Implementing smart curtailment to reduce bat fatalities and energy loss at wind facilities

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INTRODUCTION

Curtailment of wind turbines during low wind speeds (i.e., below a set cut-in speed) is a leading solution in the reduction of bat fatalities caused by collision with turbines. This approach, referred to as blanket curtailment, has been found to significantly decrease fatalities up to 93% (Arnett et al. 2011) and if applied throughout North America, it could lead to an average of 62% reduction in fatalities (Whitby et al. 2021). To counter impacts to sensitive species, or all bat species, blanket curtailment is often recommended every night during the fall migratory period and sometimes during the spring and summer months.

Although blanket curtailment has been shown to decrease bat fatalities, it also results in a loss of energy production that is concerning to industry. A solution to this is smart curtailment, a strategy that considers real-time bat activity and weather conditions to maximize energy production when bats are not present or there is a low level of risk. One type of smart curtailment relies on sensor-based technology such as an acoustic detector to monitor for bats.

To minimize bat fatalities while maximizing energy production, Natural Power has developed **Echo**Sense®, a smart curtailment technology. In 2020 and 2021, we tested the effectiveness of the **Echo**Sense® system.

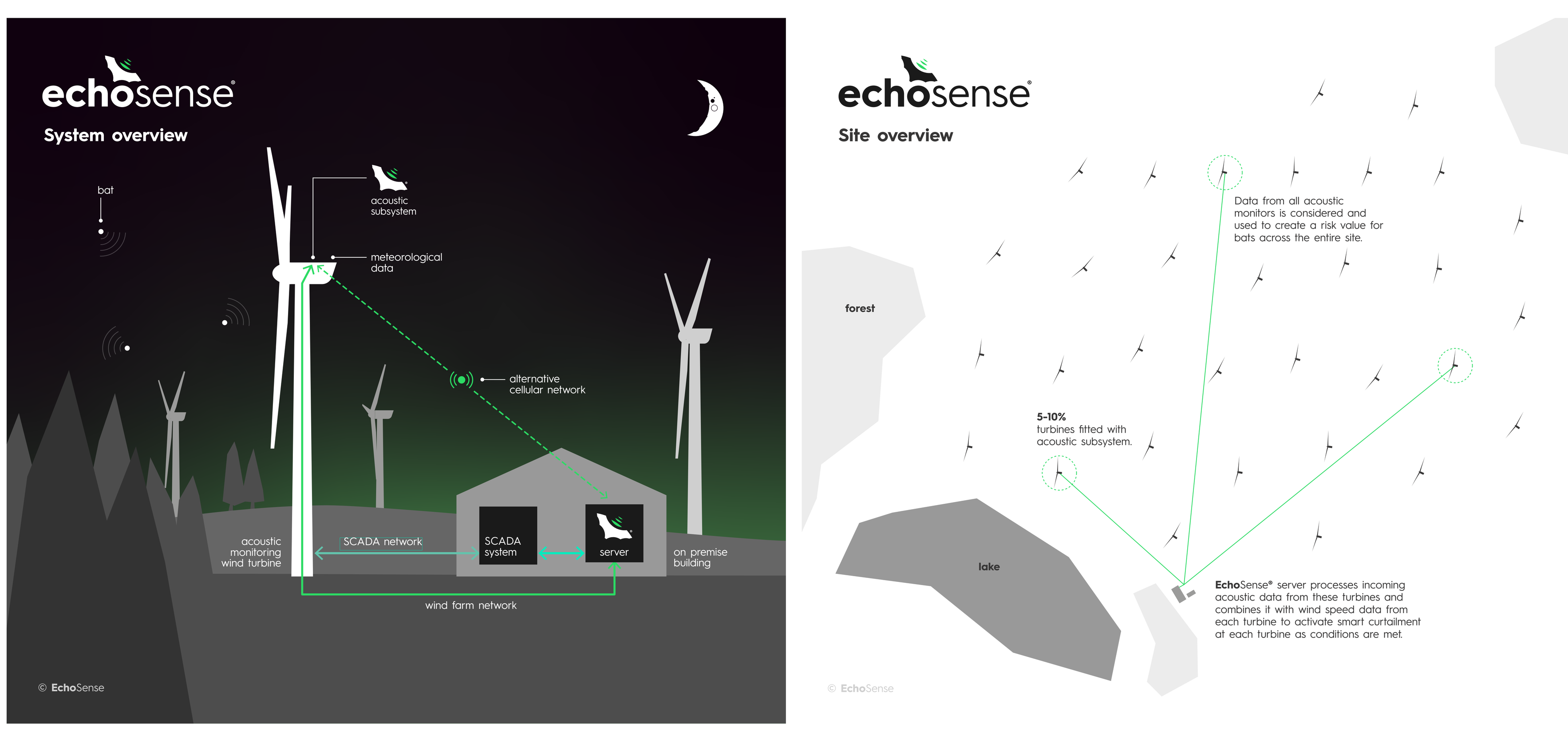

FIGURE 1: Overview of the **Echo**Sense® system.

MATERIALS AND METHODS

The study was conducted at the English Farms Wind Project, Poweshiek County, Iowa, U.S. This 170 MW facility is owned by Alliant Energy and consists of 69 wind turbines, including 11-2.3 MW and 58-2.5 MW turbines.

EchoSense® detectors were installed on the nacelles of 5 turbines. From August 4 to October 15, 2020, we compared curtailment from **Echo**Sense® to normal operation (manufacturers cut-in speed of 3.0 m/s) and blanket curtailment of 6.9 m/s. From July 31 to October 17, 2021, we compared curtailment from **Echo**Sense® to blanket curtailment of 5.0 m/s. Standard fatality searches, including searcher efficiency and carcass persistence trials, were conducted.

We used GenEst (Dalthorp et al. 2018) to estimate the overall number of bat fatalities per treatment and during each year. To compare potential differences in bat fatality rate among treatment types, we used a Generalized Linear Model (GLM) with a Poisson error structure calculated in R ver. 4.0.2 (R Core Team, 2020). We conducted an energy yield assessment of treatments and used a GLM with a Gamma error structure and Tukey's post-hoc comparisons to compare the lost production during periods of blanket and smart curtailment.

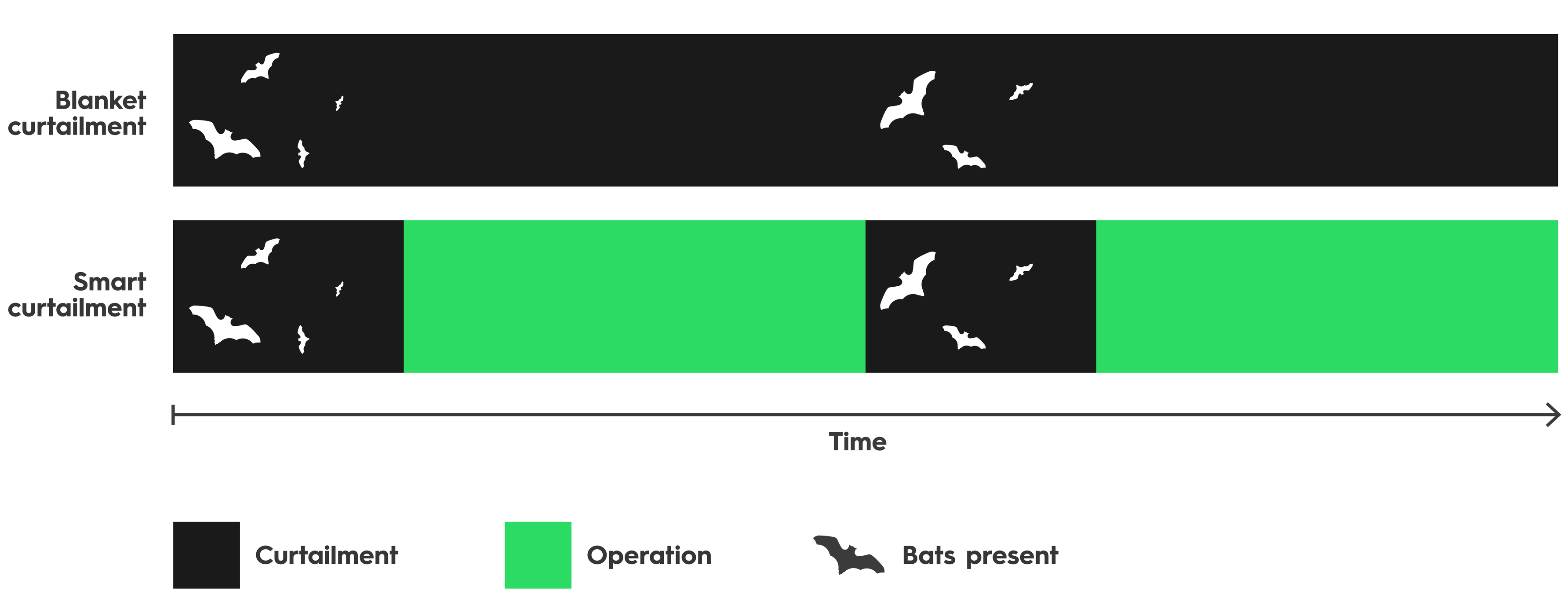

FIGURE 2: Comparison between blanket and smart curtailment strategies for the same wind speed within a given time period.

LITERATURE CITED

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RESULTS AND DISCUSSION

We found no significant difference in bat fatalities among treatments in 2020 (X^2 = 2.834, p = 0.243) and 2021 (X^2 = 0.49, p = 0.484). Smaller than expected sample sizes due to turbine operational failures may have resulted in a lack of statistical power and may explain why we didn't find a difference among curtailment types in 2020. Furthermore, higher-than-normal bat activity at high wind speeds has been documented at this project site. For example, pre-construction acoustic data recorded from August to October 2013 resulted in 72% of total bat activity detected when wind speeds were >6.9 m/s. Post-construction fatality data from 2019 demonstrated an estimate of >1,700 fatalities under a 6.9 m/s cut-in speed. The estimated rate of 10.26 bats/MW/yr at this project site is greater than the median rate of 8.39 bats/MW/yr across the midwestern U.S. (AWWIC 2020).

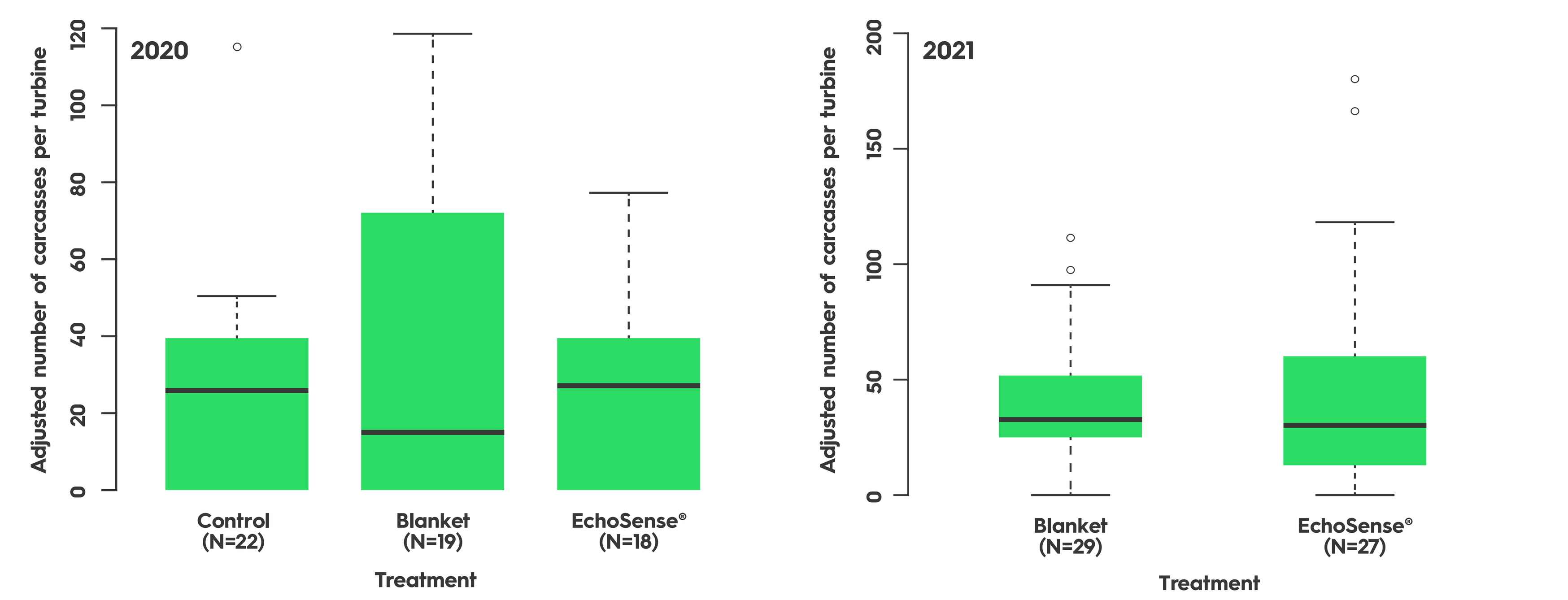


FIGURE 3: Number of bat carcasses detected per turbine adjusted for detection probability and turbine operational time.

In 2020, curtailment with **Echo**Sense® resulted in an average of 41% reduction in energy loss per turbine compared to blanket curtailment at 6.9 m/s cut-in speed. In 2021, curtailment with **Echo**Sense® resulted in an average of 56% reduction in energy loss per turbine compared to blanket curtailment at 5.0 m/s cut-in speed. Overall, use of **Echo**Sense® resulted in more energy production compared to blanket curtailment in 2020 (+5,490 MW hours) and 2021 (+1,684 MW hours).

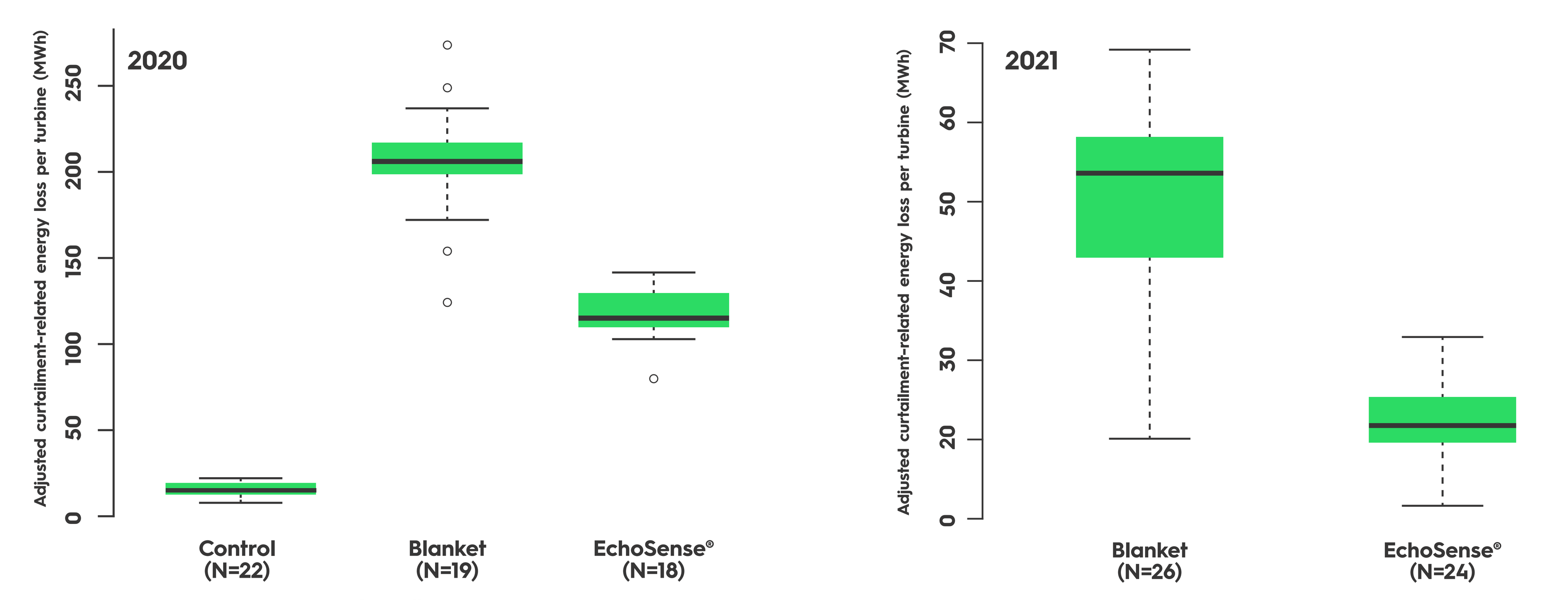
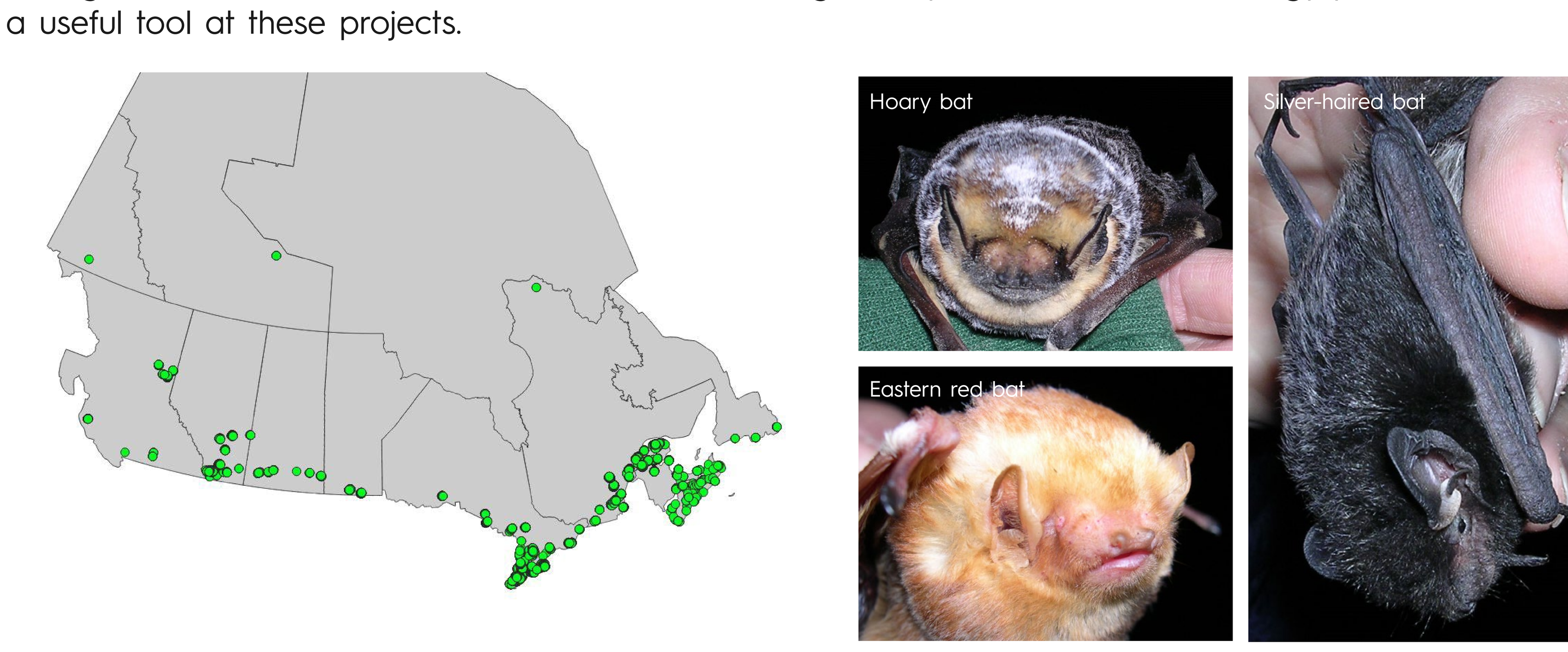


FIGURE 4: Energy yield loss estimated for all turbines per treatment.

CONCLUSION

The **Echo**Sense® smart curtailment system was able to considerably reduce turbine curtailment and lost energy compared to blanket curtailment, resulting in economic benefits for the use of **Echo**Sense® at this site. Although this study did not find a difference in the rate of bat fatalities between turbines controlled by **Echo**Sense® and turbines utilizing blanket curtailment, additional studies would be required to confirm the generalities of these findings across other geographic areas and with different bat species. With the recent recommendation that the hoary bat, eastern red bat, and silver-haired bat be listed as endangered (COSEWIC 2023), all wind energy facilities in Canada may soon be within the range of at least one endangered bat species and curtailment as a mitigation measure may be warranted. Smart curtailment technologies that have shown to be effective at balancing fatality minimization and energy production could be a useful tool at these projects.



Images courtesy of Roger Rodriguez.

FIGURE 5: Currently installed turbines and species recently recommended for listing as endangered under the Species At Risk Act. Data from the Canadian Wind Turbine Database.

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