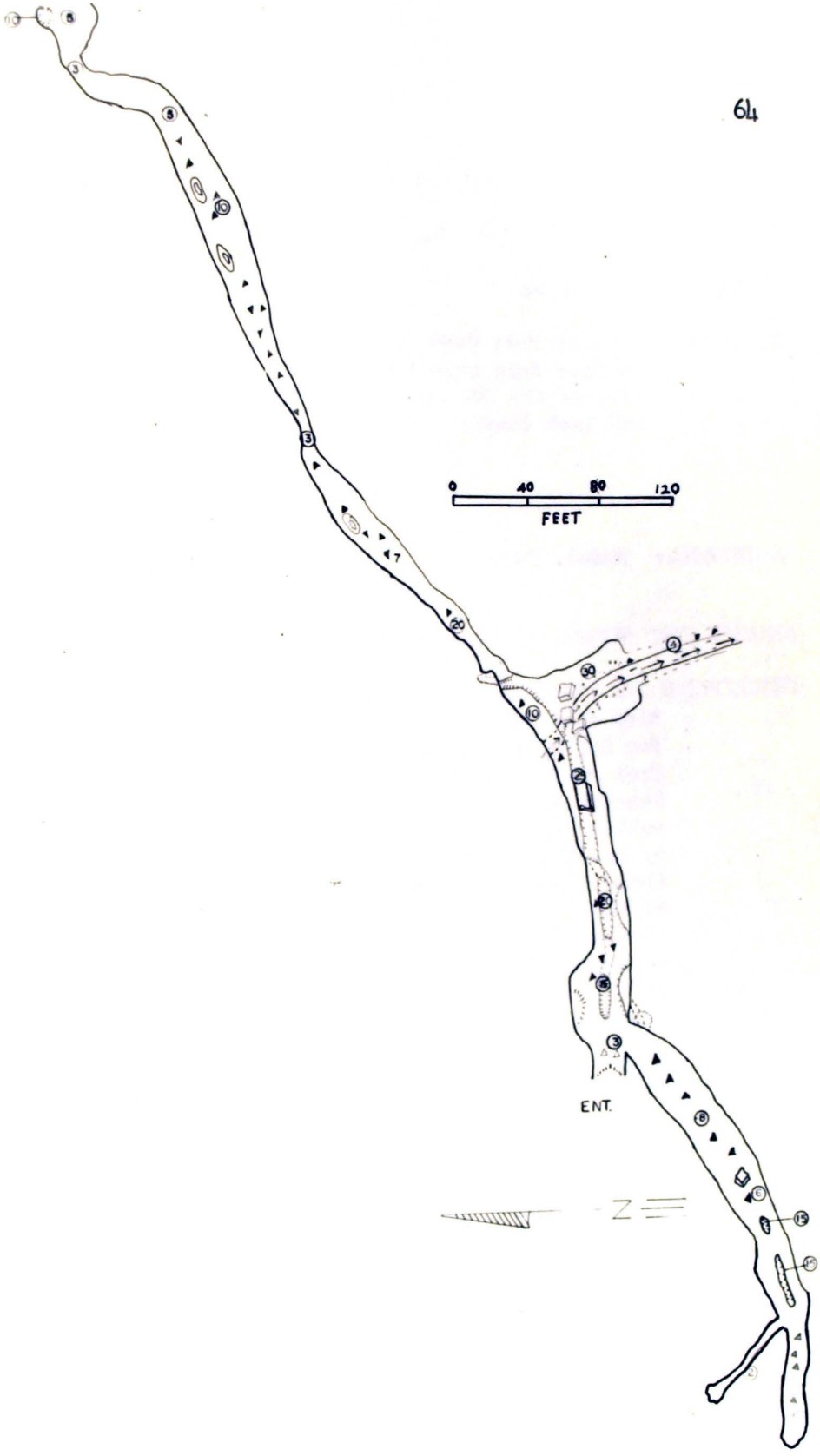
LOCATION: Silvey Cave is in the Rossview Community, 5,000 feet east and slightly south of Whites Chapel and 3,500 feet south of Rossview Road at an elevation of 490 feet.

QUADRANGLE: Sango, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The entrance opens at the south end of a long fissure that runs north and south. Just beyond the entrance the cave branches into two passages, one running southeast and the other northeast. This cave has the most interesting and beautiful formations of any cave investigated in the study area. In the rear of the left hand passage, bones from deer and other animals and old shotgun shell casings were found.

PLATE 26. Silvey Cave (Opposite)


0 40 80 120
FEET
ENT.

CAVE NAME: Tobacco Port Cave

LATITUDE: 36° 38' 45" N.; LONGITUDE: 87° 52' 57" W.

OWNER: J. J. Kingins

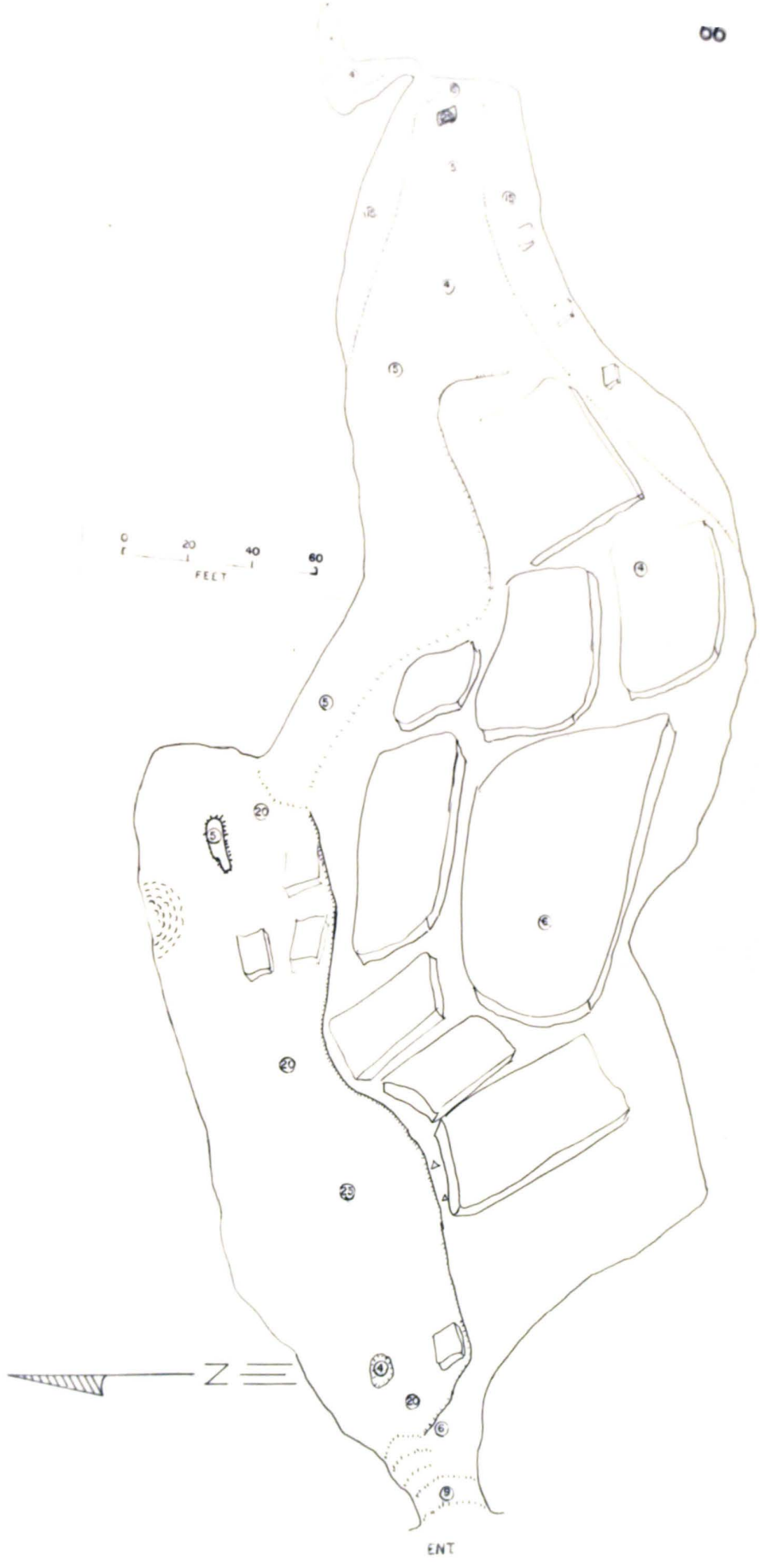
LOCATION: Tobacco Port Cave is 45/100 mile east-northeast of Tobacco Port near the head of a hollow, 400 feet east of the Shelby Creek Road, at an elevation of 445 feet (Barr, 1961).

QUADRANGLE: Model, Tennessee

NEAREST POST OFFICE: Bumpus Mills, Tennessee

DESCRIPTION AND ACCOUNT: The entrance is twenty feet wide and nine feet high and slopes downward at an angle of 30° for thirty feet. The cave extends eastward for 420 feet and is 175 feet wide at its widest point. Extensive digging associated with quests for Indian relics has been undertaken in this cave as evidenced by the large holes scattered throughout. A large flowstone formation is present near the middle of the cave on the north side. During wet weather there is a pool of water at the base of the flowstone. A small opening on the north side of the cave at the rear leads into a small passage that has a small stream of water running eastward.

PLATE 27. Tobacco Port Cave (Opposite)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FEET
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ENT

CAVE NAME: Roy Woodard Cave

LATITUDE: 36° 33' 46" N.; LONGITUDE: 87° 18' 06" W.

OWNER: Roy Woodard

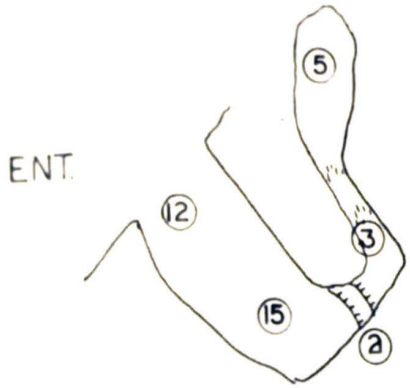
LOCATION: Roy Woodard Cave is 400 yards south of St. Bethlehem and 6/10 mile east of State Highway 79 at an elevation of 495 feet.

QUADRANGLE: Clarksville, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The entrance is at the base of a large sink on the southeast side. The sink is a local dump and much debris has washed into the small cave. The long tail salamander (Eurycea longicauda longicauda) was seen in this cave.

PLATE 28. Roy Woodard Cave (Opposite)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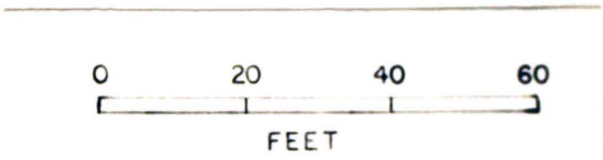

0
20
40
60
FEET

CAVE NAME: Woodson Cave

LATITUDE: 36° 31' 01" N.; LONGITUDE: 87° 12' 12" W.

OWNER: R. E. Woodson

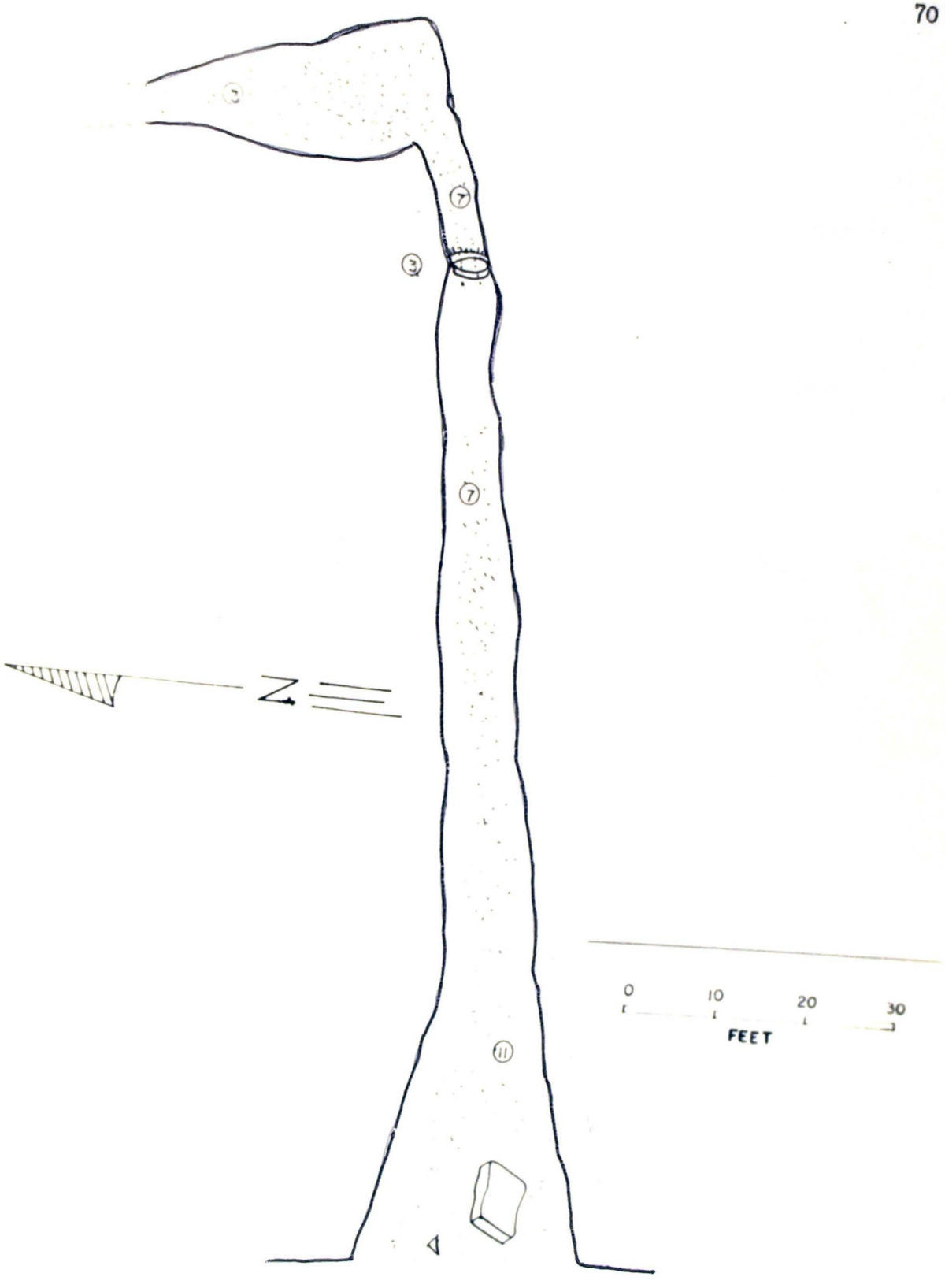
LOCATION: Woodson Cave is one and 2/10 miles northeast of Sango, on the east side of a road that runs north between the Trough Spring Road and State Highway 76, in a sink, at an elevation of 550 feet (Barr, 1961).

QUADRANGLE: Sango, Tennessee

NEAREST POST OFFICE: Clarksville, Tennessee

DESCRIPTION AND ACCOUNT: The cave entrance is twelve feet high and twenty-five feet wide. A wet weather stream empties into it and at the rear of the cave, that continues eastward for 115 feet, there is a large amount of debris.

PLATE 29. Woodson Cave (Opposite)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CHAPTER III

METHODS AND MATERIALS

The study of bats, as compared to some of the other major animal groups, received little attention until recent years. Consequently, many of the methods and materials used in this study are of recent vintage. A discussion of some of these techniques and devices follows.

Collection of Hibernating Bats

Hibernating bats that were within easy reach were simply plucked from the ceiling and dropped into a container. Those out of reach were removed by using a jointed cane pole with a piece of wire bent in the form of a ring, four inches in diameter, taped firmly to but extending beyond one end of the fifteen foot pole. Collecting was accomplished by bringing the ring along the underside of the bat and up against its feet as it clung to the wall or ceiling. This was done in such a manner that the bat either exchanged its footing from the wall or ceiling to the ring or lost its hold and dropped to the collector below. Using this method, bats could easily be collected from a twenty foot ceiling.

When collecting hibernating bats from clusters, it was commonly found that some of the bats would become aroused before the complete cluster could be removed. To overcome this, a bat picker was made from an eight foot piece of one-half inch aluminum

tubing. Number ten wire was pushed through the tubing and one end was made into a loop. The other end was attached to two short pieces of baling-wire, each bent double, to form four grasping prongs. When the loop was pulled at the lower end, the grasping tongs were partially pulled into the tube, causing them to close and secure the bat. The device, though effective, was time-consuming to use.

When bats were removed from ceilings or walls over a stream, the dislodged bats were allowed to fall into an insect net.

Bats found in fissures and cracks that were inaccessible by hand, were collected by grasping with ten-inch tweezers.

Collection of Active Bats

Two methods were used in collecting bats in flight. A mist net, similar in appearance to a woman's hair net, but much larger, was stretched across the cave entrance. When bats encountered the net, they became entangled. During heavy flights the mist net presented a serious drawback, for the entangled bats could not be removed fast enough to prevent their seriously damaging the net by chewing large holes in it during their efforts to escape.

Another trap, a modification of Constantine's (1958) trap, was developed. It is rectangular in appearance, consisting of two one-half inch by six foot sections of aluminum pipe, used for sides, and two eight foot sections of this pipe, reinforced with two by two boards, used for top and bottom. Strands of six pound test monofilament nylon fishing line are stretched vertically from top to bottom, spaced one inch apart. The line is attached to the top

by a knot and to the bottom by a small, light spring that is stretched and hooked to an eye screw. The spring simultaneously furnishes attachment and maintains tension on the line. A semi-cylindrical oilcloth collecting container is placed beneath the trap. When a bat strikes the monofilament lines, which it usually does not detect before it is too late to avoid them, it is knocked off balance and flutters helplessly to the container below. The container is lined with baffle sleeves on the sides and ends in such a manner that once the bat falls into the trap it cannot crawl out. This trap was most effective when used at the cave entrance so that the only escape available was through the trap. This was insured by restricting the exit with plastic or canvas over the other parts of the entrance. The primary disadvantage of this trap was that many bats perceived it and did not attempt to pass through it, while others struck the trap at such speed that they either recoiled from the lines or passed between them. Still a greater percentage of bats was caught by this method than by the mist net, and it was much more convenient to use.

The Banding Process

The marking of bats as a means of studying their movements, longevity, etc., is a recent innovation. A history of banding may be obtained by referring to Myers (1961).

Hitchcock (1957) states that the banding of bats in the United States began in a very small way in 1916, using bird bands. By the end of 1951, according to a survey by Mohr (1963), an estimated 67,403

bats had been banded in North America. During the next four years, 1952-1955, bat banding expanded rapidly. The Fish and Wildlife Service which supplies bands for the continent reported that for this period 92,844 bands were issued. Of this number, over 36,000 bands were issued in 1955 alone.

In all the earlier American work United States Fish and Wildlife Service size 0 aluminum bands were used. Banders using size 0 bands have recognized that this size is satisfactory on smaller species such as Pipistrellus subflavus, Myotis lucifugus, and Myotis sodalis, but wing injuries invariably occur if this size is used on larger bats. Trapido and Crowe (1946) suggested that the band be allowed to move freely on the forearm. Hitchcock (1957), concerned about the damage caused by conventional American bands, suggested use of two types of bands designed in Europe. One was a conventional band with rounded corners employed by Pieter Bels in the Netherlands, (Bels, 1952, quoted by Myers, 1964); the other, a band used by Willi Issel in Germany, had the corners rounded and a small lip turned up at either end. Hitchcock's suggestions led to the U. S. Fish and Wildlife Service manufacturing and distributing 40,000 German type bands to various American banders for experimental purposes. A comparative study of the standard #0 and #1 bird bands and the German band by Herreid, et. al. (1960) demonstrated that the German bat band caused fewer injuries than the conventional bird bands.

All of the 4,627 bats of six species banded in Montgomery County were marked with U. S. Fish and Wildlife Service serially

numbered aluminum bands (Table II). Initially bats were individually marked by code-clipping of the toes and by applying colored celluloid bands in different combinations to the wings. Both of these methods were inferior to marking with aluminum bands. The code-toe-clipping method could be used on only a relatively few individuals, due to the limited number of combinations possible, and was possibly harmful to the bat because of blood loss. The colored celluloid bands could easily be chewed off by the bat.

Depending upon the species being banded, #0 or #2 bands were used. As the study progressed, several of the recaptured bats exhibited swollen wings because of improperly applied bands. When a bat with a sore wing was found, the band was loosened and correctly replaced or the band was applied to the other wing.

Banding Techniques

Bands were opened with a variety of instruments. Number 0 bands were opened by forcing them over the blade of a small knife or by pushing them down over a dissecting probe until the right spread was attained.

Number 2 bands were opened by slipping them over the end of wire pliers that had the tips filed down to receive the band (Plate 30). When the plier jaws were spread, the band was forced to slip over the radius of a bat wing. After opening the band it was transferred to the band rack.

The #0 bands were placed in numerical sequence on straightened

TABLE II

NUMBERS, SPECIES, AND SEX COMPOSITION OF THE BATS BANDED FROM THE NORTHWESTERN HIGHLAND RIM OF TENNESSEE DURING 1964-65

Species	Males	Females	Total
Pipistrellus subflavus	344	148	492
Myotis lucifugus	668	369	1,037
Myotis grisescens	1,093	1,675	2,768
Myotis keenii	41	5	46
Myotis sodalis	126	120	246
Eptesicus fuscus	24	14	38
Total	2,296	2,331	4,627

PLATE 30. Equipment Used in Banding

clothes-hanger wire and the #2 bands in numerical sequence on the nails in the band rack. Thus, it was possible to band 100 females or males of a particular species without breaking a series of numbers. Not only was the banding process accelerated, but recording was facilitated and the chance of error was minimized.

All bats were carefully identified as to species and sex.

A container for opened bands, unopened packets of bands, banding tools, and band openers was devised using an army cartridge box, plywood, and twelve-penny nails (PLATE 30). The nails were arranged in rows from which they could be easily removed by sliding them in a groove out to the open end of the row. Each nail would hold eleven or twelve opened bands ready for use. Each row accommodated nine to eleven loaded nails and thus was suitable for a series of one hundred bands. Eleven rows in the rack held eleven hundred bands ready for use and in such a manner that when the day's banding was completed, a check of the number of the next band in each series enabled one to determine how many nails had been used for each sex of each species. The rack was removed from the box during banding and when a row of nails had been emptied, it was replaced with a new series of opened bands.

For closing the #2 bands, copper wire was wrapped around the jaws of a pair of hemostats in such a manner that the wire prevented the jaws from closing. By regulating the amount of wire on the hemostat jaws, they could be made to close just enough to close the bands properly. Number zero bands, being smaller, were closed by

squeezing the bands between the thumb and forefinger.

When the weather was suitable, the bats were banded outside near the entrance, in the sunlight, thus making identification easier. During inclement weather the banding was conducted inside the cave. When banding large numbers of bats, a portable, folding table was set up as a center for the banding operations.

One problem at the beginning of the study was to devise a method of handling large numbers of bats safely and quickly. It was relatively easy to collect hibernating bats in most caves, except for those on high ceilings, but once the bats were in hand it was important that they be placed quickly into a well-ventilated container to prevent their suffocation. Torpid bats normally became active in fifteen to twenty minutes, so the containers also had to be escape-proof.

Carrying containers devised by Dr. Wayne Davis were used in handling large numbers of bats (PLATE 31). A one gallon anti-freeze can with both ends removed had two holes drilled on opposite sides at one end and a cord was attached so that it could be carried. Then an open mesh vegetable bag, obtained from a local grocery, was put over the can and held near the top with a strong rubber band. Bats could be placed into the can by the handsful and then, in their efforts to escape, would scurry up the bag and reach a cul-de-sac between the bag and the outside of the can. Being able to go no farther, they would then settle down. By using these cages, a person could successfully collect and carry several hundred bats.

PLATE 31. Bander Holding Bat Container and Band Container

Banding Records

Most of the data obtained from banded bats was collected by the investigator, but some was contributed by others who happened upon and reported banded bats.

Data was entered on record cards provided by the Bat-Banding Office of the U. S. Fish and Wildlife Service. These record cards were then sent to Washington, D. C. Every bat banded was entered as a separate item in a ledger with all data relevant to that specific bat. This included the Fish and Wildlife Service band number and size, species, sex, cave where taken, date, capture method, date and locality of release and miscellaneous remarks. Space was also provided for entries concerning any recaptures. An alphabetical card index was also kept on each cave from which bats had been banded. This card gave the following information: cave name, date of visit, species banded, sex, composition, band numbers used, and the number of bats banded.

Length of Seasons of Activity

The length of seasons of activity may vary, depending on climatic and weather changes. Myers (1964) defines the seasons of activity for three species of myotine bats from the Ozark Plateau.

> Winter-16 November to 15 March; the period of hibernation.
> Spring-16 March to 30 April; the period of spring movement.
> Summer-1 May to 10 August; the maternity period.
> Fall-11 August to 15 November; the period when all young are flying, nursery colonies have dissolved, copulation is occurring and bats move to hibernation.

The seasons of activity for the area involved in this study were defined differently because the study was not as extensive as was Myer's and the periods of spring and fall movement were not accurately determined. Thus in this study the winter period is considered as extending from September 1 through April 30, thus being approximately equivalent to the fall, winter, and spring periods of Myers. The remaining months, from May 1 through August 31, comprise the summer period or the period of the nursery colonies.

Effects of Disturbance Due to Banding

Because this study is based largely on information obtained from placing 4,627 aluminum bands on area bats, there was concern about the effects the bands and banding activities might have upon the animals.

Early in the study, it became apparent that frequent trips to hibernating colonies caused the bats to seek new roosting areas within the same caves. Consequently the number of subsequent visits was kept to a minimum. When a cave was visited, an attempt was made to band all the bats that were present.

Myers (1964) found that maternity groups of Myotis grisescens presented a most difficult problem. He observed that disturbance near the time of parturition resulted in premature births. He also found that a disturbance under a colony of Myotis grisescens with juveniles too young to fly increased juvenile mortality. The adult females would fly from the ceiling when disturbed, dislodging and

sending many young to the floor. Only one nursery colony was found during this study and this didn't pose a problem because none were banded until after the juveniles were old enough to fly.

CHAPTER IV

SPECIES ASSOCIATIONS

The social nature of bats, i.e., their gregariousness, colonial habits, etc., varies from species to species. Some are relatively solitary, rarely or never found in groups. Others typically associate in small groups of a few individuals, while still others are notably colonial and congregate by the thousands and tens of thousands or millions. Species of each of the aforementioned types were encountered in this study, as revealed by the data presented in this chapter.

Review of Literature

In Barr's interesting account of Tennessee caves there are several maps and also summarizations of all the animal species he encountered. His faunal list includes the following bats: Myotis grisescens, Myotis sodalis, Myotis lucifugus, Myotis keenii, Eptesicus fuscus, Pipistrellus subflavus, and Plecotus rafinesquii. He notes that Plecotus rafinesquii is relatively rare and is known in Tennessee only from caves in the Eastern Highland Rim, the Cumberland Plateau, and the Smokey Mountains. Goodpaster and Hoffmeister (1952) found Plecotus rafinesquii in Western Tennessee in the Reelfoot Lake area. Hamilton's (1943) range maps are in accord with Barr's findings relative to the cave bats of Northwestern Tennessee. Miller and Kellogg (1955) concur with Hamilton and Barr except that they indicate that the Eastern big-eared bat,

Plecotus rafinesquii, occurs in the study area as found by Goodpaster and Hoffmeister. Tuttle (1964) found Myotis subulatus in Little Mammoth Cave, three miles northeast of Elk Valley, Campbell County, in eastern Tennessee and Barbour (1963) found Myotis subulatus leibii in Mammoth Cave National Park, some fifty miles north of the Tennessee border. Phillips and Mumford (1957) found Myotis austroriparius in a cave two miles north of Hopkinsville, Christian County, Kentucky, only some twenty-three miles north of the study area. As indicated by Burt (1964), Myotis grisescens, Myotis sodalis, Myotis lucifugus, Myotis keenii, Myotis subulatus, Myotis austroriparius, Eptesicus fuscus, Pipistrellus subflavus, and Plecotus rafinesquii have all been found in Tennessee caves.

Species Associations

The cave bats found in the area were Pipistrellus subflavus, Eptesicus fuscus, Myotis sodalis, Myotis lucifugus, Myotis keenii, and Myotis grisescens. All six species can be found in the study area in both winter and summer with the largest populations occurring in the winter except in the species M. keenii. Species associations within individual caves varies from only one species to all six in the same cave (Table III).

Pipistrellus subflavus was found in nineteen caves during the winter and twelve caves during the summer. Of the nineteen caves in which wintering P. subflavus were found, in eight of these nineteen it was the only species present. This species shared three

TABLE III

LIST OF CAVES VISITED FROM MAY 1964 THROUGH JULY 1965,
AND POPULATIONS OF BATS FOUND

County	State	Cave Name	Hibernating	Nursery Colony	Extensive Guano Deposits	Intermittent Summer Use	No Bats
Montgomery	Tenn.	Austin Peay State College	42 P. subflavus 2 M. lucifugus				
Montgomery	Tenn.	Baggett's	1 P. subflavus				
Montgomery	Tenn.	Ballinger's	3 P. subflavus				
Montgomery	Tenn.	Ballinger's other cave			?		X
Montgomery	Tenn.	Bearden's	1 P. subflavus				
Montgomery	Tenn.	Bellamy	139 P. subflavus 468 M. lucifugus 347 M. grisescens 3 M. keenii 94 M. sodalis		M. grisescens	60 P. subflavus 19 M. lucifugus 1,276 M. grisescens 26 M. keenii 2 M. sodalis	
Montgomery	Tenn.	Blue Spring	23 P. subflavus 4 M. sodalis				
Montgomery	Tenn.	Bone					X
Montgomery	Tenn.	Burney	61 P. subflavus 3 M. lucifugus				

TABLE III (con't).

County	State	Cave Name	Hibernating	Nursery Colony	Extensive Guano Deposits	Intermittent Summer Use	No Bats
Montgomery	Tenn.	Coleman	12 P. subflavus 1 M. lucifugus 1 M. grisescens 2 M. keenii 1 M. sodalis 4 E. fuscus			5 P. subflavus	
Montgomery	Tenn.	Dragstrip	1 P. subflavus				
Montgomery	Tenn.	Durham	1 M. lucifugus			13 P. subflavus	
Montgomery	Tenn.	Foster's	12 P. subflavus 12 M. lucifugus 4 M. keenii			4 P. subflavus 5 M. keenii	
Christian	Ky.	Glover's	9 P. subflavus 4 M. lucifugus 3 E. fusgus				
Stewart	Tenn.	Grizzard				1 P. subflavus	
Cheatham	Tenn.	Jeff Pace	2 P. subflavus				
Stewart	Tenn.	Kates'				2 P. subflavus	
Montgomery	Tenn.	Kennedy	1 P. subflavus			2 P. subflavus	
Montgomery	Tenn.	Killebrew	39 P. subflavus 1 M. lucifugus 2 E. fuscus			1 P. subflavus	

TABLE III (con't).

County	State	Cave Name	Hibernating	Nursery Colony	Extensive Guano Deposits	Intermittent Summer Use	No Bats
Montgomery	Tenn.	Kraft	3 E. fuscus			14 E. fuscus	
Montgomery	Tenn.	Little West Fork Creek	1 M. lucifugus				
Montgomery	Tenn.	McWhorter's	16 P. subflavus			1 P. subflavus	
Montgomery	Tenn.	Meriwether					X
Montgomery	Tenn.	Peacher's Mill Road					X
Montgomery	Tenn.	Porter's Bluff				2 P. subflavus	
Montgomery	Tenn.	Red Bluff					X
Cheatham	Tenn.	Ringtail			?		X
Cheatham	Tenn.	Saltpeter	6 P. subflavus	80 M. grisescens banded and 800 estimated		1 P. subflavus	
Montgomery	Tenn.	Silvey	14 P. subflavus 4 M. lucifugus				
Stewart	Tenn.	Tobacco Port	17 P. subflavus 519 M. lucifugus 1,058 M. grisescens 5 M. keenii 145 M. sodalis 13 E. fuscus			1 M. sodalis	
Montgomery	Tenn.	Woodard	1 P. subflavus 2 M. lucifugus			1 P. subflavus	
Montgomery	Tenn.	Woodson				1 P. subflavus	

caves with other species in the winter and in the remaining eight caves there were two or more species present other than P. subflavus. In the summer population this species was the only one present in nine of the twelve caves and shared the cave with only one other species in two more caves. The remaining cave was occupied by all species except E. fuscus in the summer.

Twelve caves were inhabited by Myotis lucifugus in the winter and only one during the summer. It was found in association with P. subflavus in four caves and was found alone in only one cave during the winter. In the remaining seven caves it was in association with from two to five other species. The summer population was found to share the one cave with all the other species except E. fuscus.

Three caves contained M. grisescens in the winter and two in the summer. In Tobacco Port and Coleman Caves six species were found and all species except E. fuscus were present in Bellamy Cave. In Saltpeter Cave during the summer the entire M. grisescens nursery colony shared the cave with one P. subflavus.

Myotis keenii was present in Tobacco Port, Bellamy, Coleman and Foster's Caves during the winter, while it was present in all of the above mentioned except Foster's in the summer. In the wintering caves it was in association with all five other species in Tobacco Port and Coleman Caves, with all except E. fuscus in Bellamy, and with P. subflavus and M. lucifugus in Foster's Cave. Bellamy Cave was shared by all except E. fuscus during the summer and M. keenii shared Foster's Cave with P. subflavus. Tobacco Port

contained only one specimen of M. keenii.

Four wintering caves were inhabited by M. sodalis and only one summer cave. This species was found in Tobacco Port, Bellamy, and Coleman Caves in close association with from four to five species, while in Blue Spring Cave, P. subflavus was the only other species present. During the summer two M. sodalis were found in Bellamy Cave along with all other species except E. fuscus.

E. fuscus was present in five wintering caves and one summer cave. This was the only species found in Kraft Street Quarry during the winter and summer. Two E. fuscus were banded in Killebrew Cave in association with M. lucifugus and P. subflavus. A total of sixteen were found in Tobacco Port and Coleman Caves. These two caves were shared with five other species.

Ninety-two per cent of the entire winter population was found in Bellamy and Tobacco Port Caves, while ninety-one per cent of the entire summer association was found in Bellamy Cave.

Summary

From these data it seems evident that:

1. Myotis grisescens is the most abundant bat in both winter and summer and it was always in close association with at least four of the five other species found in the area caves except during the parturition period.

2. Myotis lucifugus and Myotis sodalis also select the hibernal caves used by M. grisescens. The largest numbers of these two species may also be found in other caves shared by one or two species other than M. grisescens. Occasionally M. lucifugus may be the only species present in a cave. Both M. lucifugus

and M. sodalis occur in much larger numbers during the winter.

3. Myotis keenii is found in both periods to be in association with one or more other species at all times. It is more abundant in summer than in winter.

4. Pipistrellus subflavus is found in more different caves than any other species. It occurs in larger numbers during the winter and also in more caves.

5. Eptesicus fuscus is found in small colonies in only five caves in winter and one in summer. In all caves except Kraft Street Quarry (where it is the only species present), it is found in association with one or more species.

CHAPTER V

SEX RATIOS

Theoretically and assumedly the number of males and females in the entire population of a particular species is essentially equal. However, observation on population samples frequently reveals a significant deviation from this expected ratio, usually in favor of males (Table IV). These disparities may reflect differential susceptibilities to collecting methods, variable mortality rates, seasonal segregation of the sexes, or something else. A consideration of this problem follows.

Review of the Literature

In working with the eastern pipistrelle, Pipistrellus subflavus, Davis (1959) found that eighty per cent of the wintering population in West Virginia was males. He also found that the males among the population studies have a higher rate of survival than the females. Part of this discrepancy may be explained by the fact that P. subflavus males have a tendency to remain in the cave in a torpid state longer than the females. It could also be possible that the gravid females are more vulnerable to predators and to other trying conditions than the males. Furthermore, due to the torpid condition of the male in the cave and the females' nocturnal movements, the exposure to the dangers of the outside world are greater for the female.

TABLE IV

SEX RATIOS OF BATS IN NORTH AMERICA

Species	Number	% Males	Juveniles	% Males	Season	Author
Pipistrellus subflavus	214	73.5			Winter	Griffin (1940) N. Eng.
	17	58.8			Winter	Myers (1964) New York
	4,000	80.0			Winter	Davis (1959) N. Virginia
Myotis lucifugus	3,703	72.5			Winter	Griffin (1940) N. Eng.
	698	54.1			Winter	Wimsatt (1945) N. York
	2,252	1.7			Summer	Smith (1957) Ohio
Myotis grisescens	2,946	50.+			Winter	Hall (1962) Ky.
	17	0.0			Summer	Miller & Allen (1928) Tenn.*
	21	71.5			Summer	Miller & Allen (1928) Tenn.*
			44	50.0	Summer	Mohr (1933) Tenn.
Myotis keenii	877	77.8			Winter	Griffin (1940) N. Eng.
Myotis sodalis	2,289	51.4			Winter	Griffin (1940) N. Eng.
	14,701	51.+			Winter	Hall (1962) Ky.
Eptesicus fuscus	64	43.8			Winter	Twente (1955) Oklahoma
	3,871	68.1			Winter & Summer	Beer (1955) Minnesota

*Quoted by Myers 1964

Griffin (1940) found the sex ratio in a winter colony of P. subflavus in New England to be 73.5 per cent males from a total of 214 bats. Myers (1964) in New York banded a winter group of P. subflavus and found that 58.8 per cent of the seventeen bats were males.

Wimsatt (1945) collected 698 hibernating Myotis lucifugus from a cave in Pennsylvania and found "just over fifty-four per cent males." Over a period of seven years, Smith (1957) examined 3,768 Myotis lucifugus from attics and barns in northern Ohio. She found only 1.7 per cent adult males because these were primarily maternity roosts.

Hall (1962) found that the sex ratios of M. lucifugus in Kentucky were equal in winter populations. The sex ratios at birth of M. lucifugus were found by Griffin (1940) in Massachusetts and by Cagle and Cockrum (1943) in Illinois to be very nearly equal in number.

Large populations of M. grisescens from Kentucky were analyzed by Hall (1962) who reported exactly even ratios for two successive winters. Myers (1964) quotes Miller and Allen (1928) in Alabama to have stated that eleven out of twelve M. grisescens captured July 9 were females. The latter authors disclosed the following data on sex ratios of M. grisescens.

Indian Cave, Tenn., April---17 bats, 0.0% male
Nickajack Cave, Tenn., August---21 bats, 71.5% male
Roseclair Cave, Ill., August---9 bats, 44.5% male
Marble (Marvel) Cave, Mo., June (1892)---3 bats, 100% male

Equal sex ratios among young M. grisescens were found by Mohr (1933) in Tennessee.

Griffin (1940) found a preponderance of males in M. keenii when he banded 877 bats in New England. From this study, he had 77.8 per cent males.

Griffin (1940) in New England and Hall (1962) reported sex ratios for hibernating M. sodalis which were almost equal. Most of Hall's samples came from Kentucky.

Beer (1955) found that the sex ratio of big brown bats, Eptesicus fuscus, was 68.1 per cent males in a study of 3,871 bats banded between 1940 and 1953. Twente (1955) found 43.8 per cent males in a winter colony of E. fuscus in Oklahoma.

Adult Sex Ratios in Area Populations of Bats

Sex ratios of the area bats were determined for all inhabited caves. The caves that contained ten or more individuals of a particular species are summarized in Tables V and VI.

Winter hibernation (Table V). Sex ratios of P. subflavus in winter hibernating colonies were calculated for ten caves. A disproportionate ratio in favor of males was found in nine of the ten caves. This ratio ranged from a low of fifty-eight per cent males in Coleman Cave to a high of ninety-two per cent males in Foster's Cave. Silvey Cave had a sex ratio of only thirty-six per cent males for P. subflavus.

Calculations for three caves showed the sex ratios of M. lucifugus to be in favor of the males. These ratios ranged from sixty-one per cent in Tobacco Port Cave to seventy-five per cent in Foster's

TABLE V

SEX RATIOS OF WINTER POPULATIONS

Species	Cave Name	Sex Composition, Per cent Males	Significance*	Total	Species Composition, Per cent
P. subflavus	Austin Peay State College	79	S	42	95
"	Bellamy	72	S	139	13
"	Blue Spring	61	NS	23	85
"	Burney	62	NS	61	95
"	Coleman	58	NS	12	57
"	Foster's	92	S	12	43
"	Killebrew	64	NS	39	93
"	McWhorter's	75	S	16	100
"	Silvey	36	NS	14	78
"	Tobacco Port	59	NS	17	1
M. lucifugus	Bellamy	69	S	468	45
"	Foster's	75	NS	12	43
"	Tobacco Port	61	S	519	30
M. grisescens	Bellamy	53	NS	347	33
"	Tobacco Port	52	NS	1,058	60
M. sodalis	Bellamy	56	NS	94	9
"	Tobacco Port	48	NS	145	8
E. fuscus	Tobacco Port	75	NS	12	0.7

*The letter "S" indicates a significant deviation from the expected fifty per cent males at the ninety-five per cent confidence level; "NS" indicates no significant difference. This test for significance was run only on groups of ten or more individuals.

Cave for this species.

Bellamy and Tobacco Port Caves contained fifty-three per cent and fifty-two per cent male M. grisescens respectively. This ratio is very similar to that found by Hall (1962) for M. grisescens in Kentucky.

Myotis sodalis showed a low sex ratio of forty-eight per cent males in Tobacco Port Cave and a high ratio of fifty-six per cent males in Bellamy Cave. This ratio is very near the fifty plus per cent males found by Hall (1962) in Kentucky. The sex ratio of hibernating E. fuscus was calculated for one cave. Tobacco Port Cave contained seventy-five per cent males.

Summer population (Table VI). Ten or more P. subflavus were found in only two caves. Bellamy contained seventy-two per cent males while Durham had thirty-eight per cent males.

Bellamy Cave had the only summer population of M. lucifugus that contained ten or more of that species. The sex ratio was eighty-four per cent males.

The summer sex ratios were determined for M. grisescens in Bellamy and Saltpeter Caves. Bellamy Cave seemed to have a transient summer population consisting of twenty-seven per cent males. This cave had a large population of M. grisescens from May 2 through May 22, 1965 when bats were collected once weekly in a Constantine Trap. On May 27, 1965, the cave was examined and no Myotis grisescens were observed. On June 28, the cave was visited again and no M.

TABLE VI

SEX RATIOS OF SUMMER POPULATIONS

Species	Cave Name	Sex Composition, Per cent Males	Significance*	Total	Species Composition, Per cent
P. subflavus	Bellamy	72	S	60	4
"	Durham	38	NS	13	100
M. lucifugus	Bellamy	84	S	19	1
M. grisescens	Bellamy	27	S	1,276	92
M. grisescens (nursery)	Saltpeter	20	S	86	99
M. keenii	Bellamy	96	S	26	2
E. fuscus	Kraft	79	NS	14	100

*See explanation in Table V.

grisescens were found. It seems that the population of predominantly gravid females gathered in this cave before moving into maternity caves. The Saltpeter Cave is one such maternity cave, as indicated by the estimated 800 or more M. grisescens that occupied this cave after May 22, 1965, and also by the few bats recaptured at Saltpeter Cave that had been banded at Bellamy Cave. The sex ratio of the sample examined was only twenty per cent males, but this may not be valid because only a small portion of the population was represented in the sample. Only eighty-six bats were captured from the estimated 800 or more.

The summer M. keenii population was found to be ninety-six per cent males in Bellamy Cave which contained twenty-six of the total of thirty-two bats of this species banded during the summer.

Kraft Street Quarry contained fourteen E. fuscus which represented the total for all of this species banded during the summer banding. This population was seventy-nine per cent male.

Summary

From the 3,106 bats banded during the winter hibernal period, a sex ratio of fifty-eight per cent males was calculated (Table VII). The sex ratios ranged from a low of fifty-one per cent males in M. sodalis up to seventy-one per cent for M. keenii.

During the summer banding, there were 1,521 bats banded and only 482 bats were males (32%) (Table VIII).

TABLE VII

SEX RATIOS AS DETERMINED BY WINTER BANDING

Species	Males	Females	Total	Per Cent Males
P. subflavus	277	123	400	69
M. lucifugus	652	366	1,018	64
M. grisescens	738	668	1,406	53
M. keenii	10	4	14	71
M. sodalis	124	120	244	51
E. fuscus	13	11	24	54
Total	1,814	1,292	3,106	58

TABLE VIII

SEX RATIOS AS DETERMINED BY SUMMER BANDING

Species	Males	Females	Total	Per Cent Males
P. subflavus	67	25	92	73
M. lucifugus	16	3	19	84
M. grisescens	355	1,007	1,362	26
M. keenii	31	1	32	97
M. sodalis	2	0	2	100
E. fuscus	11	3	14	79
Total	486	1,039	1,521	32

CHAPTER VI

MOVEMENT

Except for birds, bats are the only vertebrates capable of true and sustained flight. Unlike birds the migratory tendencies of some species have only recently been demonstrated, as a result of some of the early experimental bat banding work. In addition to their migratory habits, many have considerable powers of homing. Although this study did not deal with the problem of homing, it did produce some data and observations relevant to the problem of bat migration.

Review of Literature

There is a voluminous literature on bat movements, both migrational and homing. Griffin (1958) has reviewed the literature dealing with the movements of bats. There has been a great deal of data collected on gregarious species because they are easily accessible in maternity colonies and in hibernacula.

Banding has made possible a thorough study relating to the movements of bats. As cited earlier, Allen (1921) in 1916 did the first banding with aluminum bands, but systematic banding did not begin until 1932 in Germany (Myers, 1964).

In the northeastern United States, the greatest migratory distance recorded for a bat was a Myotis lucifugus (Griffin, 1940) that flew 169 miles from a summer colony in eastern Massachusetts

to a hibernaculum in west central Vermont.

Most banders have reported that the distance traveled by migrating individuals is less than one hundred miles. Beer (1955) reported that Eptesicus fuscus in Minnesota and Wisconsin

> . . . does not travel great distances. A maximum distance of thirty-three miles for summer and sixty-one miles for winter movements were found, but most of the movements, both winter and summer, were within a ten mile radius of the point of banding.

Cockrum (1956) found that Myotis myotis, Myotis lucifugus, Myotis velifer, Myotis keenii, Myotis sodalis, and Pipistrellus subflavus as well as Eptesicus fuscus made movements from zero to 169 miles between winter and summer, summer and summer, and winter and winter seasons. The majority flew less than one hundred miles, the average being approximately sixty miles for all species.

In 1962, Hall published the results of his work with Myotis sodalis. He was able to establish that this species migrated, but he found that he could study these bats satisfactorily only during hibernation. He banded Myotis sodalis in northern and southern Illinois, south central Indiana, and eastern and central Kentucky in winter and summer "between late 1956 and early 1961." Of the 9,864 bats banded in the winter, approximately eighty per cent were marked in Dixon, Colossal, Coach, Long's, and Bat Caves, Edmondson County, central Kentucky. He found that 0.2 per cent of the bats banded in the winter were recovered in the summer, while 3.8 per cent of the ones banded in summer were recovered in the winter.

Winter to Summer Recoveries

From the 3,106 bats banded during the winter in the area caves, fifty-five were recovered from either the cave banding site or a different area cave or were reported by someone that captured the bat and reported the band number (Table IX). Myotis grisescens and Myotis lucifugus were the only species recovered in significant quantities. There were thirty-one Myotis grisescens banded at Tobacco Port Cave January 30, 1965 that were recovered at Bellamy Cave between May 2 and May 22, 1965. Bellamy Cave is twenty-one airline miles southeast of Tobacco Port Cave. From the total number of thirty-one, four were females. Ten M. grisescens banded at Tobacco Port Cave February 18, 1965, were recovered at Bellamy between May 2 and May 22, 1965. Of this number, three were females. One M. grisescens male that was banded January 30, 1965 in Tobacco Port Cave was captured in an attic on April 12, 1965 five miles north of Dover, Tennessee. The distance from Tobacco Port Cave to the site of capture was six miles. Another M. grisescens male banded on the same date was captured at Lock C, on the Cumberland River, on March 28, 1965. Lock C is five miles south of Bellamy Cave. On March 5, 1965 at Camden, Tennessee a Myotis grisescens female was captured that had been banded at Bellamy Cave February 13, 1965. This Myotis grisescens had flown forty-two miles southwest of the banding site. Myotis grisescens banded February 13, 1965 in Bellamy Cave were recaptured in Bellamy Cave between May 2 and May 9, 1965. One male Myotis lucifugus banded January 30, 1965 at Tobacco Port Cave

TABLE IX

MOVEMENT AND RETURNS

Species	Sex	No.	Banding Locale	Recaptured/ Recovered	Distance Miles	Duration Movement	Direction Movement	Type Movement
M. grisescens	♂	27	T.P.C.*	Bellamy	21	Jan.-May	S. E.	Winter-intermittent
M. grisescens	♀	4	T.P.C.	Bellamy	21	Jan.-May	S. E.	Winter-intermittent
M. grisescens	♀	3	T.P.C.	Bellamy	21	Feb.-May	S. E.	Winter-intermittent
M. grisescens	♂	7	T.P.C.	Bellamy	21	Feb.-May	S. E.	Winter-intermittent
M. grisescens	♂	1	T.P.C.	5 miles north of Dover in an attic	6	Jan.-Apr.	S.	?
M. grisescens (killed)	♂	1	T.P.C.	McKinnon, Tenn.	24	Jan.-Apr.	S.	?
M. grisescens	♀	1	Bellamy	Lock C, Cumberland River	5	Feb.-Mar.	S.	?
M. grisescens	♀	1	Bellamy	Camden, Tenn.	42	Feb.-Mar.	S. W.	?
M. grisescens	♂	3	Bellamy	Bellamy	0	Feb.-May		
M. grisescens	♀	2	Bellamy	Bellamy	0	Feb.-May		
M. lucifugus	♂	1	T.P.C.	T.P.C.	0	Jan.-Apr.		
M. grisescens	♀	3	Bellamy	Saltpeter	22	May-July	S. W.	Winter-nursery
M. grisescens	♂	1	T.P.C.	Saltpeter	43	Jan.-July	S. E.	Winter-nursery

*Tobacco Port Cave

was recaptured April 23, 1965 at Tobacco Port Cave.

On May 28 and June 28, 1965, Bellamy Cave was investigated for Myotis grisescens colonies. On both occasions, not one Myotis grisescens was observed. The only indications that they had been there were three large fresh guano deposits. On June 13, 1965 and July 2, 1965, Tobacco Port Cave was checked for bats and the only bat found was a single Myotis keenii on the first visit. The next visit revealed that all the bats were absent.

A nursery colony of Myotis grisescens was discovered in Neptune Saltpeter Cave on July 2, 1965. It was estimated that the entire population of adult females, and immature males and females was 800 or more. Eighty-six bats that had not been previously banded were collected in mist nets, along with four recaptures. Three Myotis grisescens females that were banded in Bellamy Cave May 22, 1965 were taken and subsequently released along with one Myotis grisescens male that had been banded in Tobacco Port Cave January 30, 1965. The three females had flown a distance of twenty-two miles southeast to arrive at the nursery colony, while the yearling male had flown from Tobacco Port Cave which is forty-three miles northwest of Saltpeter Cave.

Summary

These data suggest that: (1) Large populations of Myotis grisescens winter in Bellamy and Tobacco Port Caves. (2) In early May some of the Myotis grisescens move from Tobacco Port Cave southeast

to Bellamy Cave where the population remains fairly large and stable until late May. Bellamy Cave is devoid of Myotis grisescens by the last of May, and Tobacco Port Cave is certainly empty of Myotis grisescens by mid June, and probably by late May. (3) Some, but certainly not all, of the female Myotis grisescens which winter in Tobacco Port and Bellamy Caves move southeast to Neptune Saltpeter Cave to give birth there.

CHAPTER VII

SUMMARY AND CONCLUSIONS

This study was a survey of all the caves and the bat populations which they harbor that could be found in the northwestern section of the Highland Rim of Tennessee. Its purpose was to determine the number of caves in the area, to map, describe, and locate these caves, to learn the size of the winter and summer bat populations in the various caves, to ascertain sex ratios and species associations, and to study the seasonal patterns of movement between caves.

During the study, which extended from May, 1964, through July, 1965, a total of 149 visits to thirty-two caves were made and a total of 4,627 bats of six species were wing banded. Most of the bats were found in Bellamy and Tobacco Port Caves.

Visits to caves were made systematically and on each visit an attempt was made to band all bats present in that particular cave.

Injury from banding was very slight and when discovered on recaptured bats was corrected. Number 0 aluminum bird bands were used on Pipistrellus subflavus and number 2 aluminum bird bands were used on all other species.

Of the thirty-two caves visited during the study, thirty were described and located on an area map. Twenty-seven were mapped, and Bellamy and Coleman Caves were previously mapped by Thomas Barr (1961). Glover's Cave in Christian County, Kentucky, Kennedy Cave in

Montgomery County, Tennessee, and Jeff Pace Cave in Cheatham County, Tennessee were not mapped, and Jeff Pace Cave and Kennedy were not plotted or described.

Six species of bats were found in both winter and summer. Myotis grisescens was the most abundant but least widely distributed bat during both seasons. It was found in three caves in the winter in close association with at least four other species and in two caves in summer. In one of the summer colonies it was found in association with all other species except Eptesicus fuscus and in the other cave, a nursery colony, in association with one P. subflavus. Of the 1,406 M. grisescens banded during the winter, fifty-three per cent were males, in contrast to the thirty-six per cent males of the 1,362 banded in the summer.

Myotis lucifugus was the second most abundant bat banded but 1,018 of the 1,037 of this species banded were wintering bats. The sex ratio ranged from sixty-four per cent males in the winter to eighty-four per cent males in the summer. M. lucifugus was found in all but one (that harboring the nursery colony) of the caves that were inhabited by M. grisescens. In one winter cave, it was alone and in five winter caves it was in association with P. subflavus only. In the remaining five winter caves, it was in association with P. subflavus and M. keenii, or E. fuscus.

Pipistrellus subflavus was found in nineteen caves in winter and twelve in the summer, thus making it more widely distributed than any of the other species. The sex ratio for winter and summer were

sixty-nine and sixty-seven per cent males respectively. Eight of the winter caves and nine summer caves were populated by P. subflavus only. Four hundred P. subflavus were banded during the winter and ninety-two were banded in the summer.

Two hundred and forty-four Myotis sodalis were banded during the winter and only two in the summer. In the winter, this species was found in the three caves occupied by M. grisescens and in Blue Spring Cave. The winter sex ratio was fifty-one per cent males and the two in the summer were both males.

Myotis keenii was found in Foster's, Bellamy, and Tobacco Port Caves in summer and winter and also in Coleman Cave during the winter. Fourteen were banded in the winter and thirty-two in the summer. A sex ratio of 71 per cent males was found in winter and a ratio of ninety-seven per cent males in the summer.

Kraft Street Quarry was inhabited in the summer by fourteen Eptesicus fuscus that were seventy-nine per cent males. Five caves combined contained twenty-four of this species during the winter. The sex ratio for the winter was fifty-eight per cent males. This species was in association with two or more other species in the winter except in Kraft Street Quarry where it was alone.

One nursery colony of an estimated 800 Myotis grisescens was found in Saltpeter Cave. This colony was composed primarily of lactating females and juvenile males and females.

Bats were found to enter hibernacula in late September and early October. Emergence from hibernation occurs before the first of

May for most species. Myotis keenii males and Pipistrellus subflavus males were found in a torpid state after this date but it is possible that they had awakened, fed, returned to the cave, and again entered a torpid state.

It was found that some of the Myotis grisescens population from Tobacco Port Cave emmigrate to Bellamy Cave where the population remains fairly large and stable until late May. At this time, the population disperses from Bellamy and moves to other summer caves. One such cave is Saltpeter Cave where many gravid female Myotis grisescens congregate and form a nursery colony. The direction of flight from Tobacco Port Cave, to Bellamy, to Saltpeter Cave is southeast. The greatest distance covered by a Myotis grisescens was forty-three miles. In all recaptures the bats had flown in a southerly direction from the banding site.

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