RECOMMENDATIONS FOR MANAGING ACCESS TO SUBTERRANEAN BAT ROOSTS TO REDUCE THE IMPACTS OF WHITE-NOSE SYNDROME IN BATS

Background

White-nose syndrome (WNS) is a devastating fungal disease that has killed unprecedented numbers of hibernating bats in eastern North America. The first evidence of WNS was documented in photographs from New York State in 2006; as of January 2016 WNS has spread to 26 states and five Canadian provinces. The fungus causing the disease, *Pseudogymnoascus destructans* (*Pd*), has been detected in an additional four states where signs of the disease have not yet been observed (see current map available at www.whitenosesyndrome.org).

In North America, seven bat species have been confirmed with WNS, and five additional species have been detected carrying *Pd*. *Pd* invades the skin of hibernating bats and the resulting disease often leads to death. Genetic analyses indicate the fungus is likely not native to North America and it is expected that human activity led to its introduction to North America. *Pd* may have originated in Europe or Asia, where it or the disease has been confirmed on 13 bat species. There have been no documented deaths of European bats from WNS.

The best available information indicates *Pd* will continue to spread across North America, exposing more populations and species to the disease. Although bat-to-bat and bat-to-environment-to-bat transmission are believed to be the primary ways *Pd* is spread, human-assisted transmission is also possible. The severity of the impacts of WNS on bat populations justifies taking universal precautions[1] to reduce the risk of human-assisted transmission of *Pd* and to minimize disturbance to hibernating bats potentially susceptible to WNS.

Purpose

The recommendations below are intended to reduce the potential for humans to disturb hibernating bats or inadvertently transport *Pd* to uncontaminated bat habitats. However, we acknowledge that in some cases, subterranean bat roosts[2] may be under regulatory authority or usage policies that cannot accommodate these recommendations. Where possible, we advise following these recommendations to the extent practicable in the development of site-specific recommendations or policies. Additional guidance is being developed to assist with implementing these recommendations at subterranean sites managed specifically for visitation or tourism. The recommendations below address four main objectives to help wildlife and resource management agencies and non-government organizations develop local strategies to protect bats and subterranean ecosystems.

Objectives

1. Minimize the risk of human-assisted spread of *Pd* to decrease the probability of long-distance transfer of the fungus to uncontaminated areas.
2. Avoid disturbing bats in their roosts to the greatest extent possible.
3. Carry out science-based best management practices for achieving conservation and recovery goals for bats.
4. Foster cooperation and collaboration among government agencies, non-government organizations, and landowners.

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[1] http://www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_2011-05_UniversalPrecautions.pdf

[2] For the sake of these recommendations, “subterranean bat roost” refers to cave-like habitats where bats roost or cave-like habitats identified by site-management authorities to be suitable for use as bat roosts (e.g. caves, abandoned mines, tunnels, bunkers or other structures, etc.).

Supporting Evidence for Concern (See Appendix 1 for description of scientific literature.)

1. *Pd* can persist and grow in the absence of bats.
2. Spores of *Pd* can remain viable outside of subterranean environments.
3. Spores of *Pd* cling to clothing, footwear, and gear and can be inadvertently transported out of contaminated sites.
4. *Pd* may be present on bats or in bat roosts without being visibly detectable.
5. Spread of *Pd* may be slowed by geographic or biological barriers to bat movements that may not be barriers to human movement.
6. Repeated and/or prolonged human disturbance during hibernation is detrimental to bats, especially bats already stressed by WNS.

Recommendations

1. Where feasible, prevent unrestricted access to subterranean bat roosts, especially while bats are present.
2. Decontamination protocols greatly reduce the risk of transporting viable *Pd* spores on gear but are not 100% effective. In accordance with the National White-nose Syndrome Decontamination Protocol[3], equipment that has been used in a subterranean bat roost should only be reused in a roost that is similarly or progressively more contaminated.
3. Require visitors to subterranean bat roosts to clean and treat clothing and gear after visiting a subterranean bat roost regardless of season or time of year (refer to the National WNS Decontamination Protocol). On a site-specific basis, management agencies may consider identifying reduced or additional cleaning requirements for gear between roosts in small geographic areas.
4. Minimize disturbance to bats by coordinating and combining, when possible, scientific and management activities involving access to subterranean bat roosts, especially while bats are likely present.
5. Designate "no entry" restriction for subterranean bat roosts when wintering bats are present unless access is to conduct agency-sanctioned or permitted activities. The period of winter occupancy may include fall and spring as well. Additional restrictions to access may be required for sites with sensitive colonies of bats during summer.
6. Partner with individuals and organizations that utilize subterranean bat roosts to best conserve underground environments and their fauna and flora.
7. Work to educate visitors and local communities about WNS and conservation of bats, caves, and other subterranean habitats.

Conclusion

Many species of North American bats are highly vulnerable to this lethal fungus. Multiple efforts are underway to determine how we can halt the spread of *Pd* and/or reduce the threat of WNS to bats. These efforts involve states, provinces, tribes, federal agencies, universities, conservation organizations, and local communities. Our collaborative efforts are essential to bat and cave conservation. Key to this effort is reducing the risk of human-assisted spread of the fungus and avoiding activities that disturb bats during critical periods of hibernation.

This document is the product of a multi-agency and organization committee working within the framework of the National WNS Plan (A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats, finalized May 2011). On March 18, 2016, this document, Recommendations for Managing Access to Subterranean Bat Roosts to Reduce the Impacts of White-Nose Syndrome in Bats, was accepted by the WNS Executive Committee, a body consisting of representatives from Federal, State, and Tribal agencies which oversees the implementation of the National WNS Plan. These recommendations serve as a revision to the 2009 Cave Advisory issued by the U.S. Fish and Wildlife Service (USFWS 2009).

[3] https://www.whitenosesyndrome.org/topics/decontamination

Appendix 1. Supporting evidence for *RECOMMENDATIONS FOR MANAGING ACCESS TO SUBTERRANEAN BAT ROOSTS TO REDUCE THE IMPACTS OF WHITE-NOSE SYNDROME IN BATS*

Since the discovery of WNS in January 2007 and the identification of *Pseudogymnoascus. destructans* in 2009 (initially as *Geomyces destructans*, Blehert et al., 2009), considerable attention has been paid to understanding the cause and occurrence of this disease, and the biology and distribution of the fungus. Research in these areas has been funded and conducted by numerous government agencies and nonprofit, private, and academic institutions. The findings of the following studies, published and unpublished, have provided evidence that indicates human activity in subterranean bat roosts has the potential to contribute to the spread of WNS and may impact the survival of hibernating bats.

In the statements below, we use "*Pd*", although the cited publications may have used the "*Gd*" nomenclature for the fungus.

1. *Pd* can persist and grow in the absence of bats.
    a. Genetic tests (PCR) confirmed presence of *Pd* and related species in sediment samples from caves and mines that previously held infected bats (Lindner et al., 2011; Lorch et al., 2012a; Peuchmaille et al., 2011a).
    b. Caves can harbor viable *Pd* for over two years after bats are absent (Lorch et al., 2013).
    c. Growth of *Pd* on a variety of cave sediments can lead to accumulation of *Pd* spores in the absence of bats (Reynolds et al., 2015).
2. Spores of *Pd* can remain viable outside of subterranean environments.
    a. *Pd* can remain viable for at least 5 months at room temperature, and under laboratory conditions (USGS-National Wildlife Health Center, unpublished data).
    b. *Pd* spores can remain viable after being stored for up to eight months dry and/or frozen (Puechmaille et al., 2011b).
    c. *Pd* stored on dry agar plates at 5°C and 20-30% relative humidity (which is low compared to typical hibernaculum conditions) can remain viable for more than 5 years in the absence of bats (Hoyt et al., 2014).
3. Spores of *Pd* cling to clothing and footwear and can be inadvertently transported out of contaminated sites.
    a. *Pd* spores were identified by morphology on clothing and gear used in contaminated caves and mines (Joe Okoniewski, New York Dept. of Environmental Conservation, unpublished data).
    b. Viable fungal spores (many species, not specifically *Pd*) were retrieved from shoes of visitors after tours through Mammoth Cave (Hazel Barton, University of Akron, unpublished data).
    c. *Pd* has been detected by genetic screening (PCR) and fungal culture on equipment used to capture bats and on gear used in contaminated sites (USGS – National Wildlife Health Center, unpublished data).
4. *Pd* may be present on bats or in bat roosts without being visibly detectable.
    a. Bats, including Rafinesque's big-eared bats, eastern red bats, and silver haired bats, in and near contaminated sites may test positive for presence of *Pd* via PCR or fungal culture while failing to exhibit obvious signs of WNS (USGS – National Wildlife Health Center, unpublished data; Bernard et al., 2015; Langwig et al., 2015).
    b. *Pd* was detected by microscopy, genetic screening (PCR), and culture on bats and bat houses during summer months in upstate NY (Dobony et al., 2011; US Army, unpublished data); *Pd* was detected by PCR on two species of bats in May and June in Tennessee (Grace Carpenter, University of Tennessee, unpublished data).
5. Spread of *Pd* may be slowed by geographic or biological barriers to bat movements that may not be barriers to human movement.

a. Genetically dissimilar colonies of wintering little brown myotis in westernmost Pennsylvania remained *Pd*-free for 1-2 years after WNS had spread through the rest of Pennsylvania and beyond to the south (Miller-Butterworth et al., 2014).

6. Repeated and/or prolonged human disturbance during hibernation is detrimental to bats (McCracken, 1989; Mohr, 1972; Thomas, 1995; Tuttle, 1979), especially bats already stressed by WNS.
   a. More frequent arousals during hibernation hasten depletion of critical fat reserves (Boyles and Willis, 2009), which can threaten bats' survival.
   b. Increased arousal frequency is associated with more severe cutaneous infections in WNS-affected bats and likely contributes to mortality (Reeder et al., 2012).

Secondary evidence:

7. If done correctly, current decontamination procedures have a high probability of significantly reducing the risk of spreading viable *Pd*.
   a. The effective kill rate of correctly applied decontamination agents or techniques is greater than 99.995% in laboratory experiments (Shelley et al., 2013).
   b. Appropriate application methods are critical for effective decontamination.

References

Bernard, R.F., J.T. Foster, E.V. Willcox, K.L. Parise, and G.F. McCracken. 2015. Molecular detections of the causative agent of white-nose syndrome on Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) and two species of migratory bats in the Southeastern USA. Journal of Wildlife Diseases. 51:2. doi:10.7589/2014-08-202

Blehert, D.S., A.C. Hicks, M.J. 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 323:227.

Boyles, J.G., and C.K.R. Willis. 2010. Could localized warm areas inside cold caves reduce mortality of hibernating bats affected white-nose syndrome? Frontiers in Ecology and the Environment 8: 92-98.

Dobony, C.A., A.C. Hicks, K.E. Langwig, R.I. von Linden, J.C. Okoniewski, and R.E. Rainbolt. 2011. Little brown myotis persist despite exposure to white-nose syndrome. Journal of Fish and Wildlife Management 2:190-195. doi:10.3996/022011-JFWM-014

Janicki, A.F., W.F. Frick, A.M. Kilpatrick, K.L. Parise, J.T. Foster, and G.F. McCracken. 2015. Efficacy of visual surveys for white-nose syndrome at bat hibernacula. PLoS One. doi: 10.1371/journal.pone.0133390

Hoyt, J.R., K.E. Langwig, J. Okeniewski, W.F. Frick, W.B. Stone, and A.M. Kilpatrick. 2014. Long-term persistence of *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome, in the absence of bats. EcoHealth. doi: 10.1007/s10393-014-0981-4

Hoyt, J. R., K. Sun, K. L. Parise, G. Lu, K. E. Langwig, T. Jiang, S. Yang, W. F. Frick, A. M. Kilpatrick, J. T. Foster, and J. Feng. 2016. Widespread bat white-nose syndrome fungus, Northeastern China. Emerging Infectious Diseases 22:140-142. doi: http://dx.doi.org/10.3201/eid2201.151314

Langwig, K.E., W.F. Frick, R. Reynolds, et al. 2014. Hibernation drives seasonal dynamics of a fungal disease. Proceedings of the Royal Society B. http://dx.doi.org/10.1098/rspb.2014.2335.

Lindner, D.L., A. Gargas, J.M. Lorch, M.T. Banik, J. Glaeser, T.H. Kunz, and D.S. Blehert. 2011. DNA-based detection of the fungal pathogen *Geomyces destructans* in soils from bat hibernacula. Mycologia 103:241-246.

Lorch, J.M., D.L. Lindner, A. Gargas, L.K. Muller, A.M. Minnis, and D.S. Blehert. 2012. A culture-based survey of fungi in soil from bat hibernacula in the eastern United States and its implications for detection of *Geomyces destructans*, the causal agent of bat white-nose syndrome. Mycologia. doi:10.3852/12-207

Lorch, J.M., L.K. Muller, R.E. Russell, M. O'Connor, D.L. Lindner, and D.S. Blehert. 2013. Distribution and environmental persistence of the causative agent of white-nose syndrome, *Geomyces destructans*, in bat hibernacula of the eastern United States: Applied and Environmental Microbiology 79: 1293-1301.

McCracken, G. 1989. Cave conservation: special problems for bats. The NSS Bulletin 51: 47-51.

Miller-Butterworth, C.M., M.J. Vonhof, J. Rosenstern, G.G. Turner, and A.L. Russell. 2014. Genetic structure of little brown bats (*Myotis lucifugus*) corresponds with spread of white-nose syndrome among hibernacula. Journal of Heredity. doi:10.1093/jhered/esu012

Minnis, A.M., and D.L. Lindner. 2014. Phylogenetic evaluation of *Geomyces* and allies reveals no close relatives of *Pseudogymnoascus destructans*, comb. nov., in bat hibernacula of eastern North America. Fungal Biology. http://dx.doi.org/10.1016/j.funbio.2013.07.001

Mohr, C.E. 1972. The status of threatened species of cave dwelling bats. Bulletin of the National Speleological Society 34: 33-47.

Puechmaille S.J., G. Wibbelt, V. Korn, H. Fuller, F. Forget, et al. 2011a. Pan-european distribution of white-nose syndrome fungus (*Geomyces destructans*) not associated with mass mortality. PLoS ONE 6: e19167. doi: 10.1371/journal.pone.0019167

Puechmaille, S.J., H. Fuller, and E.C. Teeling. 2011b. Effect of sample preservation methods on the viability of *Geomyces destructans*, the fungus associated with white-nose syndrome in bats. Acta Chiropterologica 13:217-221.

Reeder D.M., C.L. Frank, G.G. Turner, C.U. Meteyer, A. Kurta, et al. 2012. Frequent arousal from hibernation linked to severity of infection and mortality in bats with white-nose syndrome. PLoS ONE 7(6): e38920. doi:10.1371/journal.pone.0038920

Reynolds, H.T., T. Ingersoll, and H.A. Barton. 2015. Modeling the environmental growth of *Pseudogymnoascus destructans* and its impact on the white-nose syndrome epidemic. Journal of Wildlife Diseases 51: 318-331.

Shelley, V., S. Kaiser, E. Shelley, T. Williams, M. Kramer, K. Haman, K. Keel, and H.A. Barton. 2013. Evaluation of strategies for the decontamination of equipment for *Geomyces destructans*, the causative agent of white-nose syndrome. Journal of Cave and Karst Studies 75: 1–10. doi: 10.4311/2011LSC0249

Thomas, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy 76: 940-946.

Tuttle, M.D. 1979. Status, causes of decline, and management of endangered gray bats. The Journal of Wildlife Management 43: 1-17.

Turner, G.G., D.M. Reeder, and J.T.H. Coleman. 2011, A five-year assessment of mortality and geographic spread of white-nose syndrome in North American bats and a look to the future. Bat Research News 52: 13-27.

U.S. Geological Survey. 2011. Wildlife Health Bulletin 2011-05. Retrieved from http://www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_2011-05_UniversalPrecautions.pdf

U.S. Fish and Wildlife Service. 2009. Cave Advisory. Hadley, Massachusetts. 4pp. http://www.whitenosesyndrome.org/resource/2009-fws-cave-advisory. Accessed 18 October 2015.

U.S. Fish and Wildlife Service. 2012. North American bat death toll exceeds 5.5 million from white-nose syndrome [press release]. Hadley, Massachusetts. http://whitenosesyndrome.org/news/north-american-bat-death-toll-exceeds-55-million-white-nose-syndrome. Accessed 18 October 2015.

Verant M.L., J.G. Boyles, W. Waldrep Jr., G. Wibbelt, D.S. Blehert. 2012. Temperature-dependent growth of *Geomyces destructans*, the fungus that causes bat white-nose syndrome. PLoS ONE 7(9): e46280. doi:10.1371/journal.pone.0046280

Warnecke, L., J.M. Turner, T.K. Bollinger, J.M. Lorch, V. Misra, P.M. Cryan, G. Wibbelt, D.S. Blehert, and C.K.R. Willis. 2012. Inoculation of bats with European *Geomyces destructans* supports the novel pathogen hypothesis for the origin of white-nose syndrome. PNAS 2012; doi:10.1073/pnas.1200374109

Zukal, J., H. Bandouchova, J. Brichta, A. Cmokova, K. S. Jaron, M. Kolarik, V. Kovacova, A. Kubátová, A. Nováková, O. Orlov, J. Pikula, P. Presetnik, J. Šuba, A. Zahradníková Jr., and N. Martínková. 2016. White-nose syndrome without borders: Pseudogymnoascus destructans infection tolerated in Europe and Palearctic Asia but not in North America. Scientific Reports 6:19829. http://dx.doi.org/10.1038/srep19829