Dooling, R. 2002. Avian Hearing and the Avoidance of Wind Turbines. Report prepared for the National Renewable Energy Laboratory. **http://www.nrel.gov/wind/pdfs/30844.pdf**

Executive Summary and Recommendations: This report provides a complete summary of what is known about basic hearing capabilities in birds in relation to the characteristics of noise generated by wind turbines. It is a review of existing data on bird hearing with some preliminary estimates of environmental noise and wind turbine noise at Altamont Pass, California, in the summer of 1999. It is intended as a resource in future discussions of the role that hearing might play in bird avoidance of turbines.

The main body of this report describes hearing measurement in birds, the effects of noise on hearing, and the relationship between avian hearing and the general noise levels around wind turbines. The main body is followed by four appendices. Appendix A is a table organized by species which provides a comprehensive bibliography of the literature on hearing in the quiet (audiograms) in birds, followed by Appendix B which provides plots of the audiograms from 49 species of birds that have been tested to date. Similarly, a bibliography of the literature on how birds hear in noise is given in a table in Appendix C, with corresponding plots of masked auditory thresholds in Appendix D.

There are a number of long-standing myths about what birds can or cannot hear. One myth is that birds hear better at high frequencies than do humans or other mammals. Another myth is that birds have exceptionally acute hearing. A considerable amount of work over the past 50 years has repeatedly shown that neither of these notions is true. When hearing is defined as the softest sound that can be heard at different frequencies, birds on average hear less well than many mammals, including humans.

Birds hear best between about 1 and 5 kHz. Acoustic deterrents or “scarecrow” devices are not generally effective because birds habituate to them and eventually ignore them completely. Devices that purport to use sound frequencies outside the hearing range of humans are most certainly inaudible to birds as well because birds have a narrower range of hearing than humans do. A review of the literature on how well birds can hear in noisy (windy) conditions suggests that birds cannot hear the noise from wind turbine blades as well as humans can. In practical terms, a human with normal hearing can probably hear a wind turbine blade twice as far away as can the average bird.

Some wind turbine blades whistle due to blade defects. Depending on the sound level of the whistle produced from a blade defect and the level of the background noise, blade whistles may help birds avoid turbine blades. Because turbine noise and wind noise are predominantly low frequency, almost all the contribution to an overall sound pressure level reading [e.g., 65 dB(A) SPL], comes from frequencies below 1 – 2 kHz. This means that adding an acoustic cue in the region of best hearing for birds (2 – 4 kHz) would add almost nothing to overall sound pressure level but might help birds hear the blades. The existence of blade defects that produce whistles suggests that minor modifications to the acoustic signature of a turbine blade, in the form of whistles, could make blades more audible to birds and at the same time make no measurable contribution to overall noise level.

It is entirely possible, however, that as birds approach a wind turbine, especially under high wind conditions, they lose the ability to see the blade (because of motion smear) before they are close enough to hear the blade. The hypothesis that louder (to birds) blade noises result in fewer fatalities is untested. Making the necessary noise measurements and comparing fatalities at turbines with noticeable whistles with those having no whistles provide one test of this hypothesis.