Breaking Wind: Measures of Bioacoustic Activity Artificially Inflated by Wind

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Objectives

- Assess whether wind impacts measures of bioacoustical activity
- Provide a standardized adjustment to account for potential impacts

Background

- The acoustic environment can tell us a lot about the health of an ecosystem [5].
- Acoustic monitoring is a non-invasive and relatively inexpensive method of determining short- and long-term patterns of ecosystem bioacoustical activity [5].
- Indices of bioacoustical activity, such as Acoustic Complexity index (ACI), are mathematical summaries of spatial temporal variation in acoustic energy and can be used to quantify activity across a landscape [2, 4].
- However, ACI may be influenced by abiotic sounds like wind, leading to misrepresentations of bioacoustical activity [1].
- Using Yellowstone National Park data, we examined how wind influences ACI and looked to provide a standard adjustment to improve measures of ecosystem health.
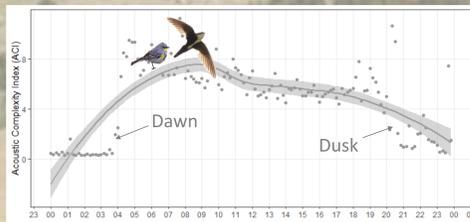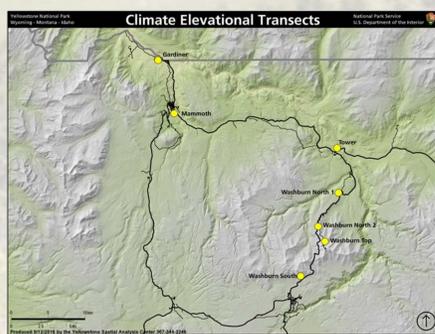
Hourly ACI: Daily bioacoustical patterns.

Daily ACI: Seasonal bioacoustical patterns.

Methods

Field Sites: Seven acoustical monitoring sites in Yellowstone National Park: Gardiner, Mammoth, Tower, Washburn North 1, Washburn North 2, Washburn Top, Washburn South.

ACI:
- We calculated ACI for every 10 minutes the hour before and after sunrise using R [3], statistical software.

Wind peaks:
- We manually counted peaks in spectrograms every 10 minutes during the hour before and after sunrise (see spectrogram right and wind events above).

Analysis:
- Linear Regression using # of peaks to predict effect of wind on ACI.

Recording equipment: Roland R05 audio recorders and weather stations recorded continuously at each site from May to July 2017 and May to October 2018.
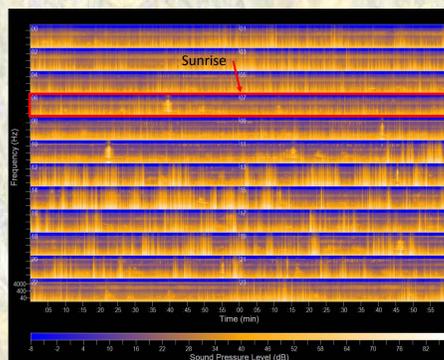
Audio file visualized as spectrogram: We sampled one week per season (spring and summer) per site to include windy and non-windy days.

Examples

ACI = 0.95

ACI = 9.42

ACI = 11.12
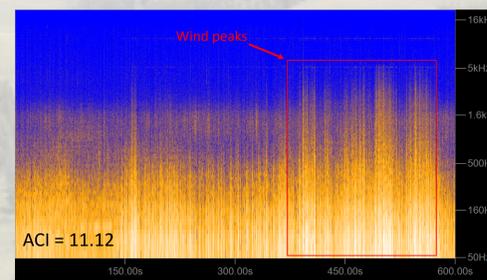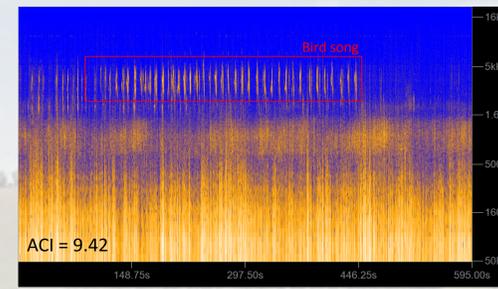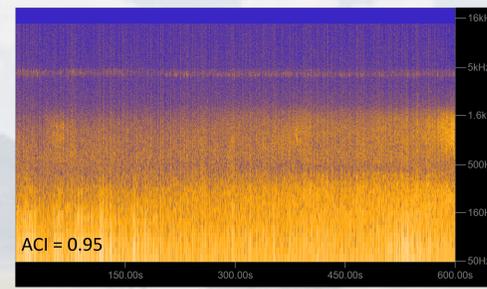
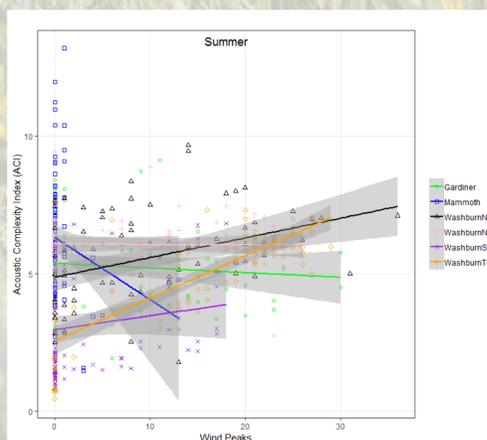**Minimal Activity** (top left): Ten minute time step with ACI = 0.95, indicating low bioacoustical activity.

Bird Activity (top right): Ten minutes with ACI = 9.42. ACI value accurately predicts bioacoustical activity, such as bird song.

Wind Events (bottom left): Ten minutes with ACI = 11.12. ACI values inaccurately predicts bioacoustical activity due to wind.

Results
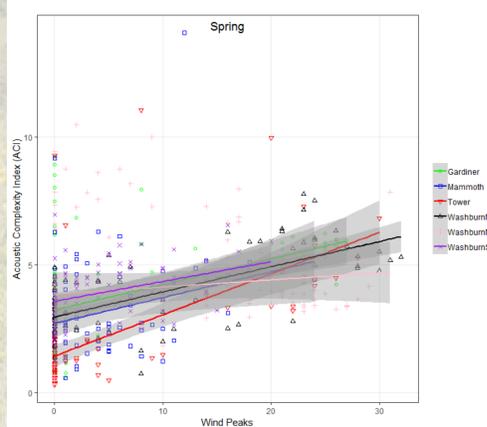
Spring ACI: Wind significantly affects ACI values similarly across sites during spring, except for Washburn North 2.

Site	Change in ACI per peak	Significant? *
Gardiner	0.099	Yes
Mammoth	0.10	Yes
Tower	0.16	Yes
Washburn North 1	0.016	Yes
Washburn North 2	0.028	No
Washburn South	0.077	Yes

Inflated ACI: Wind inflates ACI by ~0.1 at each site, except Washburn North 2.
*Significant values are below $\alpha=0.05$.

Summer ACI: Wind variably impacts ACI values during summer.

Site	Change in ACI per peak	Significant?*
Gardiner	-0.016	No
Mammoth	-0.23	No
Washburn North 1	0.072	Yes
Washburn North 2	-0.0012	No
Washburn South	0.051	No
Washburn Top	0.15	Yes

Variable ACI: Wind significantly inflates ACI at two of six sites.
*Significant values are below $\alpha=0.05$.

Conclusions

- The impact of wind is variable across seasons; with a more consistent impact across sites during spring.
- **Wind artificially inflates ACI by increasing ACI by about 0.1 per wind peak during spring. The impact of wind is inconsistent during the summer.**
- Using ACI inflated by wind could lead Yellowstone biologists to overestimate bioacoustical activity, thus misinforming seasonal patterns.
- Our results verify a need to better understand how wind influences bioacoustical indices.

Future Steps

- Automate process of quantifying wind so we can analyze larger data sets.
- Larger data sets will allow us to more thoroughly investigate temporal and spatial patterns of wind and its effect on ACI.
- From these patterns, we hope to develop a correction factor for windy days to produce better ACI values and thus measures of bioacoustical activity.

Listen

Minimal Activity

Bird Activity

Wind Events

Acknowledgements

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References

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[5] Truskinger, A., Cottman-Fields, M., Eichinski, P., Towsey, M. & Roe, P. Practical Analysis of Big Acoustic Sensor Data for Environmental Monitoring. in *2014 IEEE Fourth International Conference on Big Data and Cloud Computing* 91–98 (IEEE, 2014). doi:10.1109/BDCloud.2014.29