

Mines housing the same species or with micro-climates similar to the mine to be closed should be prioritized for protection. These should be protected by gates or fences prior to the eviction of bats from their current roosts. This was successfully accomplished by the Homestake Mining Company at its McLaughlin Mine in northern California. When a nursery colony of big-eared bats had to be evicted from a mine about to be destroyed by expansion of an open-pit mine, two nearby mines were reopened and gated. The bats were excluded from their original roost in spring and now live in one of the alternate sites where they are permanently protected. At the American Girl Mining Joint Venture in southern California, some of the newly mined underground areas were gated and left open to create new bat habitat when recent mining ceased.

The creation of artificial roosts

A new approach for mitigating the loss of underground bat habitat or enhancing habitat at active mining operations is the construction of artificial under-

ground roosts that mimic habitat conditions found in mines and caves. Several mining companies have already constructed experimental roosts by burying surplus mining materials such as large diameter culvert or mine truck tires beneath waste rock.

The Homestake Mining Company used old mine truck tires configured to create four separate adit “arms” connecting to a central precast concrete bunker at their McLaughlin Mine in Northern California. The entire structure was buried under waste rock, which was then re-contoured and planted with native vegetation. A concrete flange with a steel bat gate was inserted into two of the entrances. At Solutia’s (formerly Monsanto Corporation) Enoch Valley Mine in Soda Springs, Idaho, two steel culverts measuring eight feet in diameter and forty feet long were modified, connected, and buried in such a way as to trap warm air in the upper culvert for summer use and cool stable air in the lower culvert for hibernation. As part of a bat conservation program to mitigate for the loss of underground mine bat habitat, Canyon Resource’s Briggs gold mine constructed an artificial



At Homestake Mining Company’s McLaughlin Mine in California, surplus truck tires were buried beneath waste rock to create an innovative and cost-effective bat roost. If careful consideration is given to design and construction, artificial structures can provide important roosts for bats.

underground roost using surplus drums from cement mixing trucks buried beneath waste rock. Four drums were used, connected by an adit constructed of used mine truck tires. Environmental managers at Echo Bay Mineral's McCoy Mine in Nevada are constructing an artificial roost in a mine waste rock dump consisting of two rectangular metal bunkers connected by old mine truck tires, with an entrance on each side of the 200-foot-long structure at different elevations to promote airflow.

In order to be successful, artificial roosts must be designed to create an internal roost microclimate that meets the life history needs of the target bat species. First, information must be obtained on which species are likely to be present in the vicinity and how and when these species use underground roosts. Next, the artificial roost structure must be designed with an understanding of how airflow, mean annual surface temperatures, and seasonal and daily climate patterns will affect the internal climate conditions of the completed roost. Special consideration must also be given to factors such as ensuring that places within

the structure where the bats will roost are not accessible to predators. They must also have a rough non-metallic surface for the bats to hang on (see "How Mine Structure, Location, and Human Disturbance Affect Bat Use"). When possible, the actual site where the artificial roost will be located should be safe from flooding and be as near as possible to water and foraging habitat. While bats needs are often predictable, it is highly recommended that companies attempting to create new or alternate habitat should seek expert advice.

In summary, bats are a key natural resource, which now rely heavily on old abandoned mines for their survival. Installing a bat gate that protects both humans and bats often costs less than traditional mine-closure methods. By checking mines for bats prior to closure we can avoid unnecessary and costly endangered species problems and contribute greatly to ecosystem health. Artificial bat roosts show great promise for economically creating or enhancing bat habitat where it has been destroyed.

Table 1. Species List of Bats that Use Mines

Species	Group Size	Range	Use Time	Status
Ghost-faced bat <i>Mormoops megalophylla</i>	Dozens to hundreds	AZ & TX	Year-round	Species of Concern ¹
California leaf-nosed bat ² <i>Macrotus californicus</i>	Dozens to over a thousand	AZ & southern CA & NV	Year-round	Species of Concern ¹
Mexican long-tongued bat <i>Choeronycteris mexicana</i>	A dozen or fewer	AZ & southern CA	Summer	Species of Concern ¹
Lesser long-nosed bat ² <i>Leptonycteris curasoae</i>	Hundreds to thousands	AZ & NM	Summer	Endangered
Greater long-nosed bats <i>Leptonycteris nivalis</i>	Hundreds to thousands	TX & NM	Summer	Endangered
Southeastern myotis <i>Myotis austroriparius</i>	Hundreds to thousands	Southeastern U.S.	Year-round	Species of Concern ¹
California myotis <i>Myotis californicus</i>	Up to a hundred	Western U.S.	Year-round	Unknown
Western small-footed myotis <i>Myotis ciliolabrum</i>	Up to hundreds	Western U.S.	Year-round	Species of Concern ¹
Long-eared myotis <i>Myotis evotis</i>	Dozens	Western U.S.	Year-round	Species of Concern ¹
Gray bat <i>Myotis grisescens</i>	Hundreds to 50,000 or more	Southeastern U.S.	Year-round	Endangered
Eastern small-footed myotis <i>Myotis leibii</i>	Dozens	Eastern U.S.	Winter	Species of Concern ¹
Little brown bat ² <i>Myotis lucifugus lucifugus</i>	Hundreds to a million +	Northern U.S.	Year-round	Unknown
Arizona myotis <i>M. l. occultus</i>	Hundreds	Southwestern U.S.	Year-round	Species of Concern ¹
Eastern long-eared myotis <i>Myotis septentrionalis</i>	Hundreds to thousands	Eastern U.S.	Winter	Unknown
Indiana bat ² <i>Myotis sodalis</i>	Hundreds to 100,000 or more	Eastern U.S.	Winter	Endangered

¹ Formerly known as Category 2, candidate for federal threatened or endangered listing.² Bats known to be especially dependent on abandoned mines.

Species	Group Size	Range	Use Time	Status
Fringed myotis <i>Myotis thysanodes</i>	Dozens to hundreds	Western U.S.	Year-round	Species of Concern ¹
Cave myotis ² <i>Myotis velifer</i>	Hundreds to 100,000 or more	Southwestern U.S.	Year-round	Species of Concern ¹
Long-legged myotis <i>Myotis volans</i>	Hundreds	Western U.S.	Year-round	Species of Concern ¹
Yuma myotis <i>Myotis yumanensis</i>	Hundreds to thousands	Western U.S.	Year-round	Species of Concern ¹
Western pipistrelle <i>Pipistrellus hesperus</i>	Dozens	Western U.S.	Year-round	Unknown
Eastern pipistrelle <i>Pipistrellus subflavus</i>	Dozens to thousands	Eastern U.S.	Winter	Unknown
Big brown bat <i>Eptesicus fuscus</i>	Dozens to hundreds	North America	Year-round	Stable
Allen's lappet-browed bat <i>Idionycteris phyllotis</i>	Dozens to about two hundred	Mostly AZ, also parts of NV, CO	Year-round	Species of Concern ¹
Southeastern big-eared bat <i>Corynorhinus rafinesquii</i>	Dozens to several hundred	Southeastern U.S.	Year-round	Species of Concern ¹
Pacific big-eared bat ² <i>C. townsendii townsendii</i>	Dozens to hundreds	Western U.S.	Year-round	Species of Concern ¹
Ozark big-eared bat <i>C. t. ingens</i>	Dozens to hundreds	Ozark Mountains	Year-round	Endangered
Western big-eared bat ² <i>C. t. pallescens</i>	Dozens to thousands	Western U.S.	Year-round	Species of Concern ¹
Virginia big-eared bat <i>C. t. virginianus</i>	Dozens to thousands	KY, VA & WV	Year-round	Endangered
Pallid bat <i>Antrozous pallidus</i>	Dozens to hundreds	Western U.S.	Year-round	Declining
Mexican free-tailed bat <i>Tadarida brasiliensis</i>	Hundreds of thousands	Southwestern U.S. north to OR	Summer	Declining

¹ Formerly known as Category 2, candidate for federal threatened or endangered listing.

² Bats known to be especially dependent on abandoned mines.

Appendix I

Helpful Literature

General Bat Identification, Behavior, and Distribution

- Altringham, J. D. 1996. *Bats Biology and Behaviour*. Oxford University Press, Oxford, 262 pp.
- Barbour, R. W. and W. H. Davis. 1969. *Bats of America*. University of Kentucky Press, Lexington, 286 pp.
- Fenton, M. B. 1992. *Bats*. Facts on File Inc., New York, 207 pp.
- Hall, E. R. 1981. *The Mammals of North America, Volume II*. John Wiley and Sons, New York, 1,181 pp.
- Hill, J. B. and J. D. Smith. 1984. *Bats: A Natural History*. University of Texas Press, Austin, 243 pp.
- Kunz, T. H. (ed.) 1982. *Ecology of Bats*. Plenum Press, New York and London, 425 pp.
- Kunz, T. H. and P. A. Racey. 1998. *Bat Biology and Conservation*. Smithsonian, 576 pp.
- Richarz, K. and A. Limbrunner. 1993. *The World of Bats*. Franck-Kosmos Verlags-GMBH & Co., Stuttgart, Germany (English translation by W. Charlton), THF Publications, 192 pp.
- Nowak, R. M. 1994. *Walker's Bats of the World*. Johns Hopkins University, Baltimore, 287 pp.
- Whitaker, J. O., Jr. 1996. *National Audubon Society Field Guide to North American Mammals* (revised edition). Alfred A. Knopf, Inc., New York, 942 pp.
- Wilson, D. E. 1997. *Bats in Question: The Smithsonian Answer Book*. Smithsonian Institution Press, Washington, D.C., 168 pp.

Detecting and Censusing Bats and Protecting Sites

- Altenbach, J. S. and H. E. Milford. 1995. Evaluation and Management of Bats in Abandoned Mines in New Mexico. Pp. 326-330 *in* 1993 National Cave Management Symposium - XI Proceedings, Carlsbad, New Mexico (D. Pate, ed.). National Cave Management Symposium Steering Committee.
- Altenbach, J. S. and E. D. Pierson, 1995. The Importance of Mines to Bats: An Overview. *In* Riddle, B. R. (ed.). Inactive mines as bat habitat: guidelines of research, survey, monitoring and mine management in Nevada. Biological Resources Center, University of Nevada, Reno.
- Altenbach, J. S. 1995. Entering mines to survey bats effectively and safely. *In* Riddle, B. R. (ed.). Inactive mines as bat habitat: guidelines of research, survey, monitoring and mine management in Nevada. Biological Resources Center, University of Nevada, Reno.
- Brown, P. E. and R. D. Berry. 1997. Renewed mining and reclamation: impacts on bats and potential mitigation. Pp. 196-201 *in* Proceedings of American Society for Surface Mining and Reclamation 14th Annual National Meeting, Austin, Texas
- Brown, P. E., R. D. Berry, and C. Brown. 1995. The California leaf-nosed bat (*Macrotus californicus*) and American Girl mining joint venture—Impacts and solutions. Pp. 54-56 *in* Proceedings VI: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Colorado.
- Kunz, T. H. 1988. *Ecological and Behavioral Methods for the Study of Bats*. Smithsonian Institution Press, Washington, D.C., 533 pp.
- MacGregor, J. 1993. Responses of winter populations of the Federal endangered Indiana bat (*Myotis sodalis*) to cave gating in Kentucky. Pp 364-370 *in* 1991 National Cave Management Symposium Proceedings, American Cave Conservation Association, Horse Cave, Kentucky (D. L. Foster, ed.).
- Navo, K. W. 1994. Guidelines for the survey of caves and abandoned mines for bats in Colorado. Colorado Division of Wildlife, Monte Vista, Colorado, 55 pp.
- Pierson, E. D., W. E. Rainey, and D.M. Koontz. 1991. Bats and mines: Experimental mitigation for Townsend's big-eared bat at the McLaughlin Mine in California. Pp. 31-42 *in* Proceedings V: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Colorado, 223 pp.
- Tidemann, C. R. and D. P. Woodside. 1978. A collapsible bat-trap and a comparison of results obtained with the trap and with mist-nets. *Aust. Wildl. Res.*, 5:355-362.
- Tuttle, M. D. 1974. An improved trap for bats. *J. Mammal.*, 55:475-477.
- Tuttle, M. D. 1977. Gating as a means of protecting cave-dwelling bats. Pp. 77-82 *in* 1976 National Cave Management Symposium Proceedings (T. Aley and D. Rhodes, eds.). Speleobooks, Albuquerque, New Mexico, 106 pp.*
- Tuttle, M. D. and D. E. Stevenson. 1978. Variation in the cave environment and its biological implications. Pp. 108-121 *in* 1977 National Cave Management Symposium Proceedings (R. Zuber, J. Chester, S. Gilbert and D. Rhodes, eds.). Adobe Press, Albuquerque, New Mexico, 140 pp.*

* Reprints available from Bat Conservation International.

Regional References about Bats

Western Region

- Armstrong, D. M., R. A. Adams, and J. Freeman. 1974. Natural History Inventory of Colorado, No. 15: Distribution and ecology of bats of Colorado. University of Colorado Museum, Boulder, Colorado, 85 pp.
- Carraway, B. J. and L. N. 1998. Land Mammals of Oregon, University of California, 800 pp.
- Clark, T. W. and M. S. Stromberg. 1987. Mammals in Wyoming. University of Kansas Press, Lawrence, 314 pp.
- Findley, J. S., *et. al.* 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque, 360 pp.
- Hoffmeister, D. F. 1986. Mammals of Arizona. The University of Arizona Press, Tucson, 602 pp.
- Ingles, L. G. 1965. Mammals of the Pacific States. Stanford University Press, Stanford, California, 506 pp.
- Jameson, E. W., Jr., and H. Peeters. 1987. California Mammals. University of California Press, Berkeley, 403pp.
- Ulrich, T. 1986. Mammals of the Northern Rockies. Mountain Press, Missoula, Montana, 160 pp.

Central Region

- Caire, W., *et. al.* 1989. Mammals of Oklahoma. University of Oklahoma Press, Oklahoma City, 582 pp.
- Choate, J. R., *et. al.* 1994. Handbook of Mammals of the South-Central States. Louisiana State University Press, Baton Rouge, 304 pp.
- Hazard, E. B. and N. Kane. 1982. Mammals of Minnesota. University of Minnesota Press, Minneapolis, 286 pp.
- Hoffmeister, D. F. 1989. Mammals of Illinois. University of Illinois Press, Chicago, 356 pp.
- Jackson, H. T. 1961. Mammals of Wisconsin. University of Wisconsin Press, Madison, 504 pp.
- Jones, J. K., Jr., D. M. Armstrong and J. R. Choate. 1985. Guide to Mammals of the Plains States. University of Nebraska Press, Lincoln, 371 pp.
- Jones, J. K., Jr. and E. C. Birney. 1988. Handbook of Mammals of the North-Central States. University of Minnesota Press, Columbia, 346 pp.
- Schmidley, D. J. 1991. The Bats of Texas. Texas A&M University Press, College Station, 188 pp.
- Sealander, J. A. and G. A. Heidt. 1991. Arkansas Mammals: Their Natural History, Classification, and Distribution. University of Arkansas Press, 308 pp.

Eastern Region

- Barbour, R. W. and W. H. Davis. 1974. Mammals of Kentucky. University Press of Kentucky, Lexington, 321 pp.
- Brown, L. N. 1997. A Guide to Mammals of the Southeastern United States. University of Tennessee Press, Knoxville, 256 pp.
- Harvey, M. J. 1992. Bats of the Eastern United States. Arkansas Game and Fish Commission, Little Rock, 46 pp.
- Kurta, A. 1995. Mammals of the Great Lakes Region. University of Michigan Press, Ann Arbor, 350 pp.
- Linzey, D. W. 1996. Mammals of Virginia. McDonald and Woodward Publishing Co., Blacksburg, 450 pp.
- Merritt, J. F. 1987. Guide to the Mammals of Pennsylvania. University of Pittsburgh Press, Pittsburgh, 408 pp.
- Mumford, R. E. and J. O. Whitaker, Jr. 1982. Mammals of Indiana. Indiana University Press, Bloomington, Indiana, 537 pp.
- Webster, W. D. *et. al.* 1985. Mammals of the Carolinas, Virginia, and Maryland. University of North Carolina Press, Chapel Hill, 267 pp.
- Whitaker, J. O., Jr. and W. J. Hamilton. 1998. Mammals of the Eastern United States. Third Edition. Cornell University, 608 pp.

Canada

- Nagorsen, D.W. and R.M. Brigham. 1993. Bats of British Columbia. University of British Columbia, Vancouver, 176 pp.
- van Zyll de Jong, C. G. 1985. Handbook of Canadian Mammals: Volume 2, Bats. National Museum of Natural Sciences, Ottawa, 212 pp.

Appendix II

Available Resources

Training Opportunities and Educational Materials

Bat Conservation International

P.O. Box 162603, Austin, TX 78716, 512-327-9721. BCI provides several Bat Conservation and Management Workshops annually, including some specifically devoted to bats and mines issues. BCI also produces a wide variety of slide and video programs, posters, and other educational materials about bats. For more information, or for a free catalogue, write or call BCI

Bat Conservation International Web Site

Visit our web site at www.batcon.org for up-to-date information on bat conservation workshops, available grants, on-line library of bat resources, and more.

Consultation Resources

American Cave Conservation Association

P.O. Box 409, Horse Cave, KY 42749, 502-786-1466. The ACCA is a leader in development of vandal-resistant, bat friendly gate designs and can provide information on gate design and construction.

Bat Conservation International

BCI maintains a list of bat experts throughout North America who are knowledgeable about bat ecology and behavior and who are willing to consult on bat conservation issues. The Director of BCI's North American Bats and Mines Project, founded in partnership with the U.S. Bureau of Land Management, is also available for consultation.

U.S. Fish and Wildlife Service, Asheville Field Office

160 Zillicoa Street, Asheville, NC 28801-1038. 704-258-3939. Available for consultation, either on endangered species issues or on gate designs, use of gates, and alarm systems to protect bats. Also contact the Asheville Field Office for locations of the nearest Fish and Wildlife Offices responsible for formal or informal consultation under the Endangered Species Act.

Bat Line.

An international electronic information forum for the exchange of research ideas, questions, and information on bat ecology, management, and conservation. Information about subscribing to BATLINE can be found at gopher://gopher.unm.edu:70/00/academic/biology/batline/about/BATLINE (or through a link at BCI's web page: www.batcon.org)

Equipment Sources

Alarm Systems

Light sensitive systems for detecting and recording mine/cave visitation.

Ozark Instruments, Route 2, Box 322, Russellville, AR 72801

Onset Computer Corporation, P.O. Box 3450, Pocasset, MA 02559-3450, Tel: 508-759-9500, FAX: 508-759-9100

Bat Detectors

Anabat2 Ultrasound Detector; Titley Electronics, P.O. Box 19, Ballina, NSW 2478, Australia, FAX/Tel. 066-86-6617

Batbox III, Stag Electronics, 1 Rosemundy, Saint Agnes, Cornwall TR5 OUF, United Kingdom, Tel: [+44](0) 872-553441, FAX: [+44](0) 872-553074

Eco-Tranquility, by David J. Bale, 3 Suffolk Street, Cheltenham, Gloucestershire GL50-2DH, United Kingdom, Tel/FAX: [+44](0) 1242-570123

Mini-3 Bat Detector, by Ultra Sound Advice; available from Bat Conservation International, P.O. Box 162603, Austin, TX 78716, Tel: 1-800-538-BATS

Pettersson Ultrasound Detector D 100; available from Bat Conservation International, P.O. Box 162603, Austin, TX 78716, Tel: 1-800-538-BATS

Ultra Sound Advice: 23 Aberdeen Road, London N5 2UG, U.K., Tel: 44 171 359 1718, FAX: 44 171 359 3650

Bat Traps

May be individually constructed from plans—see Appendix I - Detecting and Censing Bats and Protecting Sites: Tidemann, et al. 1978 and Tuttle 1974 or available from:

Ausbat Research Equipment, 32 Longs Road, Lower Plenty, Victoria, 3093, Australia, Tel/FAX: [+61] (0) 3-9435-7004

General Gear for Underground Work

Headlamps, opaque lenses, red filters, helmets, ropes, and more.

Bob and Bob, P.O. Box 441, Lewisburg, WV 24901, Tel: 800-262-2283, FAX: 304-772-3076

Guadalupe Mountain Outfitters, P.O. Box 2429, Carlsbad, NM 88220, Tel: 505-885-9492

Inner Mountain Outfitters, R1, Box 263, Greenville, VA 24440-9727, Tel: 540-377-2690

Speleobooks, P.O. Box 10, Schohaire, NY 12157, Tel: 518-295-7978

Mine Safety Equipment

Including headlamps, gas detectors and respirators (be sure to order the correct size respirator and have it fitted to properly seal completely against the face prior to using in a hazardous environment).

Mine Safety Appliances, 600 Penn Center Boulevard, Pittsburgh, PA 15235

National Mine Safety Service Co., 4900/600 Grant Street, Pittsburgh, PA 15216

Nite Lite: P.O. Box 8300, Little Rock, AR 72222, Tel: 1-800-648-5483

Forestry Suppliers, Inc., P.O. Box 8397, Jackson, MS 39284-8397, Tel: 800-430-5566

Mist Nets and Poles (permit needed)

Avinet, Inc., P.O. Box 1103, Dryden, NY 13053-1103, Tel: 607-844-3277 or 800-340-6387

Spotlights — Quartz Halogen

Rechargeable 500,000 (or more) candle power lights.

Cabela's, One Cabela Drive, Sidney, NE 69160-9555, Tel: 800-237-4444, FAX: 800-496-6329

Lectro Science Incorporated, 6410 West Ridge Road, Erie, PA 16506, Tel: 814-833-6487

Plow and Hearth, P.O. Box 5000, Madison, VA 22727-1500, Tel: 800-627-1712

Night-Vision Equipment

Night-vision devices should be equipped with biocular eyepieces. A wide angle or normal lens is best for observing mine entrances. Most night viewing devices also require additional illumination for optimum bat viewing. A headlamp with an opaque lens and a Wratten 89B photographic filter or any red or infra-red filter is suitable.

Night Vision System Noctron VI or night goggles available from:

Aspect Technology and Equipment Inc., 811 East Plano Parkway, Suite 110, Plano, TX 75074

Electrophysics Corporation, 48 Spruce Street, Nutley, NJ 07110, Tel: 201-882-0211

Meyers & Co., Inc., 17525 NE 67th Court, Redmond, WA 98052, Tel: 800-327-5648 or 425-881-6648, FAX: 425-687-1759

Varo, Inc., Electronic Devices Division, 2203 W. Walnut Street, P.O. Box 469014, Garland, TX 75046

Thermometers — Digital

Davis Instruments, 4701 Mount Hope Drive, Baltimore, MD 21215, Tel: 410-358-3900 or 800-368-2516, FAX: 410-358-0252 or 800-433-9971

IMC Instruments, Inc., 14434 Kaul Avenue, Menomonee Falls, WI 53051, Tel: 414-252-4620

Programmable Temperature Dataloggers

Onset Computer Corporation, P.O. Box 3450, Pocasset, MA 02559-3450, Tel: 508-759-9500, FAX: 508-759-9100