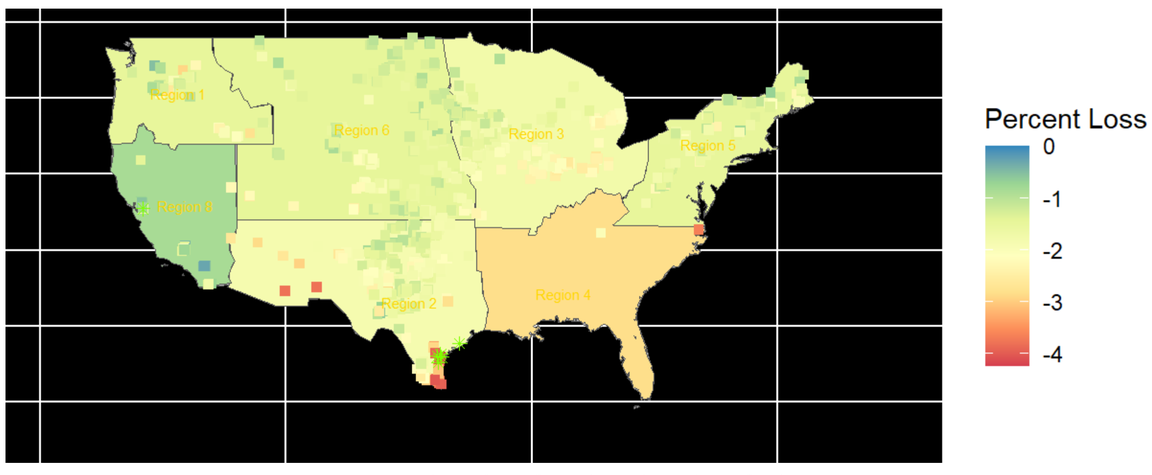
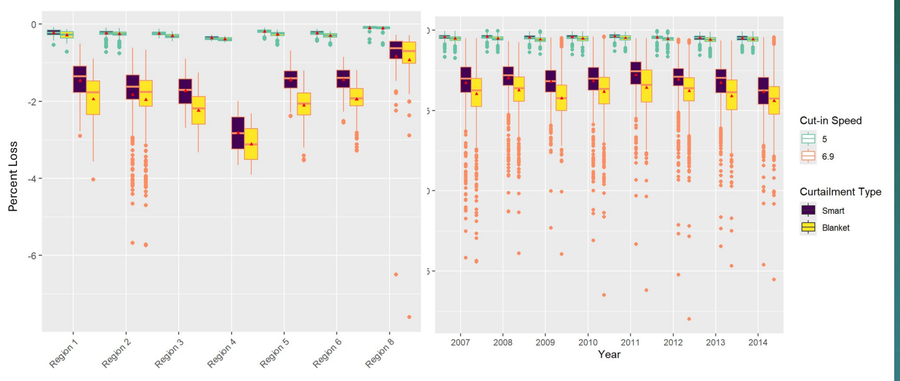
Financial Implications for Existing US Wind Facilities from Turbine Curtailment for Bats Are Highly Variable

Exploration of regional and interannual impacts energy and revenue from bat-specific curtailment regimens



Region	Smart 5 m/s	Smart 6.9 m/s	Blanket 5 m/s	Smart 6.9 m/s
Region 1	-0.22	-0.26	-1.35	-1.77
Region 2	-0.22	-0.25	-1.62	-1.76
Region 3	-0.24	-0.31	-1.71	-2.18
Region 4	-0.36	-0.39	-2.83	-3.11
Region 5	-0.18	-0.24	-1.40	-2.06
Region 6	-0.22	-0.29	-1.39	-1.92
Region 8	-0.08	-0.09	-0.62	-0.69

Median percent loss of AEP by FWS region when years are averaged for each wind farm.



Intro

Curtailing operating turbines is currently the primary way wind energy facilities approach reducing bat fatalities. USFWS has issued guidance for both the northern long-eared and tri-colored bat that include various curtailment strategies by location (e.g., State) and date. Curtailment results in the loss of energy production for individual wind farms but also reduces the availability of renewable energy for the grid. There have been various curtailment studies that, in addition to assessing fatality reductions for curtailment strategies, have also reported energy annual production (AEP) loss from those studies, but there is a lack of understanding of how operational curtailment strategies impact energy production and revenue at a larger scale. Maclaurin et. al. (2022) was the first modeling effort to evaluate energy production on hypothetical wind farms. This project is building on that effort by evaluating how current wind farms would be impacted.

Methods

- Energy production was simulated for >900 wind farms over 8 years using historical weather data.
- USFWS Regional and yearly energy and revenue loss for 4 curtailment strategies compared to when no curtailment occurs.
  - Blanket = Wind speed threshold only
  - Smart = Wind Speed, Precipitation, and Temperature thresholds
- Revenues were estimated based on average wholesale market energy values from 2023.

Results

- Regional and annual differences are most evident at higher curtailment strategies.
- Smart curtailment is more important at higher curtailment.
- Regional variation > Yearly variation

Discussion

- NOTE: Lots of assumptions and for this analysis “smart” is not “smart curtailment”
- Understanding financial impacts is important for all decision makers
- Additional analysis is needed to understand grid energy impacts from curtailment

Average Wind Fram Revenue Loss

FWS Region	Smart 5 m/s	Smart 6.9 m/s	Blanket 5 m/s	Blanket 6.9 m/s
Region 1	-$23,261	-$175,854	-$31,066	-$232,886
Region 2	-$66,920	-$481,402	-$73,405	-$525,980
Region 3	-$41,134	-$297,338	-$51,384	-$383,682
Region 4	-$104,379	-$860,688	-$112,747	-$924,739
Region 5	-$25,487	-$194,532	-$32,358	-$267,300
Region 6	-$53,250	-$334,139	-$72,451	-$472,229
Region 8	-$12,498	-$111,138	-$13,703	-$121,987

Average Wind Farm Yearly Revenue Loss

Year	Smart 5 m/s	Smart 6.9 m/s	Blanket 5 m/s	Blanket 6.9 m/s
2007	-$55,048	-$405,758	-$69,069	-$520,499
2008	-$57,438	-$391,542	-$71,092	-$508,492
2009	-$36,550	-$260,445	-$47,587	-$360,420
2010	-$37,340	-$269,477	-$47,077	-$341,304
2011	-$33,595	-$230,993	-$42,635	-$305,687
2012	-$32,127	-$208,690	-$38,850	-$269,932
2013	-$38,718	-$264,330	-$48,602	-$336,044
2014	-$48,271	-$369,957	-$55,473	-$433,803

Cumulative Average Regional Revenue Loss

FWS Region	#	Smart 5 m/s	Smart 6.9 m/s	Blanket 5 m/s	Blanket 6.9 m/s
1	74	-$2.66 M	-$18.37 M	-$3.39 M	-$24.35 M
2	299	-$18.06 M	-$141.79 M	-$19.96 M	-$152.46 M
3	263	-$9.04 M	-$65.86 M	-$11.28 M	-$83.18 M
4	2	$-0.21 M	-$1.72 M	-$0.23 M	-$1.85 M
5	83	-$2.26 M	-$17.41 M	-$3.16 M	-$25.34 M
6	196	-$11.58 M	-$70.62 M	-$14.67 M	-$91.84 M
8	66	-$1.05 M	-$8.58 M	-$1.17 M	-$9.59 M
Total	**983**	**-$44.86 M**	**-$324.37 M**	**-$53.86 M**	**-$388.6 M**

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