

Missouri Bat Hibernacula Results of 2011-2017, Following White-nose Syndrome Arrival



Missouri Department of Conservation



Citation: Colatskie, Shelly. (2017). Missouri Bat Hibernacula Survey Results from 2011-2017, Following White-nose Syndrome Arrival. *Missouri Department of Conservation, Technical Brief.*



Cover Photo: A northern long-eared bat (*Myotis septentrionalis*) exhibiting signs of white-nose syndrome with the fungus *Pseudogymnoascus destructans* presence on the specimen's wing membranes, forearm, and face. Photo: Ron Colatskie (MDNR).

Contents

Definitions:	iii
Missouri Bat Hibernacula Survey History and Methodology	1
White-nose syndrome in Missouri and Current Status	1
2011 – 2017 Hibernacula Survey Highlights:	3
2016/2017 Winter Hibernacula Bat Population Count Summary:	3
Discussion and Outlook for Missouri Bat Populations	3
Collaborators	4
Figures and Tables	5
Table 1. Indiana bats population estimates in 11 major Missouri hibernacula from 1979-2017	6
Table 2: Gray bat counts at the 4 major gray bat hibernacula in Missouri. * During the 2014/2015 survey at Martin Cave, a major hibernating population of gray bats was discovered in a room that had never been surveyed.	7
Table 3. Population counts between 2012/2013 and 2016/2017 at 183 Missouri hibernacula of all documented bat species post-discovery of WNS in the state (winter 2011/2012).	7
Table 4. USFWS standardized Indiana bat count years between 2010/2011 and 2016/2017 in Missouri and number of hibernacula surveyed and associated population. These numbers do not include population counts from SNP.	8
Table 5. Summary of Missouri bat hibernacula surveyed between 2010/2011 and 2016/2017, encompassing 850 unique hibernacula in 66 counties. *The year the state wide cooperative hibernacula surveys began. ** Do to data sharing agreement issues with particular intra-agency partners, only caves surveyed by MDC personnel are included.	8
Table 6: Total number of individuals per species observed in 502 hibernacula during 2016/2017, with the number of hibernacula each species was observed.....	8
Table 7. Population counts between 2010/2011 and 2016/2017 at 20 Missouri hibernacula of four species with the largest documented declines from WNS in North America.....	9
Literature Cited	10

Definitions:

Priority 1 Indiana bat hibernacula: sites which historically or presently harbor 10,000 or more Indiana bats (USFWS, 2007).

Priority 2 Indiana bat hibernacula: sites with historic or current numbers between 1,000 to 9,999 Indiana bats (USFWS, 2007).

Priority 1 gray bat hibernacula: sites which historically or presently harbor greater than 25,000 gray bats (USFWS, 1982)

White-nose Syndrome (WNS): A skin infection of hibernating bats caused by fungal agent (*Pseudogymnoascus destructans*) which through completely described processes, causes mortality in several species of cave-hibernating bats.

WNS Suspect: Location where WNS fungus visibly observed on bats or swabs have tested positive for the genetic presences of the fungus that causes WNS. This status can be assigned at the site and county scale.

WNS Confirmed: Location where WNS disease process was confirmed through histological examination of a whole bat carcass or skin samples at an approved laboratory.

Missouri Bat Hibernacula Survey History and Methodology

With over 7,000 known natural caves and more than 8,400 abandoned subterranean mines, quarries, railroad tunnels, and storm sewers, Missouri harbors a diverse array of karst and karst-like features with associated fauna. The majority of these sites are privately owned while state and federal agencies own over 1,941 representing 27% of caves and an unknown percentage of subterranean mines. The Missouri Department of Conservation (MDC) owns over 301 caves; just over 7% of the known caves in the state. Previously unknown sites are continually discovered through ongoing survey efforts.

Beginning in 1975, MDC staff initiated monitoring efforts of priority bat hibernacula for the federally endangered Indiana bat (*Myotis sodalis*) and gray bat (*Myotis grisescens*). With the onset of white-nose syndrome (WNS) disease in Missouri in 2012, MDC staff and partner entities increased the number and frequency of surveys to document WNS's effect on bat numbers state wide.

Hibernacula counts are ideal for monitoring fluctuations in cave-hibernating bats given their fidelity to particular sites. The counts are generally conducted throughout the winter period of December through March.

Exact counts of bats in hibernacula are impossible because the complex nature of subterranean strata provides ample opportunities for concealment. Hibernacula range from small caves less than 50 feet of passage, to elaborate caves with miles of passage in multiple directions. The amount of effort required to produce an exact count would be labor and cost prohibitive and would require an excessive amount of time spent in sites that increasing the disturbance of bats to unacceptable levels.

In order to produce a replicable survey effort, portions of caves that harbor the highest concentrations of bats are surveyed within a 3 hour time limit. When numbers are small, individual bats are counted and tallied on paper. When bats roost in larger clusters, often with 50 or more bats, as is typical with Indiana bats, photographs are taken for later review. ArcMap™ is then utilized to obtain an accurate count from photos by uploading the individual images, generating a point shapefile and dot is placed on each nose of each observable bat. Each dot is tabulated on an attribute table, effectively avoiding double counting for the final number.

For over 30 years major Indiana bat hibernacula have been monitored. Even though the hibernacula still retain their priority status designations, most of these sites no longer support their previous numbers. Presently, only one hibernaculum in Missouri harbors over 10,000 Indiana Bats, with an estimated 198,000 individuals in 2017. A select few sites harbor 1,000 to 5,000 bats while most hibernacula in Missouri contain less than 1,000 individuals. In 1979, the Indiana bat population was estimated at 176,045 in 10 sites (Elliott and Clawson, 2007); however, as of 2017, those 10 sites now harbor 4,691 Indiana bats (Table 1).

Gray bat hibernacula are not consistently monitored. Priority 1 gray bat hibernacula are typically surveyed every 5 years in Missouri. As of 2017, there are 11 of these hibernacula throughout their range, 4 of which are found in Missouri (Table 2).

Other bat species present or hibernating in caves and mines were counted on an inconsistent basis until WNS became an issue in 2007. For Missouri, consistent hibernacula counts of all bat species encountered began winter 2008/2009.

White-nose syndrome in Missouri and Current Status

WNS was first discovered in the state of New York during the winter of 2006/2007 and rapidly spread southwestward through Appalachia and towards bat hibernacula in Missouri.

In Missouri, WNS was first observed on a bat in a cave at Cuivre River State Park in Lincoln County in March of 2012. Samples were taken and WNS was confirmed for the first time in the state. The discovery led biologists from state and

federal agencies, universities, and other institutions across Missouri to initiate a more concerted and collaborative effort in regards to bat hibernacula surveys statewide in the winter of 2012/2013.

For the purpose of tracking WNS's progression across the state in Missouri, 'suspect' and 'confirmation' are combined. Most Missouri counties that are mapped as positive for WNS are 'suspect' given the obvious observation of WNS did not require specimen submissions.

Since WNS was discovered in Missouri, there are indications bat population decline both in winter hibernacula and in the across the landscape during summer. Many once common species have rapidly declined throughout their range (Blehert et al., 2009). This decline contributed to the U.S. Fish and Wildlife Service designating the northern long-eared bat (*Myotis septentrionalis*) as federally threatened in 2015.

Although pre-WNS data are lacking for the majority of Missouri bat hibernacula, 183 hibernacula were routinely surveyed during 2012/2013, 2014/2015, and 2016/2017. Results of the population counts for all bat species during these years are presented in Table 3.

A slight decline in **big brown bats** (*Eptesicus fuscus*) has been recorded. However, since big brown bats are more heavily associated with hibernating in both man-made structures and subterranean sites and have been known to move between sites during the hibernation season, big brown bat population estimates are difficult to track (Mills et.al., 1975; Whitaker and Gummer 1992, 2000).

While there is a slight decline in **gray bats** at the 183 hibernacula surveyed biannually since 2012/2013, gray bats hibernate in very large numbers, and accurate counts are difficult to attain. Just from visual observations, the gray bat population in Missouri seems to be stable.

Little brown bats (*Myotis lucifugus*) have declined 86.7% in the 183 hibernacula; however, the most recent surveys suggest that some populations may be stabilizing, though at much reduced levels relative to previous years.

The survey efforts since WNS discovery in Missouri do not show dramatic reductions in **Indiana bat** populations. However, in other states declines in Indiana bat populations take longer to appear than in other species. The 183 hibernacula includes the new priority 1 Indiana bat hibernaculum named Sodalis Nature Preserve (SNP) in Hannibal, Missouri that was first surveyed in 2012/2013. The 2016/2017 population count at SNP yielded over 197,000 Indiana bats. The survey effort has increased during each subsequent biannual count at SNP, therefore results of these counts do not indicate increases since the first survey. However, increases in Indiana bats in the other hibernacula have been observed (Table 4). The survey effort has been consistent in these sites since 2011, both in personnel and man hours. In addition, two new sites with relatively large populations of Indiana bats were discovered and surveyed in 2016/2017. One site in Shannon County has approximately 1,000 Indiana bats, and a site surveyed in Madison County has around 600 Indiana bats.

The most profound reductions were observed in the **northern long-eared bats**, which are now virtually absent from the selected 183 hibernacula with only 2 individuals observed during the 2016/2017 population counts.

Tri-colored bats (*Perimyotis subflavus*) have shown a dramatic decrease from 2012/2013 to 2016/2017 with a 53.8% population decline.

2011 – 2017 Hibernacula Survey Highlights:

- Visible WNS fungal growth has been documented at over 240 hibernacula since 2012.
- Over 800 unique sites were surveyed in 66 Missouri counties (Figure 1).
- At least one cave in 46 (40%) of Missouri's counties had documented signs of WNS as of 2017.
- Bats were swabbed at 8 hibernacula as part of the continental WNS study being conducted by Dr. Winifred Frick (UC-Santa Cruz). These results have documented the arrival and spread of *Pseudogymnoascus destructans* ahead of the visible expression of WNS.

2016/2017 Winter Hibernacula Bat Population Count Summary:

- 502 hibernacula were surveyed between November 1, 2016 and April 1, 2017.
- Surveys were conducted in November (14 surveys), December (117), January (178), February (128), and March (65).
- 1,027,860 total bats of 9 species were counted (Table 6).
- No bats were encountered at 99 (20%) of the 502 sites.
- At least one cave was surveyed in 61 (53%) of Missouri's counties (Figure 1).
- 183 (37%) of the 502 sites surveyed during the winter of 2016/2017 had signs of WNS (visible fungal growth or detection of *Pseudogymnoascus destructans*).
- This work was conducted by at least 190 people from various agencies, NGOs, and private individuals.
 - 30% of the surveys were conducted by volunteers in 2017 versus 87% in 2016. This is likely due to the fact that 2017 was an on-year for Indiana bat and gray bat surveys which typically require presence of either federally permitted individuals or government officials.

Discussion and Outlook for Missouri Bat Populations

Biologists in the eastern U.S. where WNS has impacted populations for the longest period of time report that counts at individual hibernacula increase, sometimes dramatically, as the disease first impacts bats at the site, and then drop precipitously (J. Coleman, USFWS, pers. comm.). This trend may not be concurrent for all species even at the same site. Our data reflect this pattern with northern long-eared, little brown, and tri-colored bats having peaked and declined, but Indiana bats still increasing (see Table 3 and Table 7).

Most Missouri hibernacula surveyed do not have a history of regular monitoring that would allow a comparison of bat populations before and after the arrival of WNS. However, 20 caves were surveyed during the winter months in 2010/2011, 2012/2013, 2014/2015, and 2016/2017. We summarized trends in bat count data at these sites for four species with the greatest documented declines since the discovery of WNS (Indiana bat, northern long-eared bat, little brown bat, and tri-colored bat) in Table 7. Population counts at individual sites are available upon request.

Although a significant decline in most of our hibernating bat populations in Missouri has been observed, it is not completely accurate to state that these bats are disappearing from our state by relying on hibernacula counts alone. The potential hibernacula habitat includes over 16,000 sites relative to 500 sites surveyed in one winter season. Some of these bats, such as the northern long-eared bat, prefer to roost in small cracks and crevices making them difficult to locate in

hibernacula, and are known to routinely switch hibernacula in the middle of the winter (L. Robbins pers. communication). Other states are observing bats moving to hibernacula that are colder than usual hibernacula locations with up to a 5°F increase (G. Turner, PA Game Commission pers. communication).

To better document species declines in Missouri, biologists need to utilize both hibernacula survey counts as well as summer mist netting records. During the summer of 2016, there was a major decline in captures of northern long-eared bats and little brown bats all across the state (MDC unpub. Data). Though not statistically confirmed, the lack of captures for these species correlates with the decline in cave counts.

Collaborators

Contributors include (but not limited to) representatives from Fort Leonard Wood, Missouri Bat Census, Cave Research Foundation, Missouri Speleological Survey, Department of Natural Resources – Division of State Parks, National Park Service – Ozark National Scenic Riverways, U.S. Forest Service - Mark Twain National Forest, Missouri Department of Conservation, Missouri Department of Transportation, Green County Park Board, Springfield Plateau Grotto, Missouri Caves and Karst Conservancy, Meramec Valley Grotto, Kansas City Area Grotto, SEMO Grotto, MMV Grotto, the Kansas City Area Grotto, the Leo A. Drey Foundation, Clay County Parks and Recreation, the City of Kansas City, St. Francois County, the City of Hannibal, U.S. Fish and Wildlife Service, and other caving enthusiasts. We thank all for providing access to caves or data to make this work possible.

Acknowledgements:

Thanks to Ron Colatskie, J.T. Layne and Anthony Elliott for their comments and edits to earlier drafts of this document.

Figures and Tables

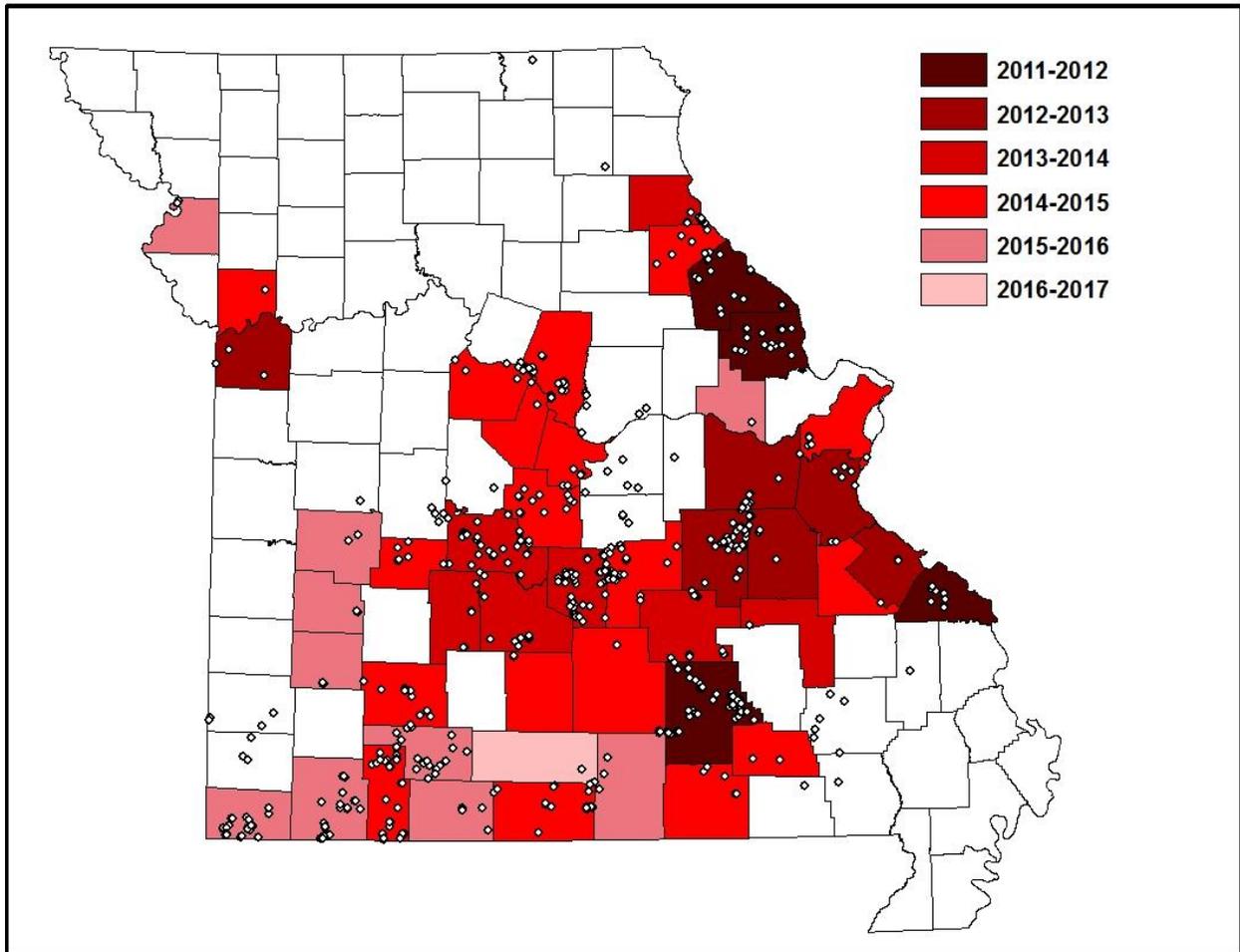


Figure 1: The spread of WNS based on suspect and confirmed Missouri counties following six years of hibernacula surveys. White dots represent most of the 850 unique hibernacula surveyed 2010/2011 to 2016/2017. Some locations not available due to landowner confidentiality.

Table 1. Indiana bats population estimates in 11 major Missouri hibernacula from 1979-2017.

	Onyx - Crawford	Bear - Crawford	Copper Hollow Sinkhole - Franklin	Brooks - Pulaski	Great Spirit - Pulaski	Ryden - Pulaski	Bat Cave - Shannon	Martin - Shannon	Great Scott - Washington	Pilot Knob Mine - Iron	Scotia Hollow - Washington	
1979	11,100	3,250	8,850	19,375	549	10,550	42,821	8,100	68,700	139,000	2,750	176,045
1981	5,325	1,750	5,200	11,850	1,792	5,800	32,800	2,425	72,350	125,130	3,100	142,392
1983	3,267	1,100	3,150	11,150	1,171	4,950	30,750	5,350	85,700	111,262	4,550	151,138
1985	2,250	650	1,050	5,500	500	2,000	30,450	3,550	77,950	97,391	3,400	127,300
1987	2,050	525	600	4,900	40	700	4,150	4,900	60,650	83,521	5,300	83,815
1989	1,575	400	250	5,200	35	1,359	4,275	2,600	38,875	69,652	5,150	59,719
1991	1,275	300	160	2,700	8	160	4,275	2,975	32,125	55,782	6,225	50,203
1993	700	225	125	1,550	625	80	6,175	2,250	22,750	41,912	4,550	39,030
1995	325	190	140	750	450	40	941	2,125	14,850	28,042	3,600	23,411
1997	260	95	175	600	195	14	450	1,500	11,875	14,173	1,615	16,779
1999	155	80	155	400	175	14	6,175	1,000	9,100	303	2,375	19,629
2001	265	105	185	235	285	10	89	2,460	8,250	647	450	12,334
2003	210	90	250	130	160	13	1,020	2,100	8,875	991	290	13,138
2005	180	100	250	70	40	10	0	1,300	6,450	1,334	150	8,550
2007	180	110	380	65	60	3	16	950	5,100	1,678	90	6,954
2009	118	106	323	21	1	2	2	913	4,674		41	6,201
2011	90	120	457	50	0	3	327	781	3,936		30	5,794
2013	113	125	706	41	120*	2	136	1,268	3,556		21	5,968
2015	58	9	354	0	63	0	703	2,986	2,824		15	7,012
2017	40	0	161	0	15	0	297	1,684	2,483		11	4,691

- The Sodalis Nature Preserve, a large limestone mine complex in Hannibal, Missouri was recently discovered in 2012 as a priority 1 Indiana Bat hibernaculum with a 2017 survey yielding an estimated 198,000 +/- individuals. It is unknown for what period of time Indiana Bats have been utilizing the site as a hibernaculum. This table was adapted from Elliott and Clawson 2007.

-The Pilot Knob Mine was designated as a priority 1 site until 1999. A series of mine collapses occurred throughout the 1970's – 1980's, several of which restricted portals and airflow into the mine thus potentially impacting bat numbers.

*From 2009 – 2011, a cluster of Indiana Bats in a particular site in Great Spirit Cave was not located and thus not counted, accounting for the lower numbers relative to years prior to 2009. The cluster at this particular portion of the cave was rediscovered and again counted in 2013 – 2017.

Table 2: Gray bat counts at the 4 major gray bat hibernacula in Missouri.

Year	Bat Cave Shannon	Mose Prater Cave	Coffin Cave	Martin Cave	Totals
1980/1981	23,850	89,500	316,300	100	429,750
1983/1983	24,400	112,200	349,500	40	486,140
1984/1985	17,150	89,450	355,450	250	462,300
1988/1989	28,725	87,250		250	116,225
2002/2003	41,100	93,000		13,700	147,800
2005/2006	27,600	155,000	561,000	3,000	746,600
2009/2010	50,000	110,000		3,039	163,039
2014/2015	20,531	140,154	380,000	30,000*	540,685
2016/2017	15,000	137,432	577,850	42,535	772,817

* During the 2014/2015 survey at Martin Cave, a major hibernating population of gray bats was discovered in a room that had never been surveyed.

Table 3. Population counts between 2012/2013 and 2016/2017 at 183 Missouri hibernacula of all documented bat species post-discovery of WNS in the state (winter 2011/2012).

Species	2012/2013	2014/2015	2016/2017	% change between 2012 and 2017
Big brown Bat	1,539	1,567	1,292	-16.0%
Eastern small-footed Bat	2	0	0	-
Evening bat	0	0	1	-
Gray bat	67,053	50,565	60,239	-10.2%
Indiana bat	138,554	184,953	215,107	55.3%
Little brown bat	5,624	9,478	748	-86.7%
Northern long-eared bat	4,591	2,281	2	-99.9%
Silver-haired bat	0	0	1	-
Tri-colored bat	24,105	24,318	11,147	-53.8%
Unknown bat	1,011	1,996	97	-
Total	242,479	275,158	288,634	

Table 4. USFWS standardized Indiana bat count years between 2010/2011 and 2016/2017 in Missouri and number of hibernacula surveyed and associated population. These numbers do not include population counts from SNP.

Winter Survey Year	Number of Hibernacula Surveyed with Indiana bats	Number of Indiana bats
2010 / 2011	25	12,956
2012 / 2013	31	15,659
2014 / 2015	35	17,873
2016 / 2017	29	19,616

Table 5. Summary of Missouri bat hibernacula surveyed between 2010/2011 and 2016/2017, encompassing 850 unique hibernacula in 66 counties.

Winter Survey Year	Hibernacula Surveyed
2010 / 2011	31
2011 / 2012	42
2012 / 2013*	246
2013 / 2014**	41
2014 / 2015	375
2015 / 2016	569
2016 / 2017	502

*The year the state wide cooperative hibernacula surveys began. ** Due to data sharing agreement issues with particular intra-agency partners; only caves surveyed by MDC personnel are included.

Table 6: Total number of individuals per species observed in 502 hibernacula during 2016/2017, with the number of hibernacula each species was observed.

Species	2017 Total Count	Number of Hibernacula Observed
Big brown bat	2,709	229
Eastern small-footed bat	1	1
Evening bat	1	1
Gray bat	781,924	45
Indiana bat	217,035	32
Little brown bat	1,891	51
Northern long-eared bat	8	5
Silver-haired bat	1	1
Tri-colored bat	24,139	391
Unknown Bat	151	19
Total	1,027,860	

Table 7. Population counts between 2010/2011 and 2016/2017 at 20 Missouri hibernacula of four species with the largest documented declines from WNS in North America.

Species	2010/2011	2012/2013	2014/2015	2016/2017	% change 2010-2017
Indiana bat	12,813	15,428	19,794	17,536	+36.9%
Little brown bat	2,413	2,774	2,215	378	-84.3%
Northern long-eared bat	508	1,066	1,787	2	-99.6%
Tri-colored bat	2,376	4,122	3,188	313	-86.8%

Literature Cited

- Blehert, D.S., A.C. Hicks, M. Behr, C.U. Meteyer, B.M. Berlowski-Zier, E. L. Buckles, J.T.H. Coleman, S.R. Darling, A. Gargas, R. Niver, J.C. Okoniewski, R.J. Rudd, and W.B. Stone. 2009. Bat White-nose Syndrome: an emerging fungal pathogen? *Science* 323(5911): 227.
- Elliott, W.R., and R.L. Clawson. 2001. Gray and Indiana bat population trends in Missouri. pp.46-61, in. Elliott, W.R. (ed.): Proceedings of the 18th National Cave and Karst Management Symposium, October 8-12, 2007, St. Louis, Missouri.
- Mills, R.S., G.W. Barrett, and M.P. Farrell. 1975. Populations dynamics of the big brown bat (*Eptesicus fuscus*) in southwestern Ohio. *Journal of Mammalogy*, 56, 591–604.
- U.S. Fish and Wildlife Service (USFWS). 2007. Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision. U.S. Fish and Wildlife Service, Fort Snelling, MN. 258 pp.
- U.S. Fish and Wildlife Service (USFWS). 1982. Gray bat recovery plan. Minneapolis, MN. 26pp. + appendices
- Whitaker, J.O., Jr., and S. L. Gummer. 1992. Hibernation of the big brown bat, *Eptesicus fuscus*, in buildings. *Journal of Mammalogy*, 73, 312–316.
- Whitaker, J.O., Jr., and S. L. Gummer. 2000. Population structure and dynamics of big brown bats (*Eptesicus fuscus*) hibernating in buildings. *American Midland Naturalist*, 143, 389–396.