Status of the Indiana Bat, *Myotis sodalis*, in Pilot Knob Mine, Iron County, Missouri, 2008

Final Report to the United States Fish & Wildlife Service
Pilot Knob National Wildlife Refuge
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Cover photo: View of Pilot Knob from Fort Davidson, a Civil War battlefield. The cut in the top of the hill contains the major adits (entrances) to the mine. Photo by William R. Elliott.

Abstract

On February 25-26, 2008 we conducted a bat census and reconnaissance in Pilot Knob Mine, Missouri, and its environs in cooperation with the US Fish & Wildlife Service, Missouri Department of Conservation and Bat Conservation International. Following a written plan with safety equipment, instruments, and cameras, we documented a total of 1,678 Indiana bats (Indiana myotis, *Myotis sodalis*) in the lower and upper portions of the mine. Thirteen adits were checked and GPS fixes were obtained, but only the four adits leading into the two main cavities contained bat clusters. We provide a review of all available documents and photographs, and new estimates of the bats in the mine. *M. sodalis* declined by 98%, from about 80,000-100,000 in 1958 to about 2,000 in 2008. Intruders may have affected the bats, but much of the decline probably was the result of a partial collapse of the lower mine in 1979, which may have killed many bats, followed by probable changes in airflow and the availability of habitat. Recommendations are provided for improved, cooperative management of the mine and Refuge.

Introduction

Pilot Knob Mine, Iron County, Missouri, became a National Wildlife Refuge in 1987 (Sweet 1988). Its focus is protection of critical habitat for the endangered Indiana myotis, *Myotis sodalis*, which hibernates there in substantial numbers. Despite the decline of Indiana bats in recent years, Pilot Knob Mine remains an important mating and swarming place, hibernaculum and refuge for several species of bats.

This report presents the results of a census trip and reconnaissance of the mine on February 25-26, 2008. The authors obtained a permit from the US Fish & Wildlife Service (FWS) to survey the interior and environs of the mine for Indiana bats, after we provided a written safety plan and procedures (Appendix).

The summit of Pilot Knob is geologically and geographically unique, providing a panoramic view of the surrounding area, which includes a Civil War battlefield, Fort Davidson, at the foot of the hill (Figures 1-3). The Knob is formed in Precambrian rhyolite, which is volcanic, and sedimentary tuff. It contained a rich iron ore body that was mined from about 1835 to about 1890 (Figures 4-6). Mining resumed for a time, ending between 1912 and 1920 (Litton 1855, Nason 1892, Crane 1912, USGS 1967, Kisvarsanyi 2001). Open pits remain near the top of the hill, but the underground portions of the mine were largely mined out near the end of the mining period, and some portions were collapsed by removing pillars. Bats may have begun using the mine long ago, but we presume that they encountered fewer disturbances after 1920. However, local youths have a long tradition of visiting the mine, although it has a reputation of being dangerous. This tradition continues today despite its federal Refuge status and a high perimeter fence.

Review of Previous Studies

An attached computer disk with many files has an Excel® spreadsheet (Pilot Knob Mine.xls) containing several worksheets of interest. The contents are provided on a computer disk to FWS:

2008 census	Results of the in-mine counts, February 25, 2008 (Tables 1 and 4).
GIS	Pilot Knob Mine (pkm) adit UTM coordinates from GPS fixes (Table 2).

Calc	A recalculation of LaVal and Clawson's population estimates (Table 3).
General	A chronological list of 115 events, bat counts, harp-trap results, management actions, digital files and documents scanned from the Missouri Department of Conservation's (MDC) files (Table 5).
Myso	Table 6 of in-mine counts, revised estimates, old harp-trap population estimates, and trapping rates for *M. sodalis* (Myso), and a graph (same as Figure 31).
Trap Date	Examination of the effect of early vs. later harp-trapping dates (see p. 8).
Bat files	List of scanned field data sheets and documents with bat results.
Gate	Cost of the 2001 bat gate built on the lower mine, since removed.

On February 22, 1958, Richard Myers visited the mine with three young local men to photograph the hibernating Indiana myotis (Figures 7-12, Table 5). He visited the mine again on April 11 and December 27, 1958. In December the "Devil's Icebox," as the lower mine was called, contained about 80,000 *M. sodalis* by Myers' estimate. We believe that this was a conservative estimate, based on a density of 220 bats/foot^2 (Myers 1964, table 1, pp. 26-35). The February photograph (Figure 9) appears to have about 300 bats/foot^2, which we estimated from the size of a man's hand near the bats and counting bats in a frame. Myers also estimated at least 35,000 *M. lucifugus* in the mine. We concur with FWS that 100,000 may be a reasonable re-estimate for 1958, especially since the upper mine was not visited during Myers' trips, but we know that it now harbors bats. In February, 1958, the interior of the mine appeared to be stable, with old stulls (tree trunks used as roof supports) mostly still in place. By December he noticed that boulders had shifted and there had been some rock falls in the entrance area and on the route to the hibernaculum. Myers last visited the mine in March, 1960. (R. Myers, pers. comm.)

In 1975 Richard and Margaret LaVal from MDC began harp-trapping bats at the lower mine entrance, but they did not enter the mine, owing to its "dangerous" reputation. Richard Clawson soon joined their project, and they continued the effort until 1978 (Clawson and Titus 1988). Trapping usually was done in late September or early October during the fall mating swarm. The great majority of bats captured and released, usually over a two-hour period in two "bags," were *M. sodalis*, with some *M. lucifugus* (little brown bat) and *M. septentrionalis* (northern bat). They were identified to species, most were sexed, and some were weighed and examined in detail.

In a letter dated November 17, 1978 to Larry Visscher, FWS, Richard Laval reported,

> "…Because we know the hibernating population of Great Scott Cave, we can, if we assume bat activity at cave entrances is proportional to number hibernating in the cave, calculate the hibernating population of Pilot Knob by measuring the rate at which bats fly through the entrance on consecutive nights. Thus, on 14 and 19 October catch rates were 4.36 bats/min and 2.91 bats/min., respectively, at Great Scott. Meanwhile, on 12 and 21 October catch rates at Pilot Knob were 10.38 and 6.74, respectively. Using a mean (based on 4 years' data) population at Great Scott, the calculated population at Pilot Knob is [between] 139000 and 135000, using the two sets of data. Thus these data support our contention that PKM is the world's largest hibernaculum for Indiana bats…"

Harp trapping was done April 8, 17 and 18, 1979, with nothing unusual recorded, but on May 25, 1979 LaVal recorded in his notes,

> "A colossal collapse has occurred, blocking the two entrances used by bats. Cold air is blowing out of the rocks above the old main exit site; it appears a person could still get in, by climbing among

newly fallen giant boulders. The higher main entrance that was being used by nearly half the bats earlier this spring appears to be completely blocked. The entire south wall of the 'Devil's Icebox' has collapsed, partially filling the icebox. Rock still standing looks very unstable. There are many new cracks in the rocks and earth along the trail to the top of the hill from the icebox. The third entrance not formerly used by bats (high up on the end of the icebox) is still open. We suspect foul play, but saw no evidence of same. Note, from 2000 on, a few bats emerging from remains of lower main entrance."

A federal agent was sent to investigate, but he reported no evidence of violations. After the collapse there were no harp-trapping trips until 1992. Figures 12, 19 and 20 show quarry conditions before and since the collapse.

On September 16, 1986, a local 17-year-old boy was trapped and injured in the lower mine while exploring with a friend. After a two-day ordeal he was rescued by local responders and cavers from St. Louis (*The Mountain Echo* 1986, Kelly 1987). This incident, in which the youth nearly lost his life or his legs, prompted many to call for permanent closure of the mine. But its value as a bat refuge also was publicized. Within a year FWS received a donation of the mine and 90 acres from the Pilot Knob Ore Co. (FWS 1987).

In 1992, Richard Clawson resumed harp-trapping studies at Pilot Knob Mine, but he did not enter the mine. He continued these studies through September 2007 with the help of many people (including Elliott on occasion). These results are in Table 6.

In October 1998, Elliott, Steve Schmauch and Michael R. Sutton installed Hobo Pro temperature data loggers for a joint study by Bat Conservation International (BCI) and MDC (Elliott and Clawson 2001).

On February 7, 1999, Jim Kennedy and Sheryl Ducummon of Bat Conservation International (BCI) visited the lower mine at the request of FWS, but found only 303 *M. sodalis.* Concern about the true number of bats in the mine continued, especially as the harp-trapping results decreased (Figure 31).

Materials and Methods

On February 25, 2008, the authors and others explored Pilot Knob for accessible entrances (adits and collapses) to the mine, finding a total of 13, including the lower (known) mine (Figures 19-30). We took GPS fixes on all adits and photographed them. There was some snow cover and the temperature was hovering around freezing.

The interiors of the lower and upper mines were surveyed for bats on February 25. Bill Elliott, Jim Kennedy, Doug Foster (MDC) and Scott Pruitt (FWS) examined the lower mine from 1:12 to 3:10 PM, CST, while Mick Sutton remained at the entrance as safety officer, with a support team of Ben Mense (FWS), Dan Shamhart (FWS agent), Billy Barton (MDC agent), Jay Simpson (MDC) and Howard King (MDC). The support team maintained radio communications with those in the mine. Sutton, Kennedy, Foster and Pruitt examined the upper mine via PKM6 (largest adit, Figure 26) from 3:45 to 4:50 PM, and exited at PKM5 (Figures 23-24); Elliott and others provided safety support outside.

The surveys entailed cautious movement through the mine with constant communication among the biologists about conditions such as ice, loose rubble, side tunnels, ceilings, and frequent radio checks. Conditions were not unusually dangerous for those experienced in underground environments, but did require careful travel.

The following equipment was pooled by the authors during this study:

1. Garmin GPSmap 76S with external antenna and GPSmap 76SX with internal antenna and averaging for obtaining precise entrance locations.
2. Raytech Raynger ST Pro IR thermometer for numerous rock temperatures taken at a distance.
3. DeltaTRAK Professional digital pocket thermometer, calibrated in freezing distilled water to within 0.1°F, for precise air and rock temperatures.
4. MSA Solaris 4-gas monitor for monitoring air quality.
5. Elliott's Canon EOS Rebel XTi (400D) digital SLR camera, 10.1 megapixels, with 18-55 mm zoom lens and 100 mm macrolens, and two flashes with slave sensors used for additional lighting triggered by the camera flash.
6. Kennedy's Canon EOS Rebel XTi digital SLR camera, 10.1 megapixels, with 18-85 zoom lens, and three flashes synched to the on-board camera flash. Other multi-flash photos were taken on bulb setting with a tripod.
7. VHF radios to communicate from the mine to support team outside.
8. Elliott's home-built laser caliper, mounted on a tripod with two beams calibrated to exactly 12 inches apart, used for scale in photographs of bats.
9. Kestrel pocket weather station.
10. Standard cold-weather cave gear, including helmets, gloves, kneepads, coveralls, and polypropylene longjohns.
11. Caving helmets with chinstraps, headlamps, including bright headlamps and back-up lights.
12. 7-mm nylon handline, 2000-lb. test.

We called out bat counts to one person who wrote data in a pocket notebook. We handled no bats, but we noted their locations on a map (Figures 3-4). We photographed larger clusters that could not be easily counted and some small clusters. We frequently discussed species identifications. Clusters were photographed with two similar, high-resolution cameras, often with two laser points in the scene for density estimates afterwards.

Later, the photographs were pooled, and they were enhanced using either ACDSee® or Corel PhotoPaint® software. Bats were recounted by placing yellow dots on their noses in the photos. Sometimes a square-foot frame was drawn in the photo to measure bat densities.

We looked for additional openings on February 26, and checked some of the smaller ones. Final results were tabulated in the Excel® spreadsheet program (Table 2). GPS fixes were converted to a point table and mapped in ArcMap® 9.1.

Results

We had no particular difficulties traveling through the mine (Figures 13-14), the mine atmosphere was not hazardous, and no air contaminants were detected. It is obvious that parts of the mine collapsed, crushing old stulls (Figure 15). However, the lower mine appears unchanged since we began visiting there in 1998, and the ceiling looks stable. Of course, one must always pay attention to loose rubble on steep slopes when traversing any underground passages.

We revised our in-mine bat census after going over our many photos, enhancing them, digitally marking noses, and recalculating most of the clusters of *M. sodalis* (Figures 16-18). Small clusters did not require photos, but photos of medium to large clusters were useful. The

photo recounts increased our initial estimate by about 10%. Even so, photographs are still somewhat conservative because the three-dimensional nature of some clusters makes it very difficult to see every bat, with a few hidden ones likely missed. We had a total of 1,738 of all species in the lower and upper parts of the mine.

For *M. sodalis*, our summarized results are in Table 1, below. For details, see Table 4 near the end of this report.

Table 1. Summary of *M. sodalis* census on February 25, 2008, in Pilot Knob Mine. After recounting the photos, the census was increased by about 10%.

	In-mine	**Photos**
Lower mine	1,241	1,446
Upper mine	280	232
Total	**1,521**	**1,678**

All mapped mine adits are detailed in Figure 2 and Table 2. Our reconnaissance of the hill found bats only in the larger spaces of the lower and upper mines. At the smaller adits we did not find passages leading into spaces large enough for bat clusters.

Table 2. February 25, 2008 GPS fixes on mine adits using UTM, NAD83 datum. EPE is estimated position error in meters. The elevations probably are inaccurate, being based on satellite data and not a barometric altimeter. The parking lot of the Fort Davidson Motel is represented as “motel.” The gate in the perimeter fence is “gate,” and the parking area at the trailhead to the gate is “pkmpkg.”

Label	**UTME**	**UTMN**	**elev_ft**	**EPE_m**
gate	709388	4166173	1410	6
pkmlower	709448	4166185	1420	5
pkm1	709479	4166211	1446	5
pkm2	709592	4166215	1443	5
pkm3	709598	4166229	1512	5
pkm4	709632	4166220	1483	5
pkm5	709645	4166212	1492	5
pkm6	709659	4166205	1465	5
pkm7	709682	4166142	1465	7
pkm8	709677	4166133	1464	5
pkm9	709589	4166018	1368	3
pkm10	709549	4166052	1376	5
pkmpkg	708951	4166092	1070	5
motel	708205	4166213	980	5

Discussion

We searched the mine well, and we believe that we did not miss any obvious spaces enterable by humans that might hold vast numbers of bats. However, because of time and safety limitations, we also chose not squeeze into extremely tight openings that might lead to other

open tunnels. Therefore, we believe it is possible that some bats remain uncounted, but of course we cannot say how many. One has to consider that tight crawlways may also restrict large numbers of bats from flying, so to postulate large clusters of bats in hidden, inner chambers would be conjecture.

Our survey should provide a good, repeatable baseline for future visits to the mine, starting in 2011, to coincide with the usual, biennial round of winter surveys for Indiana myotis, as long as basic safety procedures are followed.

How does one explain the large discrepancy between the harp-trapping estimates and our in-mine counts? We believe that the harp-trapping estimates in the 1970s were fairly representative of the number of bats actually hibernating in the mine then, at least within the same order of magnitude (Figure 31). However, the bats are not required to hibernate in the mine after swarming and mating at the entrance. This is an artificial habitat, after all, which the bats probably have been using for less than 100 years. We know that they did hibernate there in 1958 and probably until 1979.

In reviewing the course of events at the mine, we think that a plausible explanation of the loss of bats is that the 1979 collapse so altered the mine that the bats began hibernating elsewhere, perhaps somewhere nearby. The collapse, which probably occurred between April 18 and May 25, 1979, may have crushed some of the few bats that would have been in the mine at that time. Airflow probably became restricted, and the lower mine became colder as a result. The lower mine often dips below freezing in winter (Elliott and Clawson 2001). The upper mine is warmer and quite damp in many places, which is less desirable. However, the entrance area was a good place to rendezvous in the fall for three bat species, and they continue to do so. The most likely conclusion is that the 1970s harp-trapping estimates probably estimated the number of bats in the mine well, but the later estimates represent only the swarm.

A remaining problem is the estimate of 50,545 Indiana bats in the mine provided by MDC to FWS since 2001. This estimate probably was based on the letter by Richard K. Laval of MDC, dated November 17, 1978, to Larry Visscher, FWS (see page 3 above). We recalculated these estimates to be sure how Laval did them.

The correct equation to compare two sites, like Pilot Knob and Great Scott, would be $\mathbf{GSC_{harp}/GSC_{census} = PKM_{harp}/PKM_{census}}$,, where PKM_{census} is the variable for which we are trying to solve (*italics* in Table 3, below), using only Indiana bats, not the total catch.

Table 3. Recalculation of LaVal's 1978 bat estimate at Pilot Knob Mine.

	PKM_{harp} 9-30-75	**PKM_{harp} 10-21-78**	**GSC_{harp} 10-14-75**	**GSC_{harp} 10-19-78**
bats/min.	10.38	6.74	4.36	2.91
bats/hr.	623	404	262	175
Method 1_{census}	*138,817*	*134,772*	58,379	58,379
Method 2_{census}	*207,829*	*90,020*		

The Great Scott in-cave count of 58,379 apparently was a mean over four winters (1974, 1975, 1977, 1978), which further complicates the calibration. Our main point is that in this case one must decide whether to compare the high or low trapping rates. The only way LaVal could have calculated the range he obtained was by using **Method 1** above, comparing high to high and low to low rates thus:

Step 1: Divide the high capture rate at PKM by the high rate at GSC, multiply by 58,379.

623/262*58,379 = 138,817, rounded to 139,000

Step 2: Divide the low capture rate at PKM by the low rate at GSC, multiply by 58,379.

404/175*58,379 = 134,772, rounded to 135,000

Mean = (139,000 + 135,000)/2 = 137,000

An alternate calculation is Method 2, in which high capture rate is divided by low rate and vice-versa. This results in a wider range and a higher mean, which LaVal did not report:

623/175*58,379 = 207,829, rounded to 208,000
404/262*58,379 = 90,020, rounded to 90,000
Mean = (208,000 + 90,000)/2 = 149,000

Overall, using the highest capture rates for estimating the PKM population seemed like a reasonable method at the time, resulting in 139,000 Indiana bats, later used by Clawson and others.

In 2001 Clawson wrote a document in which he estimated the PKM population at **50,545** based on 1999-2000 trapping rates. Apparently, this was inadvertently scaled off the mean capture rate of 407 for 1975-1978 instead of the high rate of 623 on 12 October 1978. This did not match LaVal's calculation method, which unfortunately was not clearly stated in 1978. The calculation should have been:

148/623*139,000 = 33,021, rounded to 33,000
or 148/262*58,379 = 32,977, rounded to 33,000

In hindsight, there are several problems here besides an inadvertent miscalculation:

1. The trapping rates at the same site can vary by a factor of about ± 50% from time to time because of the date, temperature and biological conditions at the site.
2. Trapping sometimes was done on suboptimal dates. The top five capture rates came between September 23-October 12, and in earlier years. The lowest five came between September 21-October 29, but mostly October 19-29, and in later years.
3. One cannot assume that a long, horizontal cave with two entrances (Great Scott Cave) would have bats that swarm exactly the same as a complex, colder mine with one main entrance and different terrain outside (Pilot Knob Mine).
4. The two main portions of the mine were not sampled, only the lower mine. The numerous other entrances to the mine, although small, may also contribute to overall swarming numbers.
5. We cannot assume that the number of bats swarming at the entrance(s), then captured scales linearly to the number in the mine.

In Table 6 and Figure 31 we have rescaled the harp-trapping estimates to the in-mine counts to provide some kind of picture of what was happening at the mine, however hazy. The revised estimate column is based on harp-trap rates rescaled to fit rounded-up, in-mine counts and LaVal's 139,000 estimate in 1978. The numbers in bold in the Revised column are the anchor points for the new estimates. For example, the 1977 estimate compares the bats/hr. in 1977 to the October 12, 1978, capture rate, thus 444/623*139,000 = 99,063. The 1992 estimate compares the

bats/hr. in 1992 to the 1998 capture rate (equivalent to about 500 bats in the mine in February 1999), thus 592/13*500 = 22,679.

The Refuge has a long-standing problem with intruders. The documents we have report repeated intrusions through breaks in the perimeter fence, which is 21 years old, and ATV tracks around the perimeter trail. We observed a broken section of fence at a corner (Figure 30) and a bent section where a tree had fallen across the fence. The tree was removed with a chainsaw by MDC staff. Throughout the Refuge there is graffiti on rocks near adits. In the mine there was no obvious evidence like spent ammunition, drill holes or blasting wire, but there was some old graffiti. Based on the amount of intrusions we found and our experience in protecting caves and mines, we would expect that some harassment and killing of bats would have occurred in the mine over the years. Predators, such as raccoons, opossums and minks (Myers 1964) would eat dead bats killed by humans, erasing evidence, and they may take some bats on their own. Some of the decline in the bats could have been from predators and human disturbance and harassment.

We conclude from current survey techniques that *M. sodalis* declined by approximately 98% from 80,000-100,000 in 1958 to about 1,678 in 2008. Much of the decline was likely the result of a partial collapse of the lower mine in 1979, which may have caused a catastrophic kill and then probably caused changes in airflow and the availability of habitat (Figure 31).

Recommendations

In reviewing events surrounding management of Pilot Knob Mine, we see that agreements were made between FWS and MDC to co-manage it. We recommend that the two agencies consider the following actions:

1. Repair and check the perimeter fence on a regularly scheduled basis. Aggressively prosecute trespassers.
2. An existing MOU between FWS and MDC calls for MDC conservation agents to be certified to enforce federal law. MDC agents are now authorized to generally enforce federal law, but they would refer violations on the refuge to federal agents. Conservation agents, federal agents and biologists should increase inter-agency communications and work cooperatively to patrol and protect the refuge.
3. Increase public support and “ownership” of the refuge by local citizens through implementation of a volunteer stewardship program utilizing qualified area individuals for additional monitoring and maintenance. For example, cave biologist Michael R. Sutton of the Cave Research Foundation and Audubon/Eastern Ozarks Chapter has expressed an interest in this type of program, and he is quite familiar with the mine and refuge.
4. Remove the large boulder in front of the adit to the lower mine to improve air flow and provide a better flight path for bats. Large explosives are not needed to do this.
5. Continue harp-trapping in late September/early October by MDC and FWS, but with a goal of pit-tagging or banding *M. sodalis* to find out where they go in the winter and summer. This should be complemented by summer mist-netting in northern Missouri and cooperative work at nearby mine hibernacula in Illinois, and possibly by future radiotelemetry studies.
6. Census the bats in the mine on a three to four-year schedule, beginning in January/February 2011. A biennial schedule is not recommended because of disturbance..
7. Ensure the safety of researchers at the site by adopting a safety plan such as that used in

this study (Appendix).

Acknowledgments

We appreciate the work of preceding biologists at Pilot Knob Mine: Richard F. Meyers, Richard and Margaret LaVal, and Richard Clawson. Dick Myers lent us his 1958 photos and provided historical information, which were invaluable in providing a record and a baseline for posterity. Rick Clawson, in particular, spent many days and years at the mine trying to unravel its mysteries, and strove to ensure its proper management even when it seemed like no one else cared. Thanks to Michael R. "Mick" Sutton of the Cave Research Foundation and Audubon/Eastern Ozarks Chapter for his many trips to the mine with us, and for his excellent sketch map of the Upper Mine. FWS personnel who participated in this study were Scott Pruitt, Ben Mense and Dan Shamhart. MDC personnel were Doug Foster, Billy Barton, Jay Simpson, Howard King and Matt Jones. Rick Clawson, Virgial Harp, Jason Lewis, Craig Gump, Andy King, and Mike Tosick did the latest harp trap at the mine on September 19, 2007. Thanks to Sue Hagan, Steve Schmauch, Sheryl Ducummon, Mike Hubbard, Paul McKenzie, Theresa Davidson, Andy King, Tony Elliott and others for their support, reviews and contributions to our knowledge of Pilot Knob Mine.

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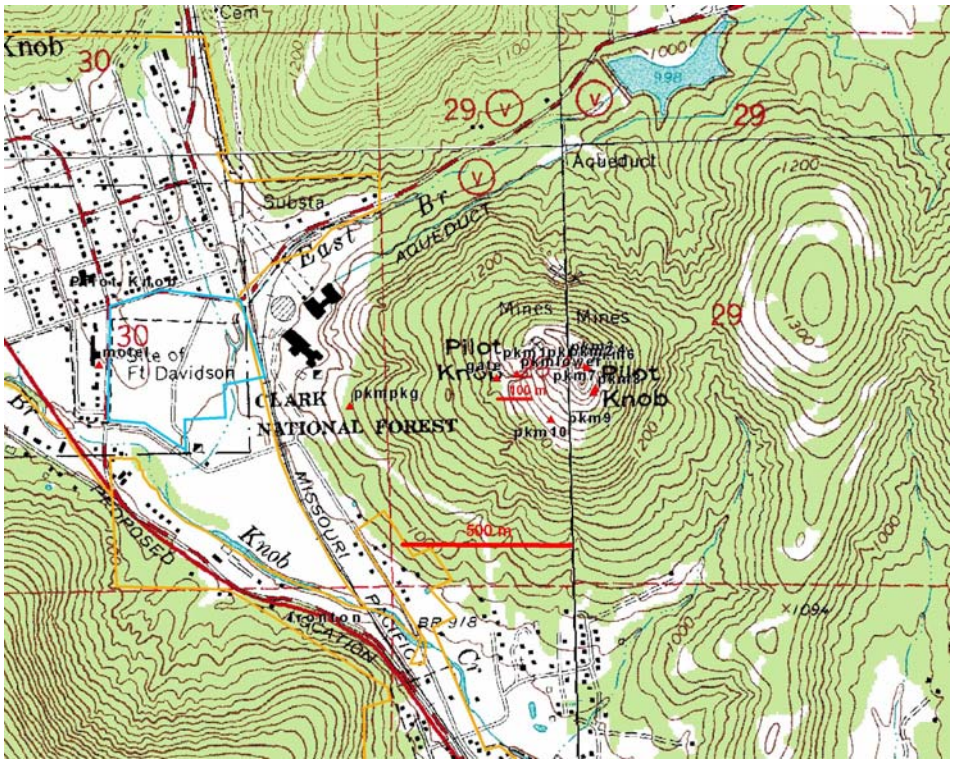

Figure 1. General location of Pilot Knob, Iron County, Missouri

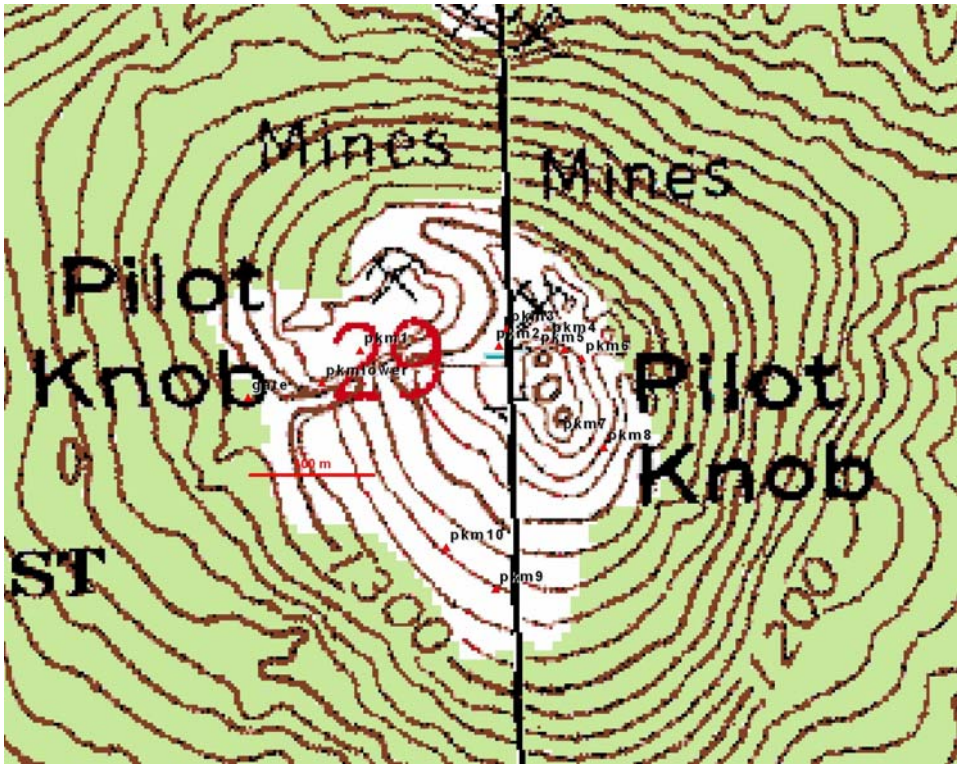

Figure 2. Map of Pilot Knob with mine adits mapped on February 25-26, 2008.

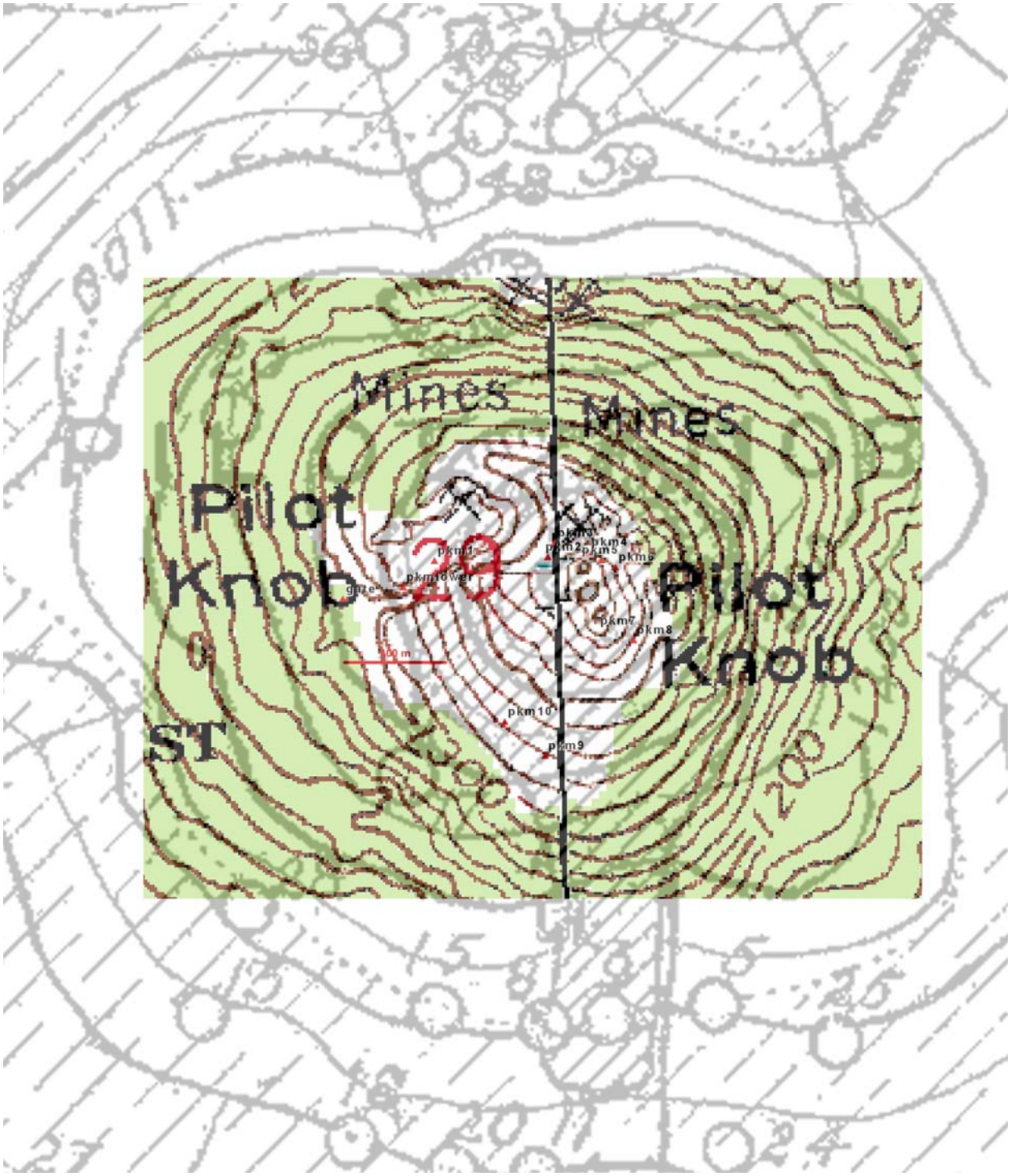

Figure 3. Map of Pilot Knob overlaid on mine map.

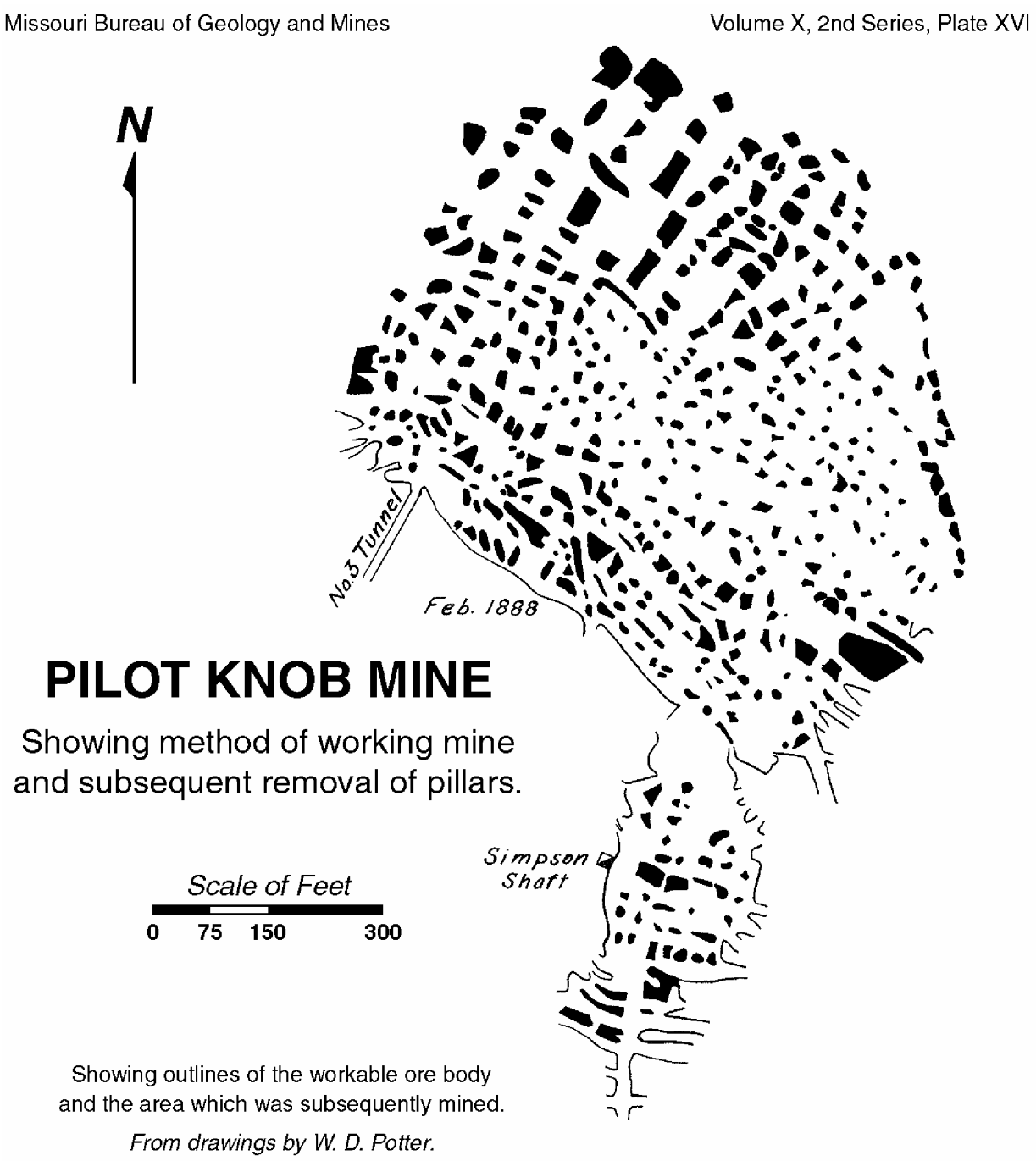

Figure 4. 1912 map of the mine.

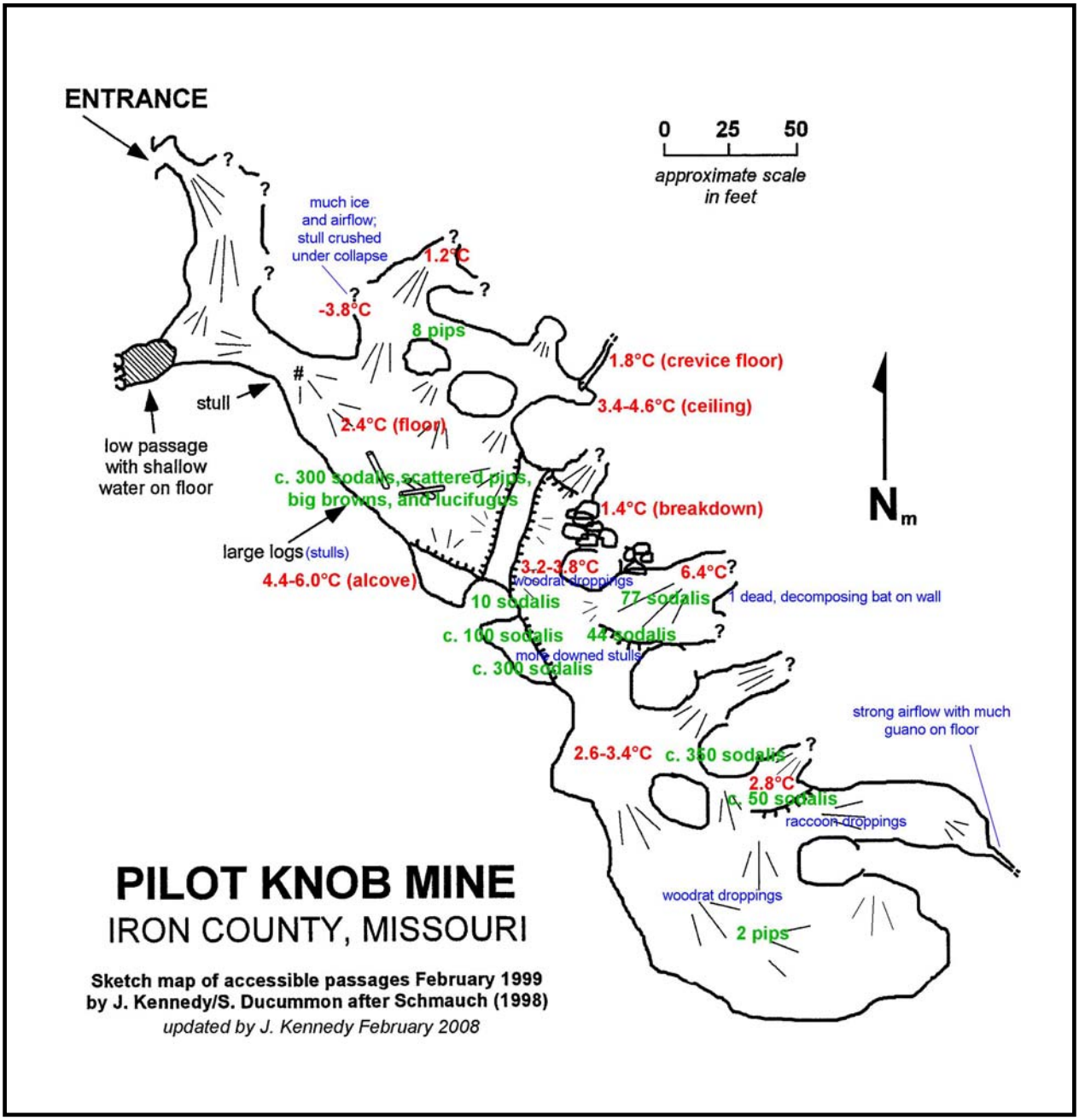

Figure 5. Map of the lower mine with notations on bats observed and temperatures on February 25, 2008.

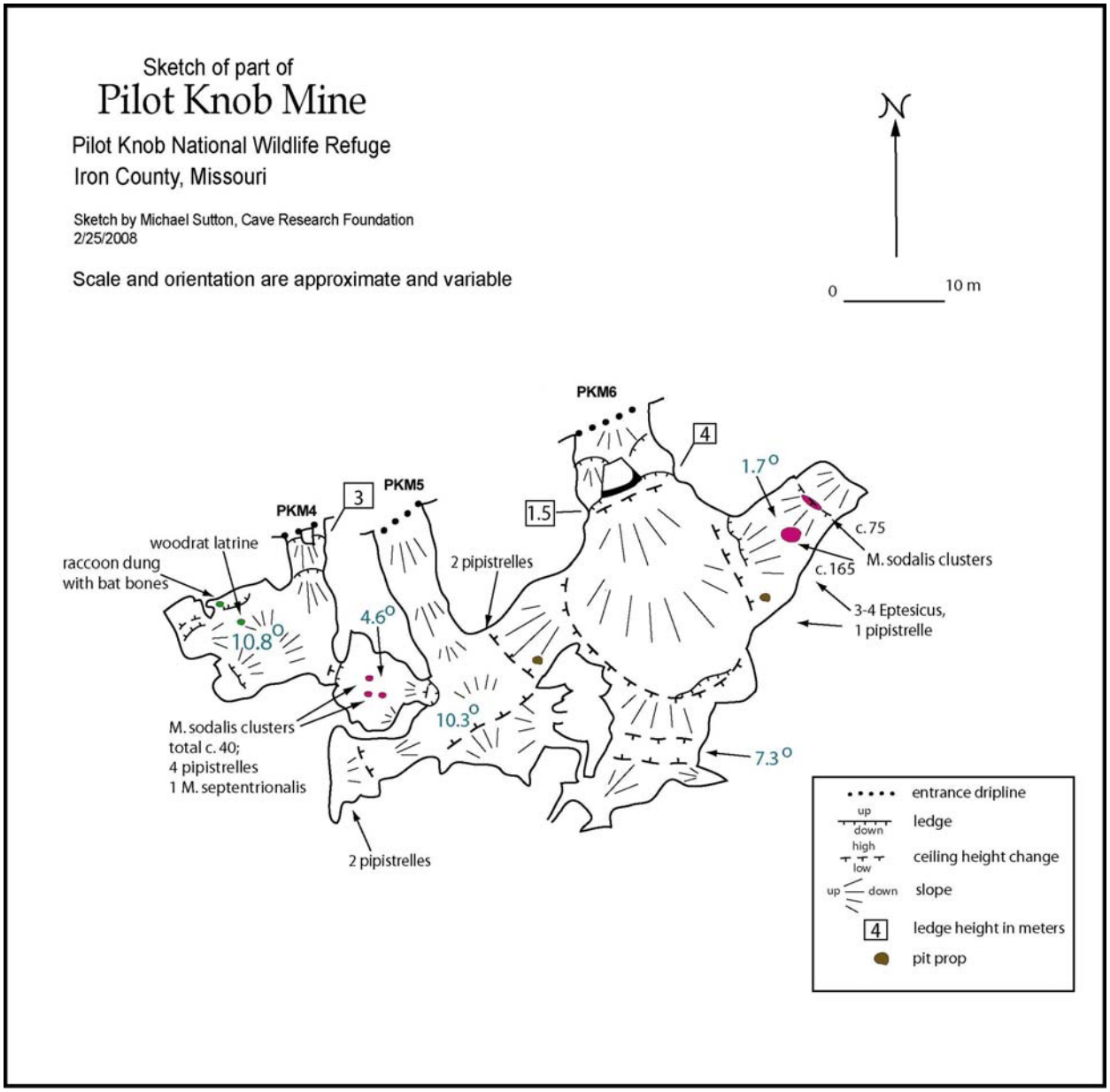

Figure 6. Map of the upper mine.

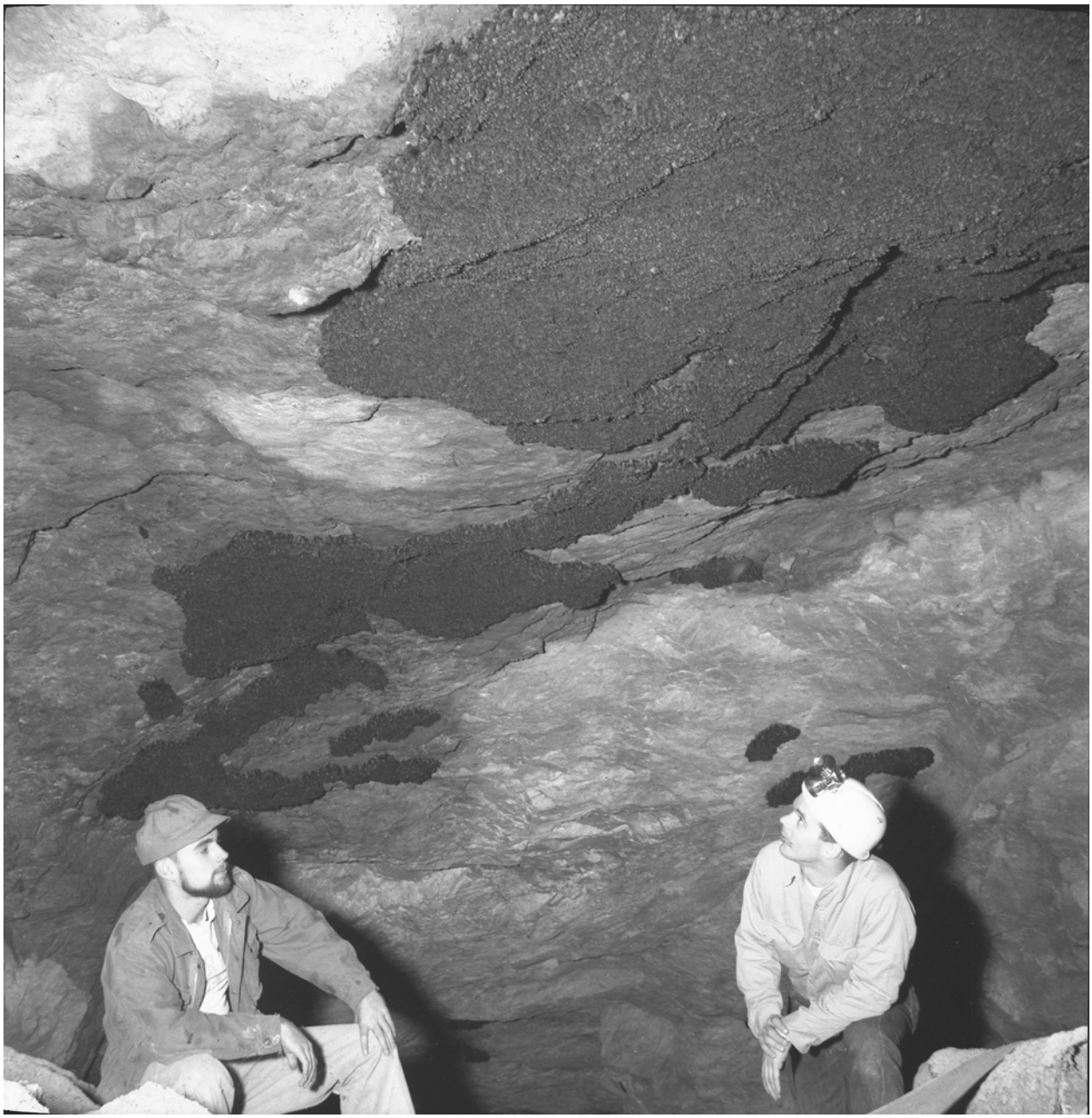

Figure 7. Hibernating Indiana bats in the lower mine, February 22,1958. Scanned from 2¼-square photo by Richard F. Myers.

Figure 8. Hibernating Indiana bats in the lower mine, continued from the right side of Figure 7, February 22,1958. By Richard F. Myers.

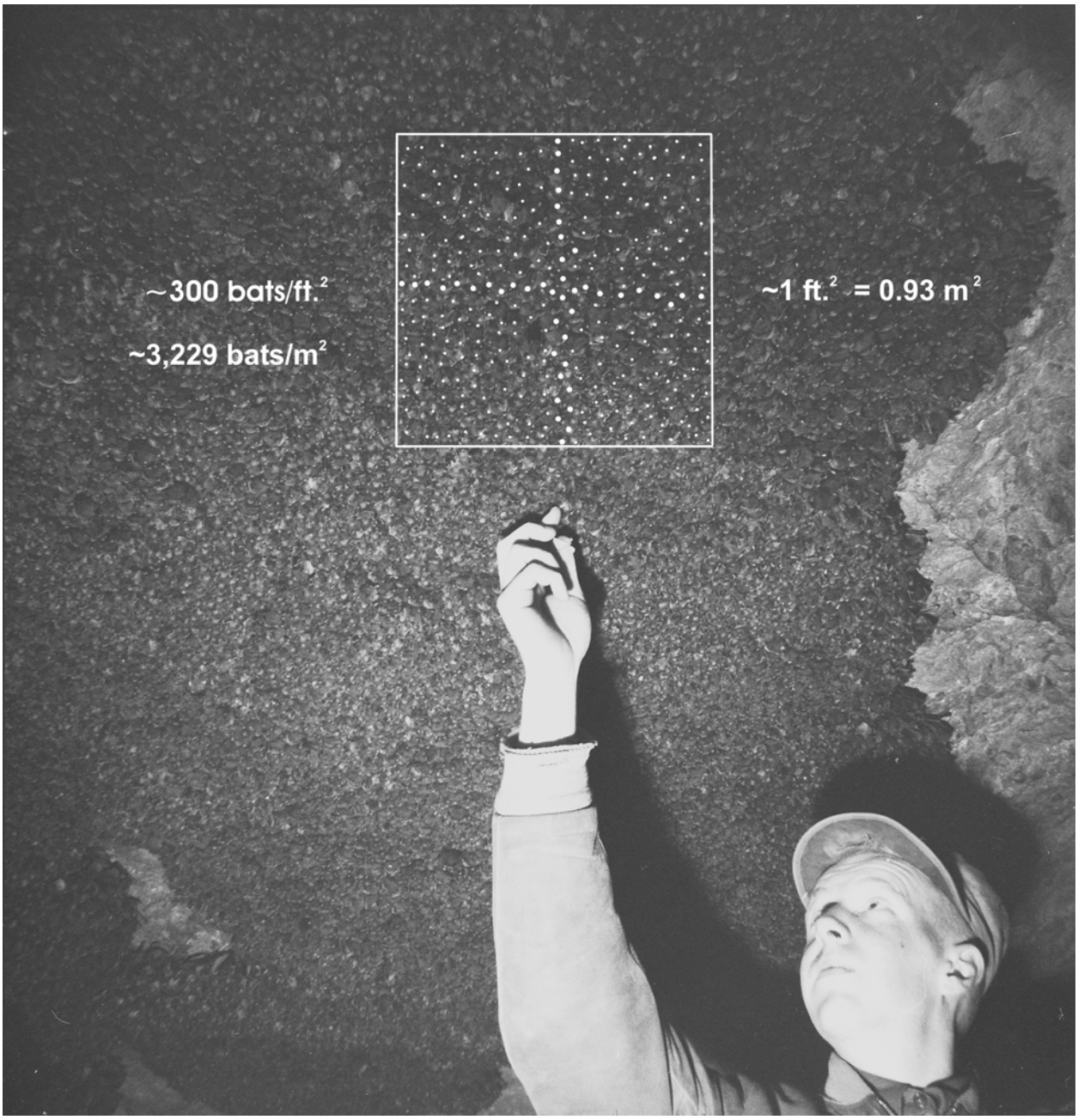

Figure 9. Estimated square-foot frame drawn by the authors on February 22,1958 photo by Richard Myers. Using Mike Hull's hand near the bats for scale, we estimate 300 *M. sodalis*.

Figure 10. Icy interior of the lower mine ("Devil's Icebox") on February 22, 1958. Left to right: Bob Wilkinson, L.B. Matthews and Mike Hull. "Rock pile behind Wilkinson is what we crawled through to get in the mine. There was much ice making it difficult to climb up or down." By Richard F. Myers.

Figure 11. Stulls (tree trunks) in the lower mine, February 22, 1958. By Richard F. Myers.

Figure 12. The lower mine adit (“Devil’s Icebox) on February 22, 1958. By Richard F. Myers. Note the relative lack of rubble.

Figure 13. Icy interior of the lower mine about 30 m from the entrance. Doug Foster is near the remaining stull, Jim Kennedy on the right. By William R. Elliott, February 25, 2008.

Figure 14. Interior of the lower mine about 60 m in. By William R. Elliott, February 25, 2008.

Figure 15. Crushed stulls in the lower mine.
By William R. Elliott, February 25, 2008.

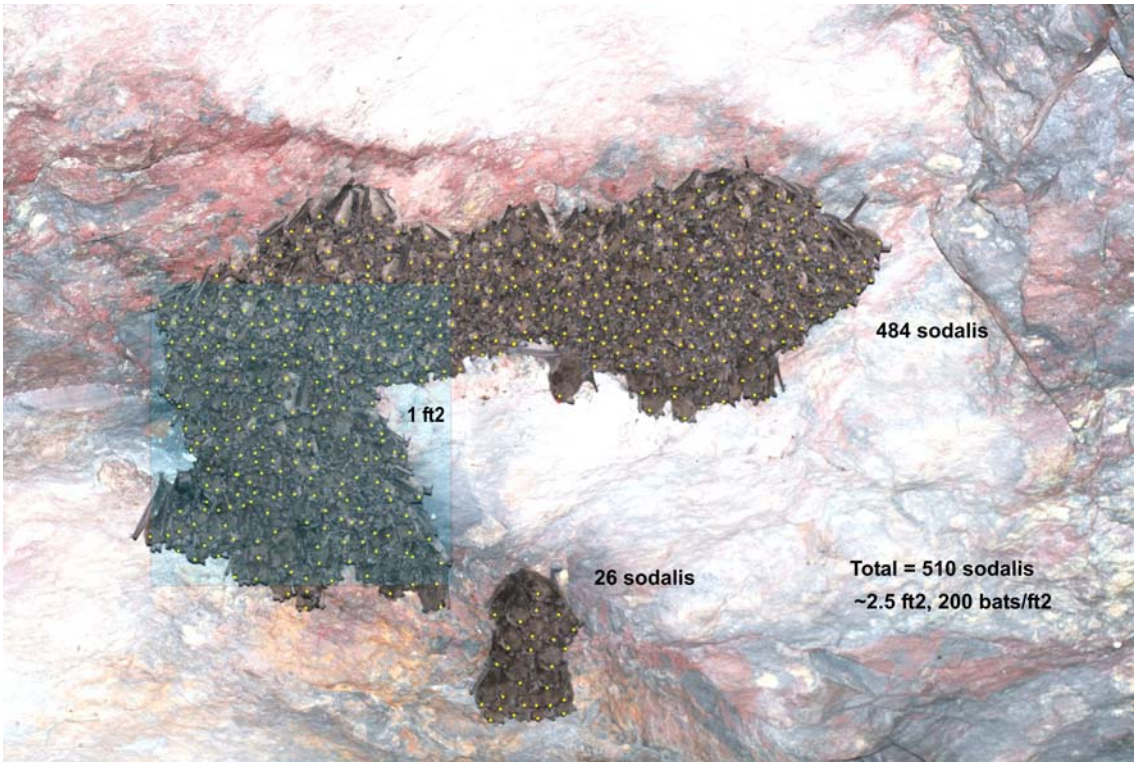

Figure 16. The largest cluster of hibernating Indiana bats in the lower mine.
By William R. Elliott, February 25, 2008.

Figure 17. A small cluster of hibernating Indiana bats in the lower mine.
By Jim Kennedy, February 25, 2008.

Figure 18. The largest cluster of hibernating Indiana bats in the upper mine.
By Jim Kennedy, February 25, 2008.

Figure 19. Partial collapse of the quarry walls and lower mine nearly closed the adit in 1979. The large, triangular boulder in front of the adit is at the right. By William R. Elliott looking uphill, February 26, 2008.

Figure 20. Bill Elliott at the boulder in front of the lower mine. This boulder may be blocking airflow and hindering bat access. By Jim Kennedy, February 25, 2008.

Figure 21. Doug Foster and Jim Kennedy at adit PKM1. William R. Elliott, February 26, 2008.

Figure 22. Top of the knob and upper quarry with the locations of adits PKM3-6 indicated. By William R. Elliott, February 25, 2008.

Figure 23. Adit PKM5 leads into the large upper mine, also connected to PKM4 and PKM6. By William R. Elliott, February 25, 2008.

Figure 24. Looking toward PKM5 from inside. By Jim Kennedy, February 25, 2008.

Figure 25. PKM4 leads into the large upper mine, but is too tight to enter or exit.

Figure 26. Dan Shamhart, FWS agent, at PKM6, which leads down a short drop into the large upper mine, and connects to PKM5 and PKM4. Old campfire on top of the large block. Photos by William R. Elliott, February 25, 2008.

Figure 27. Looking down into PKM7. Photos By William R. Elliott, February 25, 2008.

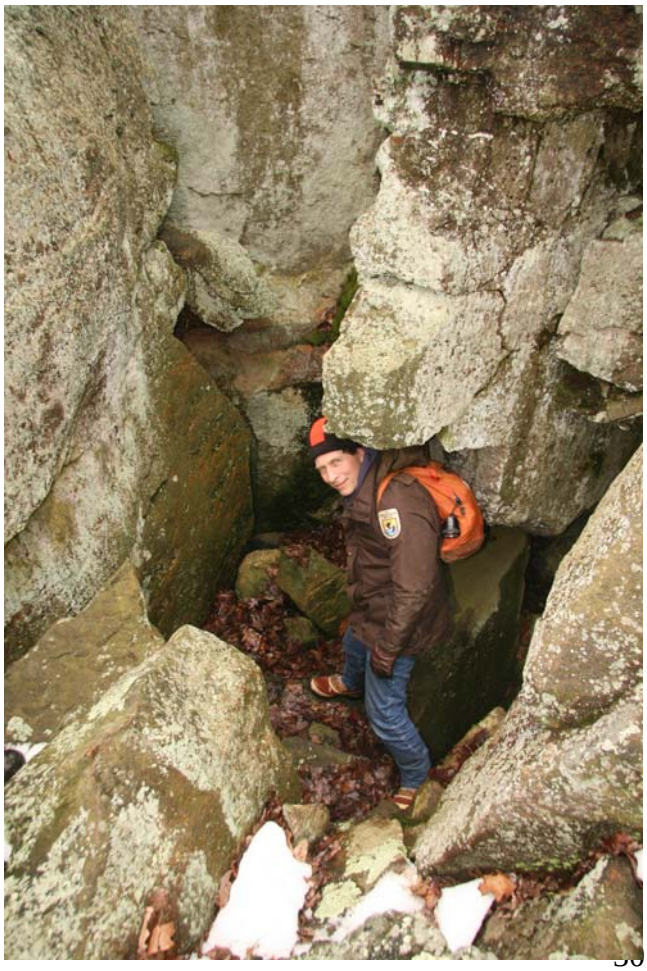

Figure 28. Scott Pruitt at PKM8.
By Jim Kennedy, February 25, 2008.

Figure 29. Scott Pruitt at PKM9. By William R. Elliott, February 25, 2008. (Bill33)

Fig. 30. A corner of the perimeter fence had fallen apart before this photo was taken by Willliam R. Elliott, February 25, 2008.

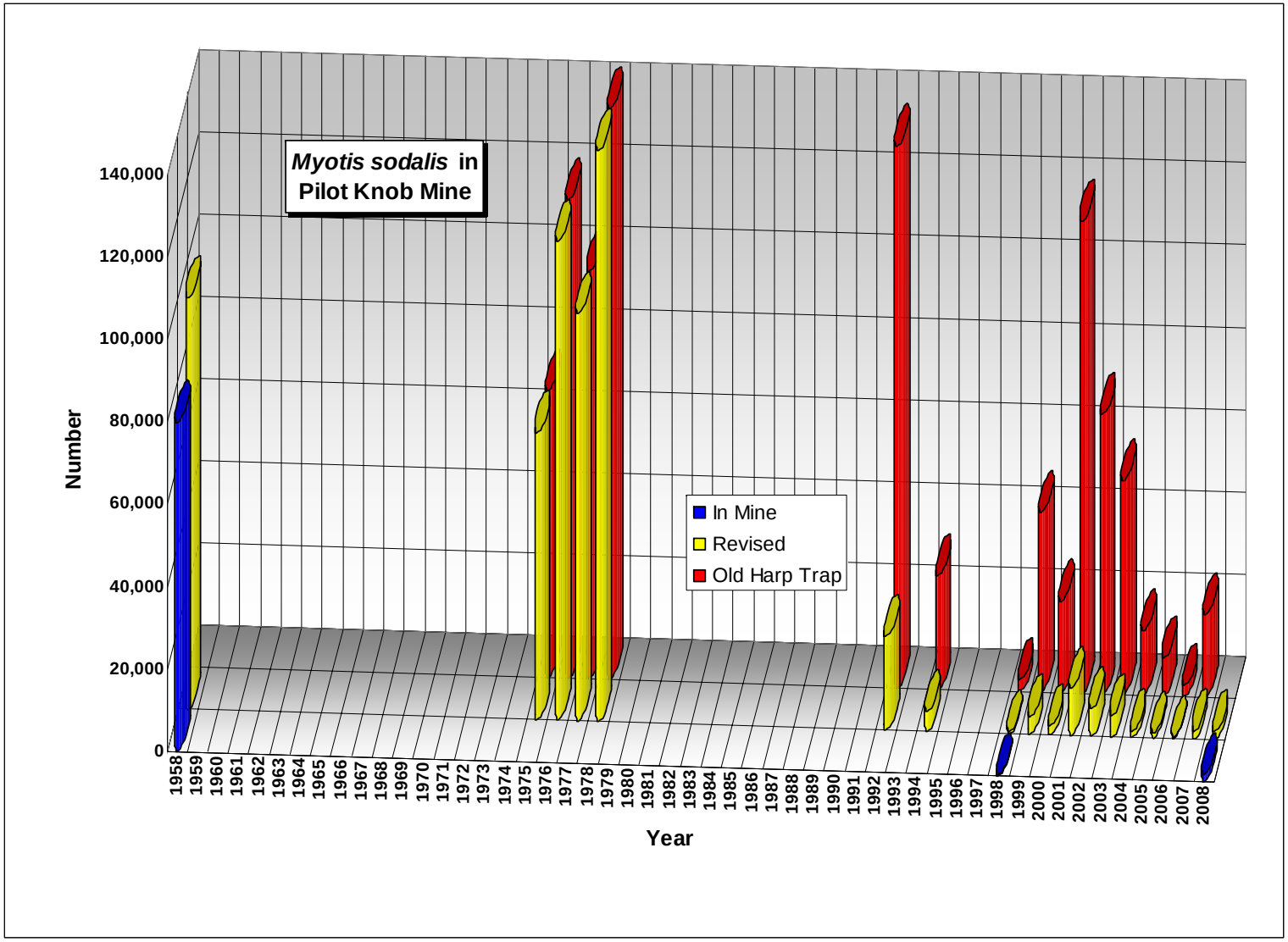

Figure 31. Three-dimensional graph of Indiana bats derived from the old harp trap results, in-mine counts, and a revised method.

Table 4. Results of the Pilot Knob Mine bat census, February 25-26, 2008. Myso = *Myotis sodalis*, Mylu = *Myotis lucifugus*, Myse = *Myotis septentrionalis*, Epfu = *Eptesicus fuscus*, Pesu = *Perimyotis (Pipistrellus) subflavus*

Pilot Knob Mine Locations and Notes*	**Time**	**IR Rock °C**	**IR Rock °C high**	**Probe Rock °C**	**Probe Air °C**	**Myso initial**	**Myso final**	**Myso/ft2**	**Mylu**	**Myse**	**Epfu**	**Pesu**	**All bats**
Lower Mine:													
Bill, Jim, Doug, Scott into Lower Mine	1:12 PM												
Area A, first alcove on left	1:15 PM	-3.8	-1.2									4	
Ice photos on first slope	1:24 PM												
VHF radio comm OK at stull. Much ice, temp. near floor	1:30 PM				3.8								
Area A, first alcove on left, crevice in floor		1.8											
Area A, first alcove on left, ceiling		3.4	4.6									4	
Area B, ceiling with 3 clusters of ~300 bats	1:49 PM	3.2	3.8			300							
Area B, floor, woodrat scat here		2.4											
Area B, rubble		1.4											
Area B, right alcove		4.4	6.0										
Area C, Jim, no photo?	2:15 PM					10	10						
Area C, 2nd alcove on left where 1st datalogger was, Bill, no photos	2:18 PM					2	2						
Area C, left alcove, mine counts, Bill, no photos						38	38						
Area C, left alcove, mine counts, Bill, no photos						4	4						

Pilot Knob Mine Locations and Notes*	Time	IR Rock °C	IR Rock °C high	Probe Rock °C	Probe Air °C	Myso initial	Myso final	Myso/ft2	Mylu	Myse	Epfu	Pesu	All bats
Area C, left alcove, mine counts, Bill, no photos						8	8						
Area C, left alcove, mine counts, Bill, no photos						2	2						
Area C, left alcove, mine counts, Bill, no photos						6	6						
Area C, left alcove, mine counts, Bill, no photos						1	1						
Area C, left alcove, mine counts, Bill, no photos						1	1						
Area C, left alcove, mine counts, Bill, no photos						6	6						
Area C, left alcove, mine counts, Bill, no photos						5	5						
Area C, left alcove, mine counts, Bill, no photos	2:25 PM			6.4	6.5	4	4						
Area C, left alcove, dead Myso, wet, emaciated, no fungus, Bill	2:25 PM					0	0						
Areas C, D, bat photos:	2:30 PM												
PKMLowcluster01Bill.jpg, 0.7 ft2							166	237			1		
PKMLowcluster02Jim.jpg, 0.4 ft2							57	143	1				
PKMLowcluster03Bill.jpg 0.2 ft2							27	135					
PKMLowcluster04Bill.jpg, 3 subclusters									28				
PKMLowcluster05Bill.jpg, 2.5 ft2							510	200					
PKMLowcluster06Jim.jpg, 2.5 ft2							310	124					

Pilot Knob Mine Locations and Notes*	Time	IR Rock °C	IR Rock °C high	Probe Rock °C	Probe Air °C	Myso initial	Myso final	Myso/ft2	Mylu	Myse	Epfu	Pesu	All bats
PKMLowcluster07Bill.jpg & PKMLowcluster07Jim.jpg							88						
PKMLowcluster08Bill.jpg							32						
PKMLowcluster09Jim.JPG, 0.2 ft2							25	125					
PKMLowcluster10Jim.JPG							11						
PKMLowcluster11Jim.jpg							10						
PKMLowcluster12Jim.JPG							86						
PKMLowcluster13Jim.JPG							37						
PKMLowEpfu1Bill.jpg											1		
PKMLowEpfu2Jim.jpg											1		
PKMLowPKMJim050.JPG									1				
Area C, mine counts, Jim						10							
Area C, mine counts, Jim						100							
Area C, mine counts, Jim						44							
Area C, mine counts, Jim		2.6	3.4			300							
Area C, mine counts, Jim						350							
Area E, mine counts and photos, sodalis in crack, Jim		2.8				50							
Area F, counts and photos, raccoon and woodrat scats												2	
Area C, photos of crushed stulls under rubble, Bill	2:48 PM												
Area C, general mine photos looking upwards, Bill	2:51 PM												
Area B, general mine photos looking up icy slope, Bill	2:59 PM												
Exit Lower Mine. Subtotal	3:10 PM					**1241**	**1446**		**30**	**0**	**3**	**10**	**1489**

Pilot Knob Mine Locations and Notes*	Time	IR Rock °C	IR Rock °C high	Probe Rock °C	Probe Air °C	Myso initial	Myso final	Myso/ft2	Mylu	Myse	Epfu	Pesu	All bats
Upper Mine:													
Mick, Jim, Doug, Scott into Upper Mine at PKM6 (largest adit)	3:45 PM												
Left alcove, all recounted on photos		1.7				165							
Left alcove, all recounted on photos						75					4	1	
Middle alcove		7.3											
Right alcove leading to PKM5		10.3										2	
Right alcove leading to PKM5												2	
Lower room, crack, recounted on photos		4.6				40				1		4	
Upper room leading to PKM4 (cannot exit), raccoon dung with		10.8											
bat bones, woodrat latrine													
UpperPKMJim093.JPG											1		
UpperPKMJim096.JPG, cluster 1							106						
UpperPKMJim098.JPG							1						
UpperPKMJim100.JPG, cluster 2, 4 subclusters in crack, "75" count?							53						
UpperPKMJim101.JPG, cluster 3							18						
UpperPKMJim102.JPG, cluster 4							20						
UpperPKMJim103.JPG, cluster 5							5						
UpperPKMJim105.JPG, , lower room from here on							1						

Pilot Knob Mine Locations and Notes*	Time	IR Rock °C	IR Rock °C high	Probe Rock °C	Probe Air °C	Myso initial	Myso final	Myso/ft2	Mylu	Myse	Epfu	Pesu	All bats
UpperPKMJim106.JPG							1						
UpperPKMJim107.JPG, cluster 6							8						
UpperPKMJim108.JPG, cluster 7							2						
UpperPKMJim109.JPG, cluster 8							14						
UpperPKMJim110.JPG									1				
UpperPKMJim111.JPG, cluster 9							3						
UpperPKMJim112.JPG										1			
Exit Upper Mine at PKM5. Subtotal for Upper Mine:	4:50 PM					**280**	**232**		**1**	**2**	**5**	**9**	**249**
Grand Total						**1521**	**1678**		**31**	**2**	**8**	**19**	**1738**

Table 5. A chronological list of 115 events, bat counts, harp-trap results, management actions, digital files and documents scanned from MDC files. See “General” worksheet in the attached Excel file.

Yr	Date	In Mine	Bats/Hr	Harp Trap	Event	filename
1815					Earliest iron mining in eastern Missouri (Kisvarsanyi 2001).	pkm 2001 geol article.pdf
1835					Iron mining began at Pilot Knob (Kisvarsanyi 2001).	pkm 2001 geol article.pdf
1848					Iron mining began at Pilot Knob (USGS 1967).	pkm 1967 mineral MO.pdf
1855					Litton published a description of Pilot Knob iron mining (USGS 1967).	pkm 1855 Litton geol.pdf
1864	9/26/1864				The Battle of Pilot Knob, Fort Davidson, Sept. 26-27. A Confederate brigade went over the top of Pilot Knob, engulfing a small Union force there. Union forces blew up the fort as they retreated.	
1873					Schmidt published a description of Pilot Knob iron mining (USGS 1967).	
1890					Mining ceased (USGS.1967. Mineral and Water Resources of Missouri. Vol. XLIII, Second Series, US Govt., Washington, DC.)	
1892					Frank L. Nason published a Report on iron ores in the Geological Survey of Missouri, Vol. 2 (USGS 1967), reviewed in The American Geologist, March 1893.	pkm 1892 Nason geol.pdf
1912					G.W. Crane published a study on iron deposits during a brief period when mining revived (Crane 1912, USGS 1967).	pkm 1912 Crane geol.pdf
1920					Mining ceased (Kisvarsanyi 2001.) Bats probably moved into the mine after this time period.	pkm 2001 geol article.pdf
1957					Hanna Mining Co. and Granite City Steel Co. announced discovery of deep iron deposits west of Pilot Knob, and plans to mine underground by 1968.	pkm 1967 mineral MO.pdf
1957	12/8/1957				Bob Wilkinson, L.B. Matthews and Mike Hull from Arcadia entered the lower mine and discovered hibernating bats.	pkm 2008 myers dates.pdf
1958	**2/22/1958**				**Richard Myers, Bob Wilkinson, L.B. Matthews and Mike Hull photographed Myso (*Myotis sodalis)* in the Lower Mine (Devil's Icebox). Photos scanned by William R. Elliott, 2008, are good enough for re-estimate. About 500-528 bats/ft.2 from one photo (Elliott).**	pkm 2008 myers dates.pdf & photos
1958	4/11/1958				Richard Myers, Bob Wilkinson, L.B. Matthews and Mike Hull visited the lower mine.	pkm 2008 myers dates.pdf

Yr	Date	In Mine	Bats/Hr	Harp Trap	Event	filename
1958	**12/27/1958**	**80,000**			**Richard Myers, Bob Wilkinson, L.B. Matthews and Mike Hull visited the lower mine. Myers made his most thorough attempt to estimate the bat populations using 220 bat/ft.2**	pkm 2008 myers dates.pdf
1960					Richard Myers' final trip to the lower mine, March.	pkm 2008 myers dates.pdf
1967					Brief description of Pilot Knob iron mine in USGS (1967).	pkm 1967 mineral MO.pdf
1975	9/30/1975		621		Harp trap trip #1 to the Lower Mine (Devil's Icebox) by LaVal et al.	pkm 1975-1981 Clawson bat summary.pdf
	10/12/1975		**626**	**139,486**	Harp trap. LaVal 1978 estimate method retrospectively applied. 626 total or per hr.?	pkm 1976-10-12 count.tif
1976	10/12/1976		**522**	**116,312**	Harp trap. LaVal 1978 estimate method retrospectively applied. 1044 total.	
1977					Realty report by USFWS.	pkm 1977-12-09 realty.pdf
1977	4/7/1977		109		Harp trap. Not used for pop estimate.	
1977	4/15/1977		297		Harp trap. Not used for pop estimate.	
1977	4/28/1977		148		Harp trap. Not used for pop estimate.	
1977	6/19/1977		201		Harp trap. Not used for pop estimate.	
1977	8/6/1977		127		Harp trap. Not used for pop estimate.	
1977	9/21/1977		444	98,932	Harp trap. LaVal 1978 estimate method retrospectively applied.	
1977	10/20/1977		**189**		Harp trap. Not used for pop estimate.	
1978	3/29/1978		638		Harp trap. Not used for pop estimate.	pkm 1978 agreement.pdf
1978	4/12/1978		299		Harp trap. Not used for pop estimate.	pkm 1978 cards.tif
1978	9/23/1978		723	161,099	Harp trap. LaVal 1978 estimate method retrospectively applied. Probably 723 bats/hr. from 1446 total, but not certain.	pkm 1978 USGS geol map portion.tif
1978	**10/12/1978**		**623**	**138,817**	**Harp trap. LaVal reports 135,000-139,000 in the mine based on trapping rates compared to Great Scott Cave.**	**pkm 1978-11-17 Laval bat calc.pdf**
1978	10/21/1978		**405**	90,242	Harp trap. LaVal 1978 estimate method applied.	pkm 1978-08-15 access.pdf
1978	8/24/1978				Access to mine for Richard and Margaret LaVal negotiated by MDC.	pkm 1978-08-24 access.pdf
1978	11/17/1978				In a letter to USFWS, Richard LaVal estimated 135,000-139,000 Myso in the mine based on harp trapping there and at Great Scott Cave, which had harp trapping and an in-cave estimate.	pkm 1978-11-17 Laval bat calc.pdf
1979					Realty appraisal, probably 1978 or 1979.	pkm 1978-79 appraisal.pdf
1979	**5/25/1979**				**Richard LaVal noted "A collosal collapse has occurred, blocking the two entrances used by bats…We suspect foul play, but saw no evidence of same." No harp trap estimates until 1992.**	pkm 1979-05-25 collapse no count.tif & .doc

Yr	Date	In Mine	Bats/Hr	Harp Trap	Event	filename
1979	10/26/1979				Cover memo and letter to LaVal that a federal agent investigated the mine collapse and found no evidence of a violation after interviewing Pilot Knob Pellet Co. employees, who claimed that freeze/thaw probably caused the collapse.	pkm 1979-06-13 collapse.pdf
1979					Note by Richard Myers with a sketch of where the Myso and Mylu used to be in 1958. Apparently the lower mine used to be more extensive.	pkm 1979-10-26 re Myers photos.pdf
1981	4/21/1981				Rick Clawson notes about visiting the entrance and observing numerous bats exiting, entrance about the same as last year. No trapping this date.	pkm 1981-04-21 no count.tif
1981	10/22/1981				Conservation Agent Bob White's note that bats were being slaughtered at the mine, blood on rocks, numerous bat wings scattered about.	pkm 1981-10-22 predators.tif
1981	11/3/1981				Bob White's memo that Ralph Duren trapped a large male opossum at the mine entrance with 14 bat wings in his stomach. Probably had eaten hundreds of bats.	pkm 1981-11-03 predators.pdf
1981	11/12/1981				Clawson memo about the opossum. The constricted entrance makes it easier for predation.	pkm 1981-11-12 predators.pdf
1985	10/21/1985				Clawson memo, mine breathing in, much scattered guano on rocks, no signs of dead bats, large numbers must still be using mine.	pkm 1985-10-11 status.pdf
1986	10/21/1986				Anon. notes about cost of gating mine by Don Rimbach, caver.	pkm 1986-10-21 gate.tif
1986	9/15/1986				John Wylie, MDC, notes about Rimbach, rescue.	pkm 1986-09-15 rescue.tif
1986	9/17/1986				Mountain Echo, Ironton, news articles about the rescue of 17-year-old Gerald Dwayne Easter, who was caught under a boulder while exploring with Eric Bennett. The accident probably occurred 9/16/1986, paper is dated 9/17/1986.	pkm 1986-09-17 rescue.pdf
1986	9/14/1986				Anon. notes about Gerald Dwayne Easter rescue.	pkm 1986-09-x rescue.tif
1986	10/2/1986				Offer to sell mine for $100 per ac.	pkm 1986-10-28 sell.pdf
1986	11/12/1986				Jim H. Wilson, MDC, notes about 9 adits, in/out airflow, bat guano etc. Recommended sealing small holes, gate Icebox entrance, tubes be installed in the two larger openings (#2 and 3).	pkm 1986-11-12 adits.tif
1986	11/13/1986				Jim H. Wilson, memo about the 12 entrances on top besides the Icebox, closing smaller ones including the Simpson Shaft on the south side, gates, tubes.	pkm 1986-11-13 alternatives.pdf
1986	11/25/1986				Larry Gale, MDC Director, declined Pilot Knob Ore Co. offer to sell, but recommended that they donate it to USFWS.	pkm 1986-11-25 mine offer.pdf

Yr	Date	In Mine	Bats/Hr	Harp Trap	Event	filename
1987					Endangered Species Technical Bulletin article on mine and 90 ac. donated to USFWS.	pkm 1987 ESTB article.pdf
1987					Draft article by Michael Sweet about the $43,000 fence built by MDC around the mine, 90% reimbursed by USFWS.	pkm 1987 fence article.pdf
1987	7/13/1987				Anon. notes about cooperative work, barricades on roads, signs, etc.	pkm 1987-07-13 alternatives.PDF
1987	7/17/1987				Deed and description of 90 ac. donated to USFWS.	pkm 1987-07-17 deed.pdf
1987	8/1/1987				Illustration from Reader's Digest article "19 Hours in Devil's Icebox", showing the trapped boy and fear.	pkm 1987-08 fear.tif
1987	8/1/1987				Reader's Digest article about the Dwayne Easter rescue. The last sentence claims that the mine collapsed on 9/16/1986, two days after the rescue, but that is inaccurate.	pkm 1987-08 rescue Readers Digest.pdf
1987	8/24/1987				Clawson? Notes, visited mine entrance, Rimbach's incomplete gate should be removed, no counts.	pkm 1987-08-24 no count.tif
1987	9/1/1987				USFWS and MDC sign an MOU agreeing to co-manage Pilot Knob National Wildlife Refuge. A conservation agent shall be commissioned as a U.S. Deputy Game Warden, 90/10 fence costs, etc.	pkm 1987-09-01 mou.pdf
1987	9/16/1987				Memo from MDC to USFWS about MOU.	pkm 1987-09-16 mou memo.pdf
1987	10/29/1987				Approx. map of fence.	pkm 1987-10-29 fence map.pdf
1987	11/10/1987				Approx. map of fence.	pkm 1987-11-10 fence map.pdf
1987	12/3/1987				Fence discussion and details.	pkm 1987-12-03 fence.pdf
1987	12/15/1987				Fence discussion and details.	pkm 1987-12-09 fence.pdf
1987	12/15/1987				Fence security discussion.	pkm 1987-12-15 fence.pdf
1988	4/4/1988				Bats striking remains of Rimbach's gate, 60 fresh bat wings and blood found, removed gate.	pkm 1988-04-04 bat deaths.tif
1988	9/28/1988				Memo from Jim H. Wilson about closures and fences.	pkm 1999-09-28 fence.pdf
1988	10/11/1988				Visit inside fence, planning, evidence of trespass found.	pkm 1988-10-11 fence.pdf
1988	10/11/1988				International Geological Congress, access to hill by MO DNR geologists granted.	pkm 1988-10-11 geologists.pdf
1988	10/20/1988				Re photos of fence.	pkm 1988-10-20 fence.pdf
1989	9/18/1989				Re access by geologists.	pkm 1989-09-18 geologists.pdf
1992	10/6/1992		**592**	**131,910**	Harp trap. LaVal 1978 estimate method applied.	pkm 1992-10-06 count.tif
1992	12/18/1992				Rick Clawson letter to Gerry Clawson with bat calculations.	pkm 1992-12-18 Clawson bat calc.pdf
1994	10/11/1994		**124**	**27,630**	Harp trap. LaVal 1978 estimate method applied. 280 total.	pkm 1994-10-11 count.tif
1995	10/16/1995				Notes re Ben Duffield's effort to buy 400 ac. around refuge to donate	pkm 1995-10-16 realty.tif

Yr	Date	In Mine	Bats/Hr	Harp Trap	Event	filename
					to DNR.	
1995	11/27/1995				Ben Duffield, map of land optioned around refuge.	pkm 1995-11-27 map note.tif
1996	10/8/1996				Clawson, much bat activity at entrance, air being sucked into [lower] mine.	pkm 1996-10-08 no count.tif
1997	4/17/1997		36		Harp trap. Not used for pop estimate.	pkm 1997-04-17 count.tif
1998	9/18/1998				BCI filed a report on the mine. Hobo Pro data loggers were placed in mine by Jim Kennedy, Bill Elliott, Steve Schmauch for a 3-year study. Few bats in lower mine, but too early to count.	pkm 1998-09-18 BCI report.pdf
1998	10/29/1998		**13**	**2,897**	Harp trap. LaVal 1978 estimate method applied. 33/2.5 hrs = 13/hr.	pkm 1998-10-29 count.tif
1999	2/1/1999	**303**			Jim Kennedy and Sheryl Ducummon, BCI, filed a report on the Lower Mine. Saw only 303 Myso. Exact date not given.	pkm 1999-02-22 BCI report.pdf
1999	9/30/1999		**196**	**43,673**	Harp trap. LaVal 1978 estimate method applied. 294/1.5 hrs = 196 bats/hr.	pkm 1999-09-30 count.tif
1999	10/7/1999				Clawson letter about number of bats trapped.	pkm 1999-10-07 bat results.pdf
2000	4/3/2000				No NWF grant for bat gate.	pkm 2000-04-03 no grant.pdf
2000	5/30/2000				USFWS agreement with MDC for $4,150 for bat gate.	pkm 2000-05-30 agreement.pdf
2000	10/24/2000		**100**	**22,282**	Harp trap. LaVal 1978 estimate method applied. 200/2.0 hrs.	pkm 2000-10-24 count.tif
2000	10/30/2000				Clawson letter about harp trapping, hole in fence, 2 juveniles seen leaving after re-opening hole.	pkm 2000-10-30 bat results.pdf
2001					Geology article by Eva B. Kisvarsanyi, MO DNR/DGLS. The iron body was deposited in sedimentary tuffs, and is very unusual.	pkm 2001 geol article.pdf
2001	7/12/2001				Planning notes for bat gate.	pkm 2001-07-12 gate notes.tif
2001	7/18/2001				Roy Powers, Kristen Bobo, Rick Clawson et al. constructed a bat gate on the Lower Mine, July 15-18, 2001. Total cost $4,862.16.	pkm 2001-07-18 gate bills.tif
2001	7/18/2001				Business cards for Roy Powers, Kristen Bobo.	pkm 2001-10 cards.tif
2001	8/16/2001				FAX cover sheet from Clawson about estimation method of Myso.	pkm 2001-08-16 fax.tif
2001	8/16/2001		**148**	**33,021**	Clawson estimated mine pop. at 50,545 based on 1999-2000 trapping rates, but scaled off the wrong rate of 407 (or 404?) of 10/21/78. He should have used the 10/12/78 rate of 623 (the one to obtain 139,000), yielding 33,021.	pkm 2001-08 Clawson bat calc.pdf
2001	8/21/2001				Clawson notes about gate expenses.	pkm 2001-08-21 notes.tif
2001	10/2/2001		**515**	**114,753**	Harp trap. LaVal 1978 estimate method applied. 772 /1.5 hrs. = 515/hr.	pkm 2001-10-02 count.tif

Yr	Date	In Mine	Bats/Hr	Harp Trap	Event	filename
2001	10/2/2001				Bill Elliott's notes on trip into the Lower Mine with Mick Sutton, 10/2/01. They retrieved data logger data, temperatures, and noted bats 1:40-3:45 PM. They saw a scat 10 m into mine, 1 Myso, 1 Myse, 1 Pisu. Photos of coon? scats on top of gate and bat carnage.	pkm 2001-10-02 mine notes.tif
2001	11/1/2001				Notes on Charlie Schaiffer finding dead Myso that struck the gate.	pkm 2001-11-01 bat deaths.tif
2001	11/6/2001				USFWS report on harp trapping, bat gate, Myso striking gate, predation, removal of bars in gate.	pkm 2001-11-06 FWS bats report.pdf
2001	12/11/2001				Email from Kristen Bobo about the gate problem.	pkm 2001-12-11 email.pdf
2002	1/1/2002				Email to dun USFWS for cost of gate.	pkm 2002 email.pdf
2002	2/12/2002				Cover memo about the gate problem.	pkm 2002-02-12 memo.pdf
2002	2/26/2002				Jim Kennedy's letter recommending removal or reduction of boulder in front of entrance, remove gate or build larger cage gate, and monitor predation. The gate was cut out but the boulder was never removed.	pkm 2002-02-26 BCI gate problems.pdf
					Report on construction of bat gate by Clawson.	pkm 2002-08-12 gate.pdf
2002	10/1/2002		**305**	**67,960**	Harp trap. LaVal 1978 estimate method applied. 609 bats/2.0 hrs = 305/hr.	pkm 2002-10-01 count.tif
					Clawson summarized 1991-2002 harp trapping rates.	pkm 2002-10-07 bat summary.pdf
2003	10/21/2003		**233**	**51,917**	Harp trap. LaVal 1978 estimate method applied. 408 bats/1.75 hrs = 233/hr.	pkm 2003-10-21 count.tif
2003	10/27/2003				Clawson summarized 2003 harp trapping rates. He noted the fence was split open enough for 4-wheelers, which left tracks inside, and bottom of fence propped up to allow intruders to crawl inside refuge.	pkm 2003-10-27 bat results.pdf
2003	12/19/2003				Kathleen Maycroft invited Clawson et al. to Jan. 13 meeting at Fort Davidson Restaurant. Did not mention it was an open public meeting.	pkm 2003-12-19 meeting.pdf
2003	12/30/2003				Discussion about attending meeting.	pkm 2003-12-30 planning.pdf
2004	1/13/2004				Pilot Knob meeting attended by Rick Clawson, Bill Elliott, Paul McKenzie, Kathleen Maycroft and other govt. reps., but also local citizens and politicians. The mayor of Ironton spoke vehemently to get rid of the bats in the mine, that they might come down and bite people, and basically demanded that FWS open the top of the Knob to public access for tourism. Elliott and McKenzie tried to explain the value of bats, but the mayor was adamant. The meeting did not go well.	
2004	10/22/2004		**70**	**15,597**	Harp trap. LaVal 1978 estimate method applied. 157 bats/2.25 hrs = 70/hr.	pkm 2004-10-22 count.tif

Yr	Date	In Mine	Bats/Hr	Harp Trap	Event	filename
2004	10/19/2005		**50**	**11,141**	Harp trap. LaVal 1978 estimate method applied. 106 bats/2.58 hrs = 41/hr. total, butsctually was less effective time, about 2.1 hrs. Rate was low, reported as 50/hr.	pkm 2005-10-19 count.tif
2005	10/21/2005				Harp trap results. Rate was low. Clawson noted that the hole in the fence had reopened in the usual place, and 4-wheelers had been inside.	pkm 2005-10-21 bat results.pdf
2006	10/19/2006		**12**	**2,674**	Harp trap. LaVal 1978 estimate method applied. 23 bats/2.0 hrs = 12/hr.	pkm 2006-10-19 count.tif
2007	4/17/2007				FWS' Comprehensive Conservation Plan for Mingo NWR, including Pilot Knob.	pkm 2007-04-17 ccp.pdf
2007	5/1/2007				Summary of FWS' Comprehensive Conservation Plan for Mingo NWR, including Pilot Knob.	pkm 2007-05 summary CCP.pdf
2007	9/21/2007		**90**	**20,054**	Harp trap. LaVal 1978 estimate method applied. Highest trap rate in 4 years.	pkm 2007-09-19 count.tif , pkm 2007-09-21 rev count.tif
2008	2/26/2008	**1,678**			Bill Elliott, Jim Kennedy, Mick Sutton, Scott Pruitt, Doug Foster checked the Lower and Upper mines, February 25-26.	This report

Table 6. In-mine counts, revised harp-trap estimates, old harp-trap population estimates, and trapping rates for *M. sodalis* (Myso). See Figure 31 and "Myso" worksheet in the attached Excel file.

Year	In Mine	Revised	Old Harp Trap	Bats/Hr	Visit Date	Event
1958	80,000	**[100,000]**			12/27/1958	February, Richard Myers photographed and estimated 80,000 Myso (*Myotis sodalis)*in the Lower Mine (Devil's Icebox. Increased to 100,000 based on high density of bats in 2/22/1958 photos.
1975		69,835	69,743	313	10/12/1975	Harp trap. LaVal 1978 estimate method retrospectively applied. 626 total?
1976		116,465	116,312	522	10/12/1976	Harp trap. LaVal 1978 estimate method retrospectively applied. 1044 total.
1977		99,063	98,932	444	9/21/1977	Harp trap. LaVal 1978 estimate method retrospectively applied. 888 total? 444/hr.?
1978		161,311	161,099	723	9/23/1978	Harp trap. LaVal 1978 estimate method retrospectively applied. Probably 723 bats/hr. from 1446 total, but not certain.
1978		**139,000**	138,817	**623**	10/12/1978	Harp trap. LaVal reports 135,000-139,000 in the mine based on trapping rates compared to Great Scott Cave.
1978		15,577	90,242	405	10/21/1978	Harp trap. LaVal 1978 estimate method applied.
1992		22,769	131,910	592	10/6/1992	Harp trap. LaVal 1978 estimate method applied.
1994		4,769	27,630	124	10/11/1994	Harp trap. LaVal 1978 estimate method applied. 280 total.
1998	303	**500**	2,897	**13**	10/29/1998	Harp trap. LaVal 1978 estimate method applied. 33/2.5 hrs = 13/hr. However, this was late Oct. and probably was low. Jim Kennedy and Sheryl Ducummon, BCI, went in Lower Mine 2/7/1999, filed a report. Saw only 303 Myso. Exact date not given.
1999		4,356	43,673	196	9/30/1999	Harp trap. LaVal 1978 estimate method applied. 294/1.5 hrs = 196 bats/hr.
2000		2,222	22,282	100	10/24/2000	Harp trap. LaVal 1978 estimate method applied. 200/2.0 hrs.
99-2000		3,289	33,021	148	8/1/2001	Clawson estimated mine pop. at 50,545 based on 1999-2000 trapping rates, but scaled off the rate of 407 (actually 404) of 10/21/78. The correct rate on 10/12/78 was 623, yielding 33,021.
2001		11,444	114,753	515	10/2/2001	Harp trap. LaVal 1978 estimate method applied. 772 /1.5 hrs. = 515/hr.
2002		6,778	67,960	305	10/1/2002	Harp trap. LaVal 1978 estimate method applied. 609 bats/2.0 hrs = 305/hr.
2003		5,178	51,917	233	10/21/2003	Harp trap. LaVal 1978 estimate method applied. 408 bats/1.75 hrs = 233/hr.
2004		1,556	15,597	70	10/22/2004	Harp trap. LaVal 1978 estimate method applied. 157 bats/2.25 hrs = 70//hr.
2005		1,111	9,136	50	10/21/2005	Harp trap. LaVal 1978 estimate method applied. 106 bats/2.1 hrs = 50/hr.
2006		267	2,674	12	10/19/2006	Harp trap. LaVal 1978 estimate method applied. 23 bats/2.0 hrs = 12/hr.
2007		**2,000**	20,054	**90**	9/21/2007	Harp trap. LaVal 1978 estimate method applied.
2008	1,678	2,000			2/25/2008	Bill Elliott, Jim Kennedy, Mick Sutton, Scott Pruitt, Doug Foster checked the Lower and Upper mines, March 25-26.

Appendix.

Proposal to Census Bats in Pilot Knob Mine

William R. Elliott, Ph.D.
Missouri Department of Conservation
Resource Science Division

Jim Kennedy
Bat Conservation International

January 16, 2008
Revised February 7, 2008

We propose entering Pilot Knob Mine, Iron County, Missouri (a Priority 1A hibernaculum), on about February 25–26, 2008, to take a new direct count and a few photos of hibernating Indiana bats, *Myotis sodalis*. This project will directly support the April 2007 Indiana bat draft recovery plan (U. S. Fish and Wildlife Service. 2007. Indiana bat (*Myotis sodalis*) draft recovery plan, first revision. U. S. Fish and Wildlife Service, Fort Snelling, Minnesota. 258 pp.). In particular, this project will address Recovery Action 1.1.1.1 (Assess current threats and conservation measures at all P1 and P2 hibernacula and develop a prioritized list of hibernacula in need of remedial actions), 1.1.1.7 (Provide guidance to local management authorities on procedures for alleviating human disturbance at hibernacula within their jurisdictions), 1.3.1.1 (Survey extant populations in all P1 and P2 hibernacula every two years), 1.3.4 [especially] (Research, develop, and field test alternative methods of surveying Pilot Knob Mine in Missouri), and 3.2.2.2 (Characterize and monitor temperature, humidity, and air flow conditions in all Priority 1 hibernacula, and in selected Priority 2 and Priority 3 hibernacula.

We had a conference call of Missouri Department of Conservation, US Fish & Wildlife Service and Bat Conservation International on Elliott's first proposal on January 15. All agreed that the census was essential to the Recovery Plan, but the initial proposal needed a safety plan and modifications based on additional information and photographs from Dr. Richard (Dick) Myers' 1958 research at Pilot Knob Mine.

Elliott, a Fellow and an Honorary Member of the National Speleological Society, has over 40 years of experience in hundreds of caves across North America. He worked in a mine with two assistants for the Corps of Engineers in California in 1977–79, and he visited Pilot Knob Mine five or six times between 1998 and 2001 for a temperature data-logger study with BCI. Elliott teaches caving and cave ecology for MDC, and he has not had a significant accident in a cave or mine. Bill was on two cave rescue teams in 1971 and 1980. Kennedy is BCI's Bat Cave Specialist, with over 35 years of caving and mine experience in many states and countries; was a former Cave Rescue Instructor with the Eastern Region of the National Cave Rescue Commission and holds certification in Abandoned Mine Entry from the US Forest Service National Minerals Training Office. He is also a Fellow and Life Member of the National Speleological Society. He will bring an MSA Solaris 4-gas monitor for this particular study.

Until recently, most bat researchers were unaware of additional extant openings to the Pilot Knob Mine, and therefore winter counts and emergence estimates do not accurately reflect the current population status. In February 1999 Kennedy and Sheryl Ducummon observed only 303

sodalis in the lower (known) mine. LaVal, Clawson and others have been performing harp-trap collections during swarming periods as a population estimate technique, but this was also only at the lower entrance. Elliott recently examined the harp trap data, and the bats-per-hour catch rate at the lower mine entrance has fallen off dramatically since the 1970s such that the current estimate may only represent 10,000–20,000 bats, not the 50,000 that has been assumed for years.

In comparison, Myers counted 80,000 *sodalis* in an upper part of the mine on February 22, 1958, but that part has been unknown to recent researchers and unentered by bat biologists since that time.

Myers sent Elliott his photos he took in the upper mine in 1958, which Elliott scanned. These black and white and color scans are being shared with FWS and BCI (attached). They clearly show a very large colony, which probably can be re-estimated using graphical techniques. In our opinion there easily were 80,000, perhaps 100,000 bats.

The mine adit leading to the bats is clearly shown in one photo, but it is not either of the two adits Elliott or Kennedy has seen. Myers says that he always came in from the east side of the knob, not the south side that we are familiar with. His photos show that the mine probably is not as hazardous as one might imagine. Old roof supports (tree trunks) that were installed in the mine were still standing intact more than 50 years after mining ceased, even though they were largely rotten. That indicates that the ceiling is more stable than long supposed.

Elliott is experienced in Indiana and Gray bat census, having worked with Rick Clawson for ten years. Last winter he and Clawson took many photos of hibernating *sodalis* at the request of FWS, which were used in an alternate census method. Elliott recently obtained a 10.2 megapixel Canon digital SLR camera and new flash units, which he will use to take high-resolution photos of the larger clusters if necessary. Kennedy is likewise veteran of many Indiana and Gray bat censuses over the past 20 years and also photographs clusters of hibernating bats.

Elliott is preparing a paper for the Proceedings of the 2007 National Cave & Karst Management Symposium on "Gray and Indiana Bat Trends in Missouri," with revised graphs of *sodalis* data. We need a better estimate of this species in Pilot Knob Mine for several reasons. The harp trap data are interesting and useful, but unfortunately they do not provide a real census, especially if the trap is at the wrong adit.

We need to comb the knob more thoroughly, taking precise GPS fixes on the known adits, and looking for a smaller adit more on the north or east side of the hill. This, according to Myers, could be the third one reported by FWS on September 19, 2007. There may be *sodalis* hibernating in more places up there than we know or have visited.

For safety, we will enter the mine with three to four people: Elliott, Kennedy and probably Doug Foster (Elliott's intern, who is experienced in caving and bat identification) and possibly Mick Sutton of the Cave Resources Foundation). Foster is learning winter bat survey methods. Elliott and Kennedy and Sutton have been in the lower mine several times and are familiar with the terrain and potential hazards. We will take a 4-gas meter and proceed slowly. If the meter indicates hazardous conditions, we will exit immediately, but based on experience, such conditions probably will not occur.

Further safety plans include having additional support personnel on the surface with radio or cell phone communication to local EMS (which will be alerted and on standby during our entry) and prepared to assist underground if necessary. For personnel safety, to minimize disturbance to the bats and habitat, and to avoid unwanted local (and media) attention, the surface team will consist of no more than 4 additional persons.

Each person entering the mine will have a good UIAA-approved helmet with non-elastic chin strap, electric headlamp, and two back-up lights (usually small flashlights or headlamps) with spare batteries. Team members will provide their own equipment. Each will dress in field clothes or coveralls appropriate to the cold and rugged conditions, with gloves, kneepads, and lace-up hiking boots with good grip soles.

The lower mine has a stable ceiling but steep slopes, and one must climb down over potentially loose boulders, then walk across areas that are sometimes bedrock, sometimes loose rubble. The loose rubble slopes require checking each footstep before taking the next so as not to dislodge rocks, which are hard, sharp-edged, angular rhyolite. On steep slopes the people should space themselves so that a dislodged rock will not hit the others. Constant communication about conditions and what each is doing is required. It is standard practice to shout "rock" if anything is dislodged. We will take a small first-aid kit. This is standard caving procedure.

We plan to count the bats using several methods: direct count, area and density measurements, and digital photography of larger clusters, as per new USFWS recommendations. We will take temperatures with digital thermometers and documentary photos of the mine, but we will limit this so as not to disturb the bats excessively. One person will be designated as note taker. Dimensioned sketch maps of the mine spaces will be made.

We will not enter the mine wearing a harness or attached to a safety rope. One has to downclimb several spots and go around two corners in the lower mine. Such a rope would only hang up, tangle, dislodge rocks and decrease safety. We plan to carry a short handline to possibly assist us on steep slopes. We do not plan rappel or ascend ropes in the mine, even though we are equipped and trained for that, as it would be risky with the loose rubble. We will have such equipment ready and available on the surface, however, should it be necessary.

If possible, we will try and establish communications into the mine via a long wire and VHF radios, which probably will not transmit out of the mine by themselves.

Elliott can pick up Kennedy at the St. Louis Airport and bring him to Pilot Knob. The FWS has offered to support Kennedy's travel costs. The survey will be followed within one month by a report by Elliott and Kennedy and pre-print of Elliott's paper, with photos and data. It is essential that FWS permission be given as soon as possible and travel support be provided to Kennedy to make this survey possible.

Attachment

Computer disk with photos and documents