Appendix 1. Supplementary information on methodology and chorus projections

Location matters: evaluating Greater Prairie-Chicken (*Tympanuchus cupido*) boom chorus propagation

Supplemental Methods

Study area

The landscape is dominated by grass species including little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and prairie sandreed (*Calamovilfa longifolia*). Land use is primarily low-density cattle ranching (80%), hay production (10%), and cultivated crop production including corn (*Zea mays*), soy (*Glycince max*), and alfalfa (*Medicago sativa*) that are supported by irrigation (5%; Miller 1998). Average temperatures range from the mid 20° Cs in July to approximately -5°C in January, and precipitation averages 53 cm annually, with 50% falling between May and July. On average, wind speeds exceed 8.5 m/s at 80 m above ground (average height of a wind turbine hub). Each of the 36 turbines at the wind facility occupies a footprint of approximately 0.002 km^2 (0.2 ha), stands 70 m tall at the hub, and has a rotor radius of 41 m (rotor swept area = 5,281 m^2) (NPPD 2017). The turbines operate intermittently, at an estimated 40% of the full capacity (1.65 MW/turbine; NPPD 2017).

Weather data

Because the weather station collected data higher above the ground than the Kestrel Weather Meter, we conducted a regression analysis to estimate the 'kestrel' data from the 'weather station' data. We conducted a separate regression analysis (PROC GLIMMIX; SAS Institute Inc., Cary, NC) for each weather variable (wind speed, temperature, and humidity) with data from days for which we had both kestrel and weather station data. The response variable in each regression analysis was the 'kestrel data.' The explanatory variables in each regression analysis were the 'weather station data' and the distance between the weather station and the lek where the 'kestrel data' was collected. We used the resulting linear models to estimate the weather data at the leks for missing at-lek measurements.

Calibration process

During the calibration, we recorded tones of known frequency and sound pressure level for one minute for each preamplifier gain and both microphones attached to each audio recorder. Sound pressure levels were confirmed with a Type-1 Sound Level Meter (Larson Davis Model 831, PCB Piezotronics, Inc., Depew, NY). The maximum power of each known sound recorded on each channel of the audio recorders was measured in Raven (Hann window type, 100ms window size, 14.4 Hz 3 dB filter bandwidth; Charif et al. 2010). The difference between the known sound pressure level (dB SPL re 20 μPa) and the maximum power (dB) was used to calculate calibration correction factors for both microphones/channels of each audio recorder. Audio recorders were calibrated before and after each field season and averaged calibration correction factors from the 'before' and 'after' season calibration sessions were assigned to each microphone for the entire field season (Whalen 2015). When correcting the boom chorus sound pressure levels, we added the calibration correction factors to the uncalibrated levels.

SPreAD-GIS

SPreAD-GIS uses a modified National Landcover Database (Homer et al. 2012) raster file collapsed into seven categories: water, coniferous forest, herbaceous grassland, deciduous forest, shrubland, and developed land. Leks were located in herbaceous grassland and background noise levels from recording were used to represent sound of herbaceous grassland landcover (Table A1.2). Roads are included in the urban/developed land cover. Topography is calculated from a digital elevation model of the study area. Sound Pressure Levels (dB unweighted) values for land covered by urban/developed (i.e., roads), barren land, forest types, and wetland sound sources were derived from Harrison et al. (1980) and (American National Standards Institute 2004) (Table A1.2). These values were used to populate background sound tables for use in calculation of audible area (i.e., excess attenuation) raster projections (resolution = 30 m) (Table A1.2; Reed et al. 2010). Excess attenuation values (dB) are what remains from the sound propagation raster after taking into account environmental influences including spherical spreading loss, atmospheric absorption, foliage/ground loss and terrain and wind effects (Fig. A1.2 in gray). Background noise levels from leks recordings were used to represent the sound of herbaceous grassland landcover; all leks were located in herbaceous grassland. Roads are included in the urban/developed land cover.

We validated the model by 1) determining the number of pixels with excess attenuation values > 0 dB that overlapped pixels containing the recording points with signal to noise ratio > 0 dB and 2) comparing dB values in excess attenuation rasters to the difference of the chorus and background noise (i.e., signal to noise ratio) at ~ 0.300 kHz recorded along locations crossing the lek (details in Whalen 2015). A total of 57% of the transect points sampled for model validation overlapped with the raster cells that were predicted to have excess attenuation values above zero dB. Therefore, more than half of the transect points with signal to noise ratios above zero overlapped raster cell values with predicted excess attenuation above zero, which allowed us to assess how well signal to noise ratio (dB) explained the spatial projections of dB at 30 m resolution. Signal to noise ratio explained 25% of the variability in the predicted excess attenuation dB values at locations along the N,S,E, and W recording locations extending out from the lek (simple linear regression: $R^2 = 0.25$, $F_{1, 2482} = 861.9$, $P < 0.001$).

Literature cited

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Table A1.1. Example source sound table for SPreAD-GIS from lek recordings on 4/06/2013 at lek A1 near Ainsworth, Nebraska. dB represents average boom chorus sound level in a five minute recording. Weather conditions were recorded at leks.

Frequency (kHz)	dB (SPL)	Measurement Distance (m)	Wind speed (m/s)	Wind direction (°)	Temp (°C)	Relative Humidity	Filename
0.315	53.24	50	9	298	8	78	A1_2013-04-06_650
0.315	49.245	50	10	286	8	80	A1_2013-04-06_710
0.315	50.925	50	8	278	9	80	A1_2013-04-06_730
0.315	41.28	50	13	275	9	76	A1_2013-04-06_750

Table A1.2. Example background sound table for SPreAD-GIS from lek recordings on 4/06/2013 at lek A1 near Ainsworth, Nebraska. Land cover (dB) extrapolated from ANSI 2004 and Harrison et al. 1980. Cover derived from National Landcover Database: conifer (CON), hardwood (HWD), shrub (SHB), barren (BAR), urban (URB) and wetlands (WAT). *Herbaceous (HEB) grassland dB are average background sound level in a five-minute recording within same range of wind speed.

Frequency (kHz)	Cover	dB (SPL)	WindMin (m/s)	WindMax (m/s)
0.315	CON	20	0	1
0.315	CON	28	1	5
0.315	CON	33	5	15
0.315	CON	41	15	300
0.315	HWD	18	0	1
0.315	HWD	22	1	5
0.315	HWD	28	5	15
0.315	HWD	30	15	300
0.315	SHB	18	0	1
0.315	SHB	26	1	5
0.315	SHB	27	5	15
0.315	SHB	29	15	300
0.315	BAR	13	0	1
0.315	BAR	21	1	5
0.315	BAR	22	5	15
0.315	BAR	23	15	300
0.315	URB	31	0	1
0.315	URB	32	1	5
0.315	URB	33	5	15
0.315	URB	34	15	300
0.315	WAT	31	0	1
0.315	WAT	36	1	5
0.315	WAT	44	5	15
0.315	WAT	45	15	300
0.315	HEB*	13	0	1
0.315	HEB*	20	1	5
0.315	HEB*	25	5	15
0.315	HEB*	32	15	300

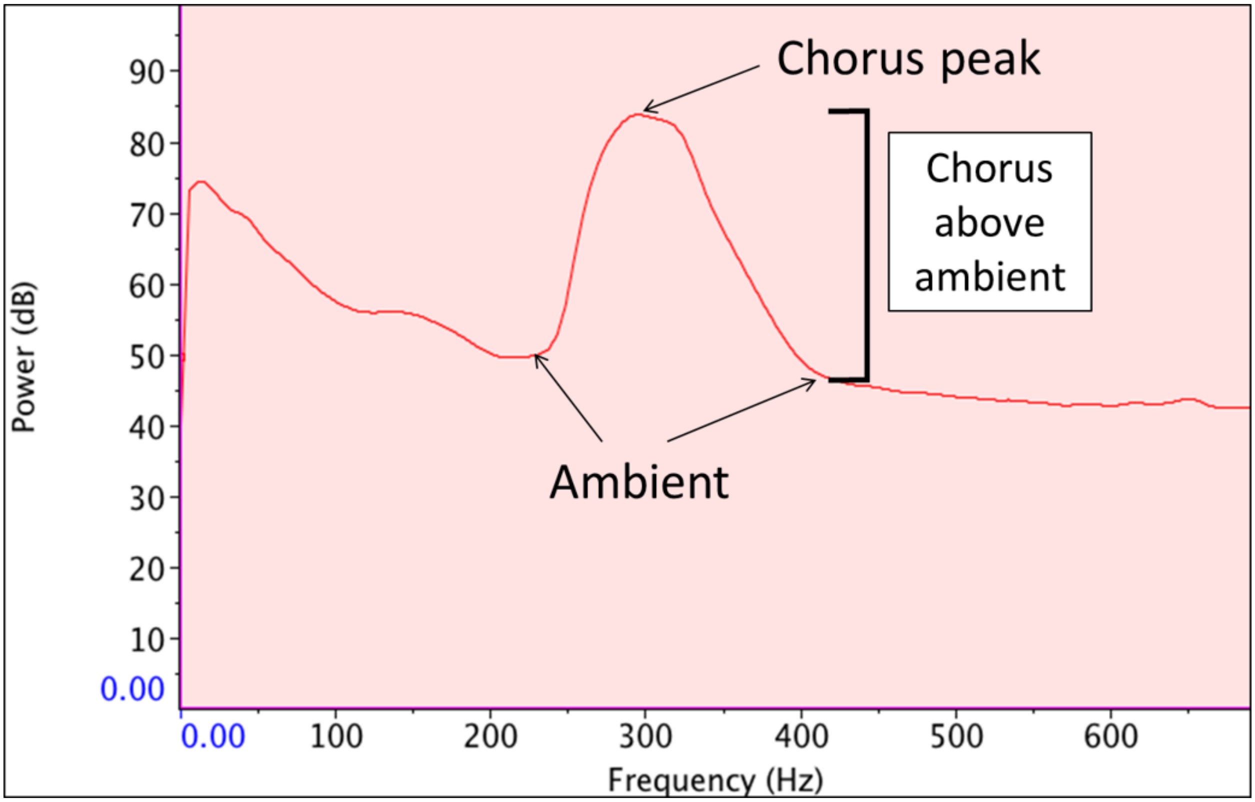

Figure A1.1. Depiction of the method used to extract boom chorus peak and ambient background noise sound pressure levels at ~ 0.300 kHz in the 383 usable recordings collected near Ainsworth, Brown County, Nebraska, USA in 2013 and 2014. The chorus peak and background sound levels at 50 m from the lek were used as the level of boom chorus (the source) originating from the lek and grassland cover type background noise, respectively, in each of the 383 chorus propagation maps generated with SPreAD-GIS.