Bats & Wind Development in North America:

Patterns, Challenges, & Opportunities

Cris D. Hein
Bat Conservation International

Bats (in a nutshell)

- ~1,400 Species (45 Species in US)
- Nocturnal, Flying Mammals
- Long-lived, Slow Reproducing
- Cave- & Tree-roosting Species
- Hibernating & Migrating Species
- Echolocation


In 2003, ~1,400–4,000 bats estimated to have been killed at the Mountaineer Wind Energy Facility, WV
BAT CONSERVATION
INTERNATIONAL
www.batcon.org

2010 Estimated Impact on Bats

- ~12 bats/MW
- 2010 Installed Capacity US/Canada = 44,465 MW
- Fatality Representative & Constant
- Estimated # bats killed in 2010 = 533,580

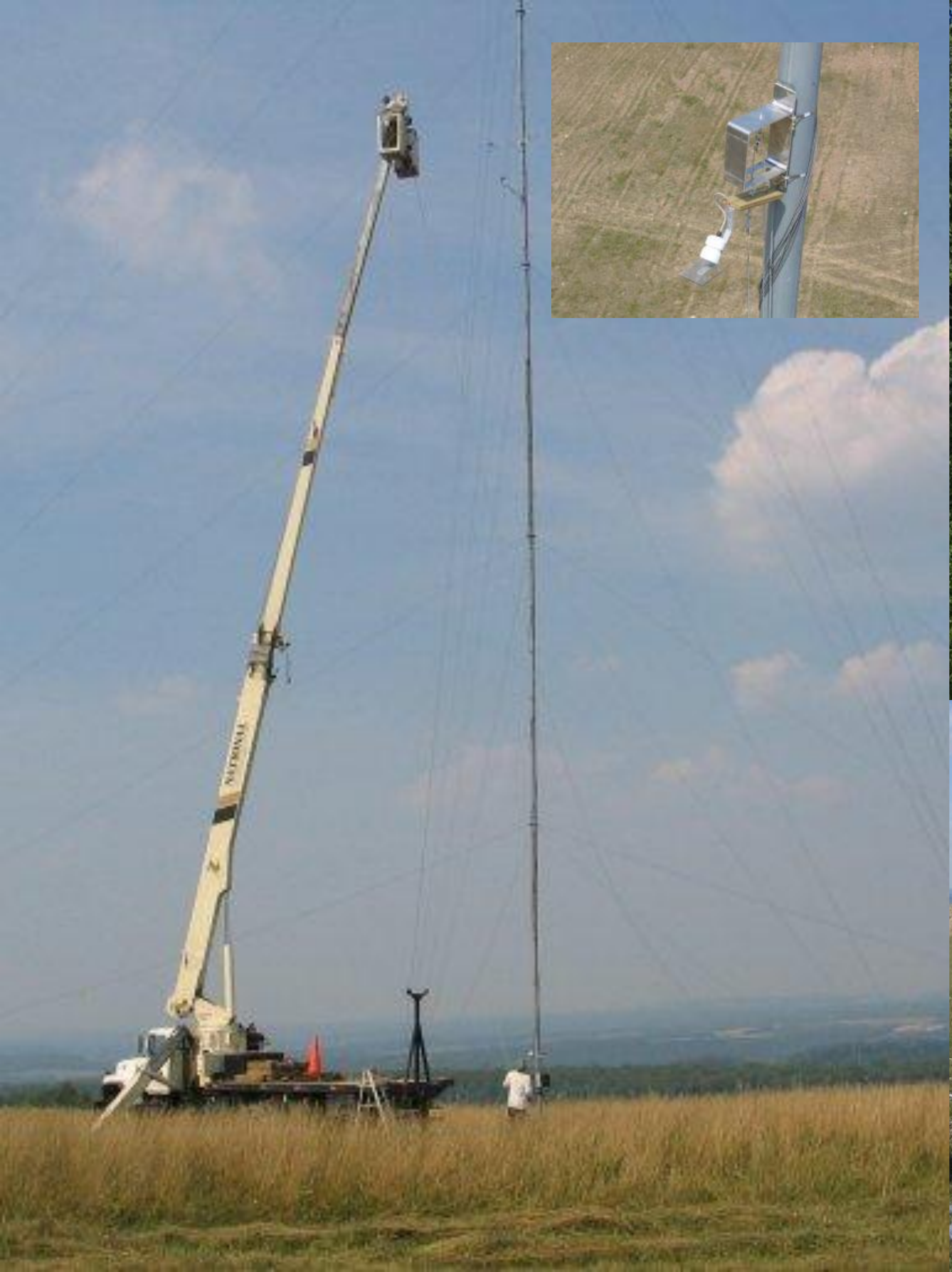
Research Priorities

- Pre-construction Acoustic
- Post-construction Acoustic & Fatality
- Operational Mitigation & Deterrents
- Population Analsis

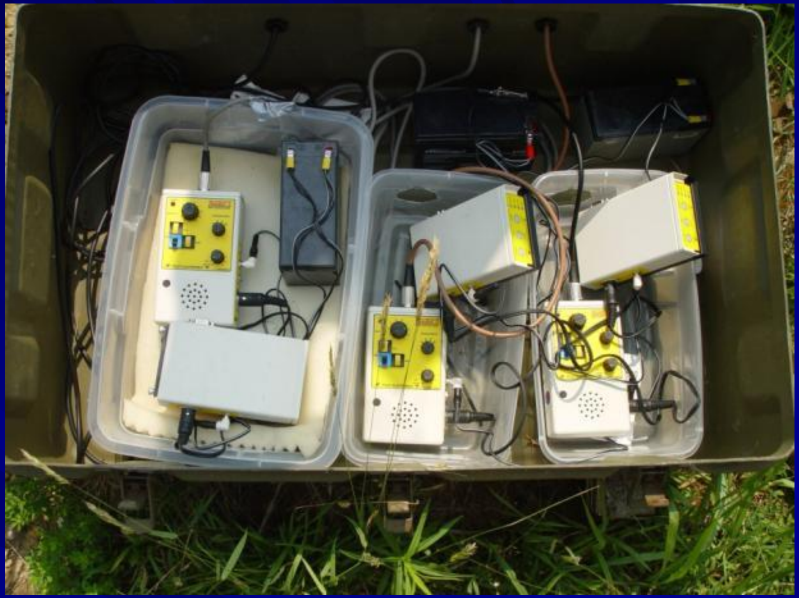
Pre- & Post-construction Monitoring

- Siting
- Seasonal Patterns
- Weather Patterns

- Species Composition
- Population Characteristics
- Collision/Barotrauma



Activity Patterns from Pre-con Studies



*Temporal (nightly, monthly, annually)

Spatial (horizontal & vertical)

*Peak activity in mid-summer through fall

Migration & mating behavior

*Wind Speed:

most activity (up to 90%) occurs below 6 m/s
high percentage of activity occurs below 4 m/s

*Ambient Temperature:

most bat activity occurs on warmer nights during migratory season
may relate to insect activity or thermoenergetic constraints

*Habitat:

activity associated with certain features

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Fatality Patterns from Post-Con Studies

11 of the 45 species north of Mexico have been found killed by turbines

~80% of fatalities are migratory tree-roosting bats…BUT… cave-roosting species comprise a high proportion of fatalities

High proportions of Brazilian free-tailed bats fatalities have been reported in CA, OK & TX

Of these, mostly pregnant females collected in May and June in OK…located within 10 km maternity cave

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Fatality Patterns from Post-Con Studies

Eastern red bat

Species experiencing highest fatalities have little or no protection

Eastern red bats suggested to be declining

(*Whitaker et al. 2002, Carter et al. 2003, Winhold et al. 2005*)

Silver-haired bat

Turbines are killing prime breeding age adults

While population impacts are unknown, considerable concern about cumulative impacts as wind energy expands

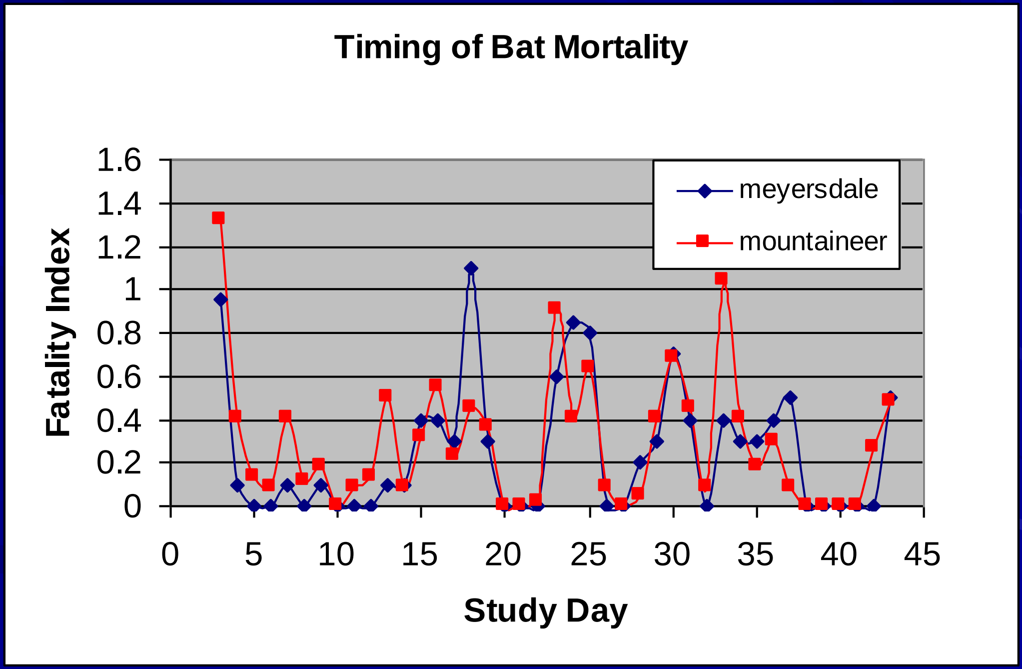
Development Characteristics

Taller, Turbines with Larger RSA > Fatality

Fatalities Tend to be Evenly Distributed Among Turbines

Timing of Fatality Events

Fatalities highest in mid-summer-fall, coinciding with migration of some species

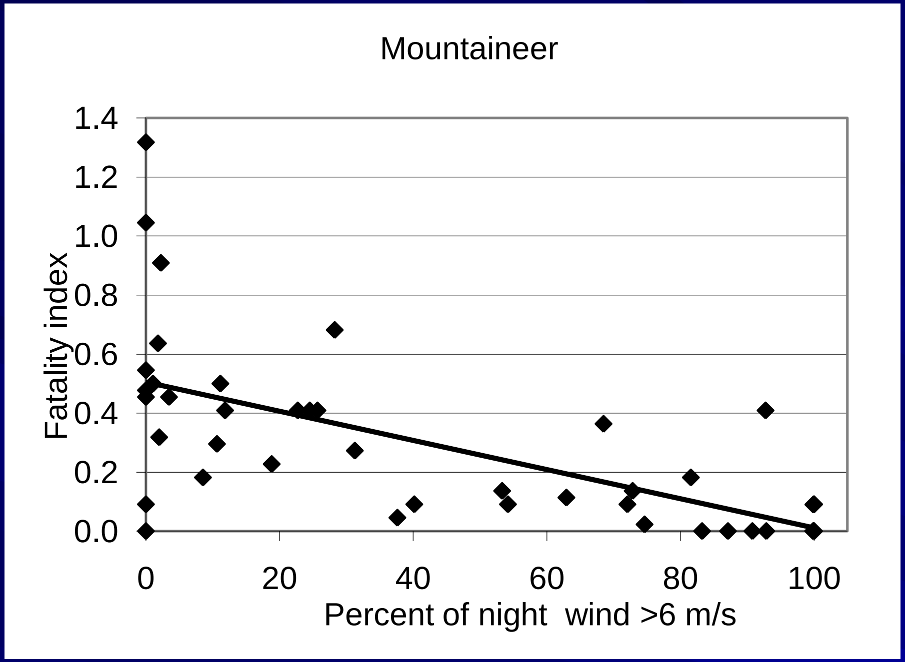


Some evidence to suggest regional patterns in timing of fatality…perhaps related to migration, weather or food

BAT CONSERVATION INTERNATIONAL

www.batcon.org

Weather Conditions

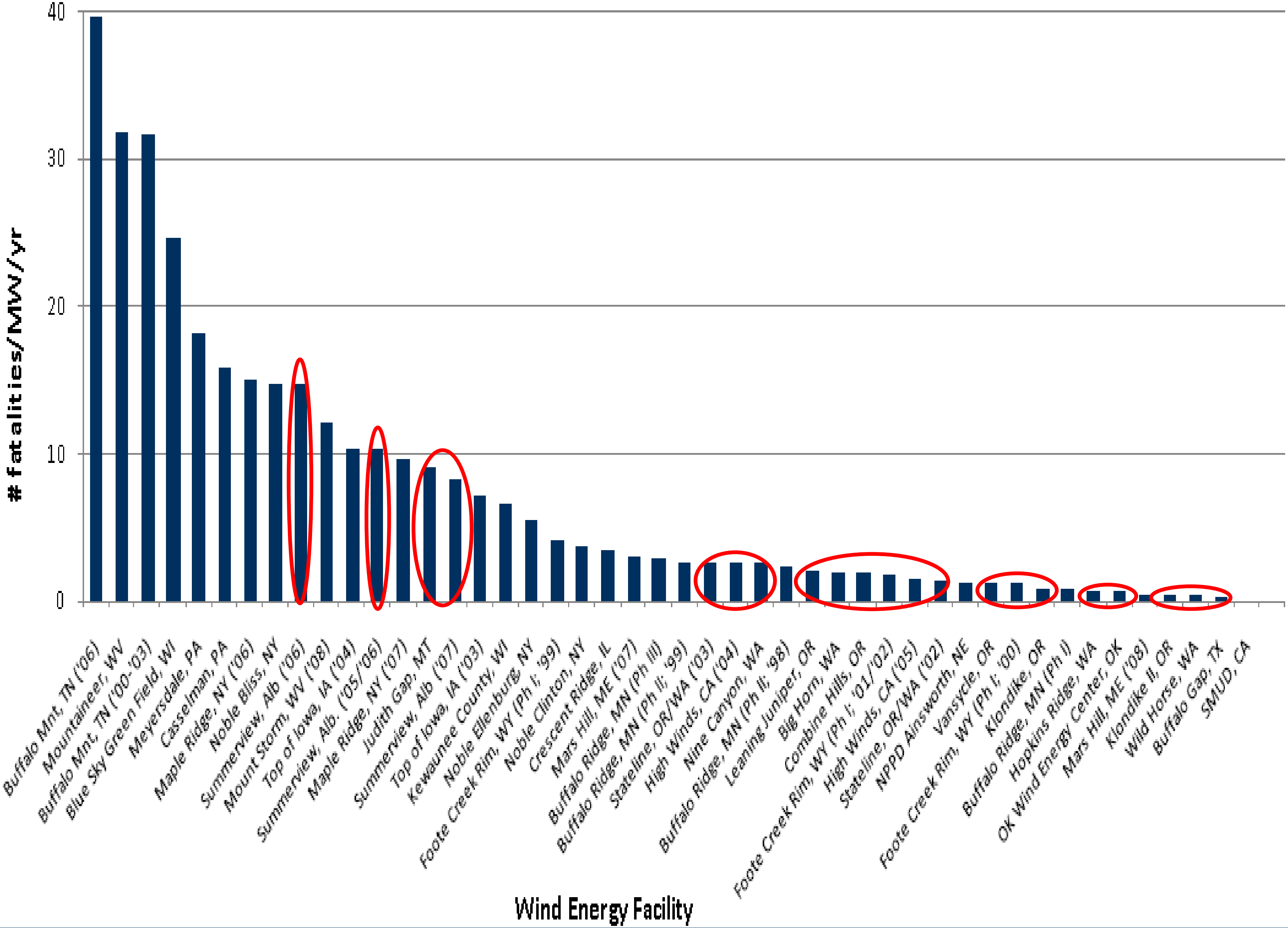


Majority of bats killed in PA, TN, WV were on low wind nights; kills negatively related to wind speed

Bat kills also associated with passage of weather fronts

Patterns may be predictable!

Figure 3: Summary of Bat Mortality Rates at Various Wind Energy Facilities*



Dearth of information…little or no data from many areas (e.g.,Southwest)

Woodward Wind Energy Facility, Oklahoma

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Future Suggestions

- Continue Monitoring & Disseminate Data
- Consistency Among Studies
- Relate Pre- & Post-Construction Data
- Determine Predictability of High Kill Events
- Use data to fine-tune mitigation options

Questions & Challenges

Migratory Patterns

Population Levels

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Questions & Challenges Cont'd

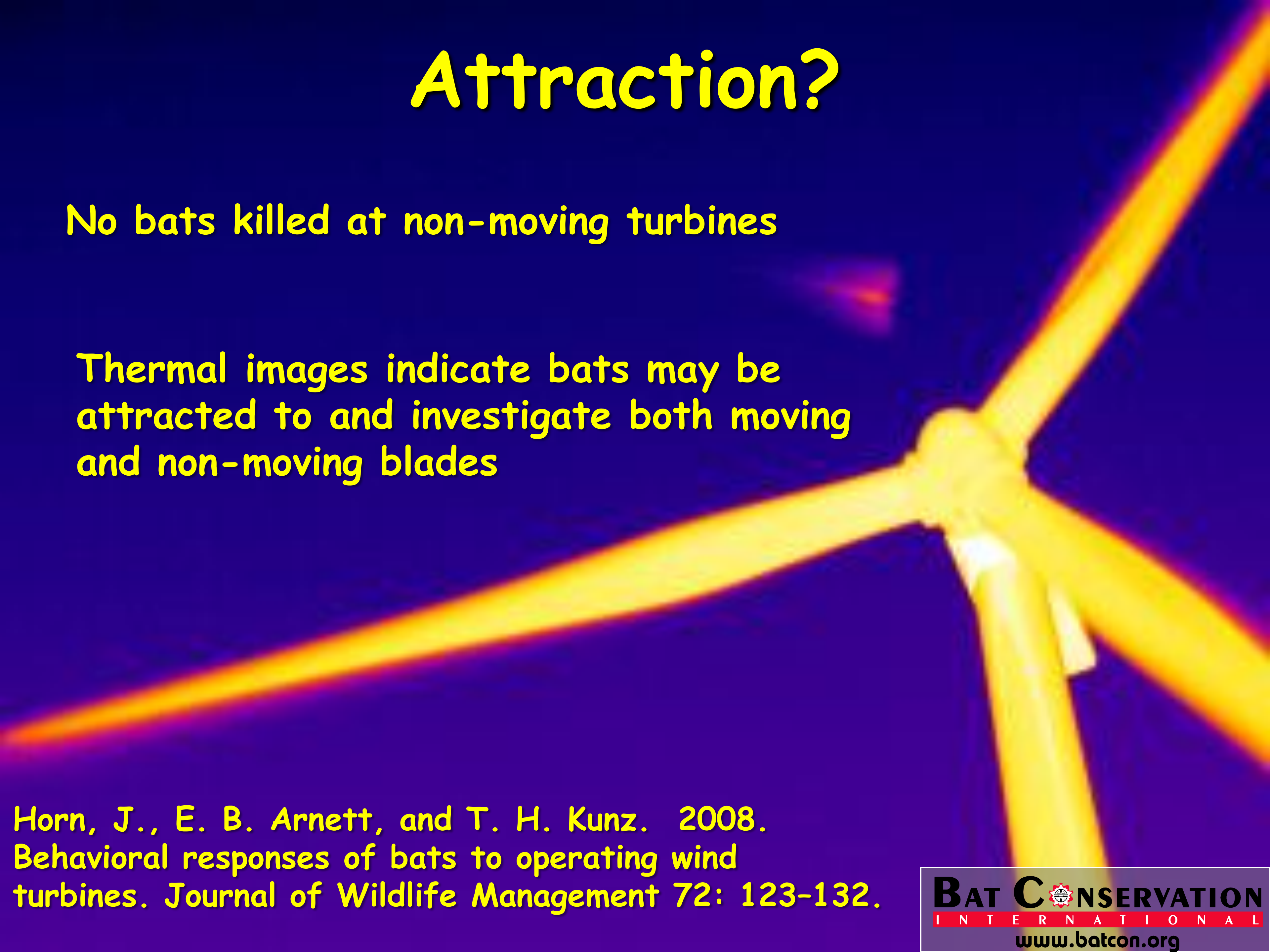
Collision/Barotrauma

Behavior Around Turbines

Attraction?

No bats killed at non-moving turbines

Thermal images indicate bats may be attracted to and investigate both moving and non-moving blades



Horn, J., E. B. Arnett, and T. H. Kunz. 2008. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management 72: 123–132.

Attraction Hypotheses

Roost Attraction

Landscape Attraction

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Proper Siting!
Must avoid development in high risk areas (e.g., TX Hill Country)

Gulf Coast / Yucatan - Mexico

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Curtailment Studies:

Study conducted in Germany (O. Behr, unpublished data) found ~50% reduction of bat kills when turbine "cut-in" speed was changed to 5.5 m/s

Study conducted in Alberta Canada demonstrated ~58% reduction in kills with 5.5 m/s cut-in (Baerwald et al. 2009)

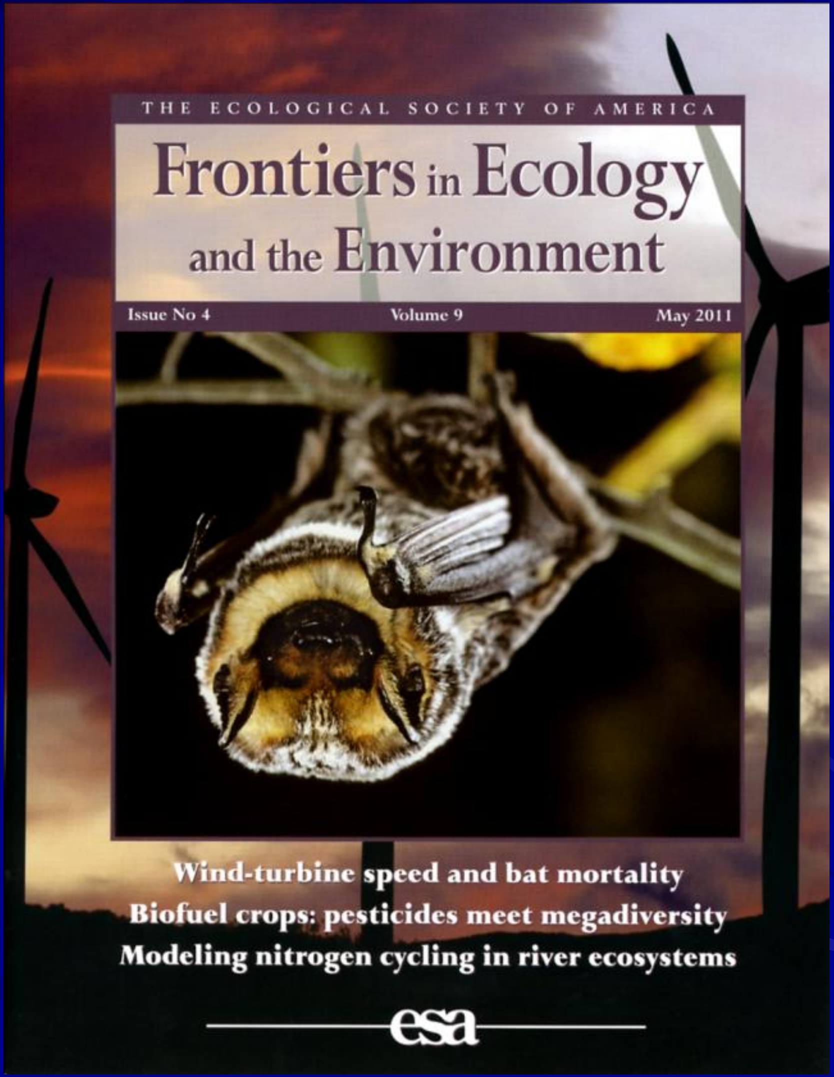
Curtailment Study: Casselman

(Arnett et al. 2011. Frontiers in Ecology and the Environment – May 2011

In 2008, 52–93% fewer bats killed at turbines with cut-in speed raised between 5.0-6.5 m/s

In 2009, 46–86% fewer bats killed at turbines with cut-in speed raised between 5.0-6.5 m/s

0.3- ~1% annual power loss with cut-in speed raised between 5.0-6.5 m/s



Fowler Ridge Results

Goode et al. 2011

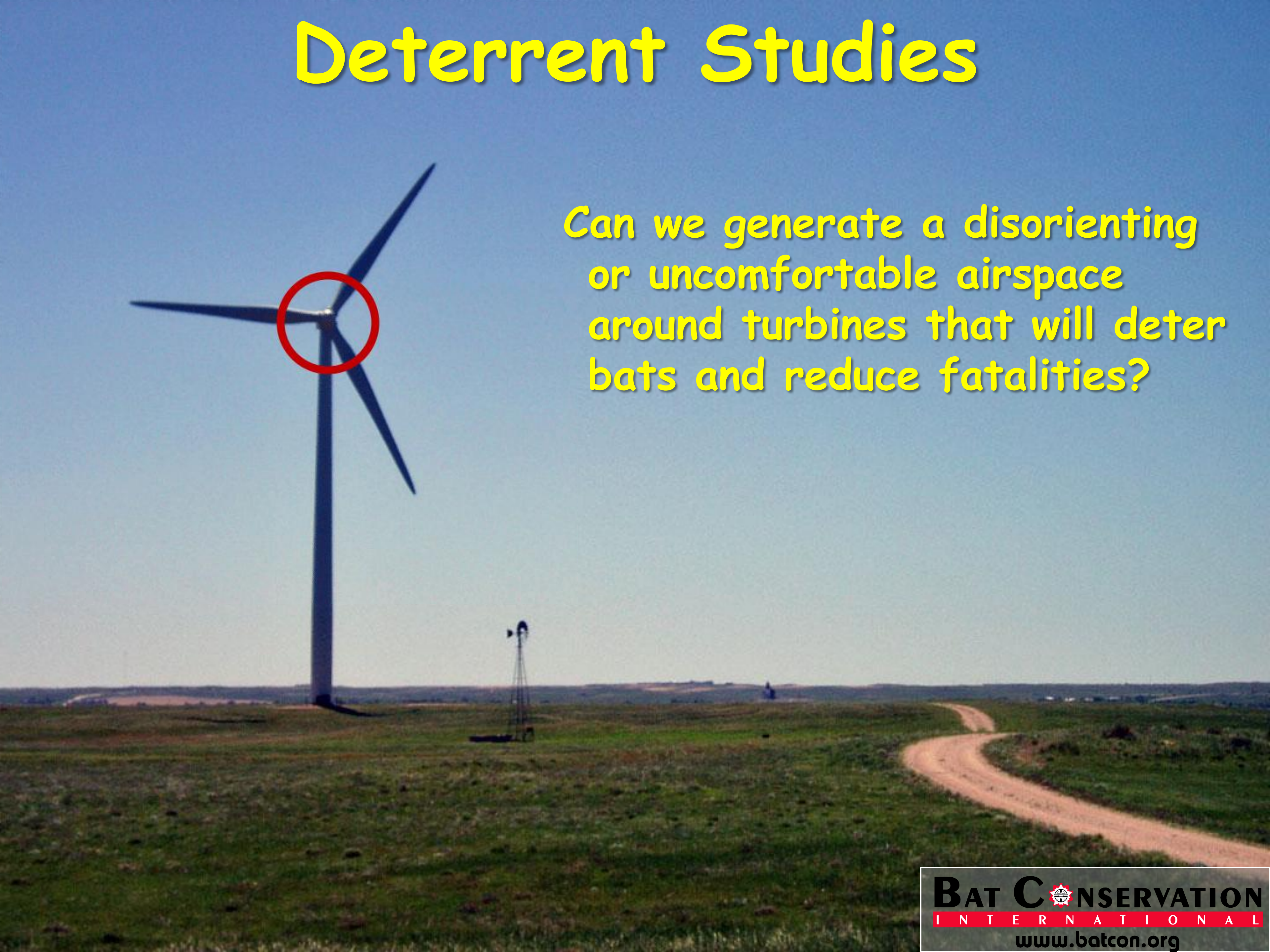
- Control: 14.0 (11.6–16.5) bats/turbine/season
- 5.0 m/s: 7.0 (7.0–9.1) bats/turbine/season
    - ~50% reduction in fatality
- 6.5 m/s: 3.0 (1.8–4.2) bats/turbine/season
    - ~78% reduction in fatality
- Significant Difference Between Tmt Groups

Next Steps

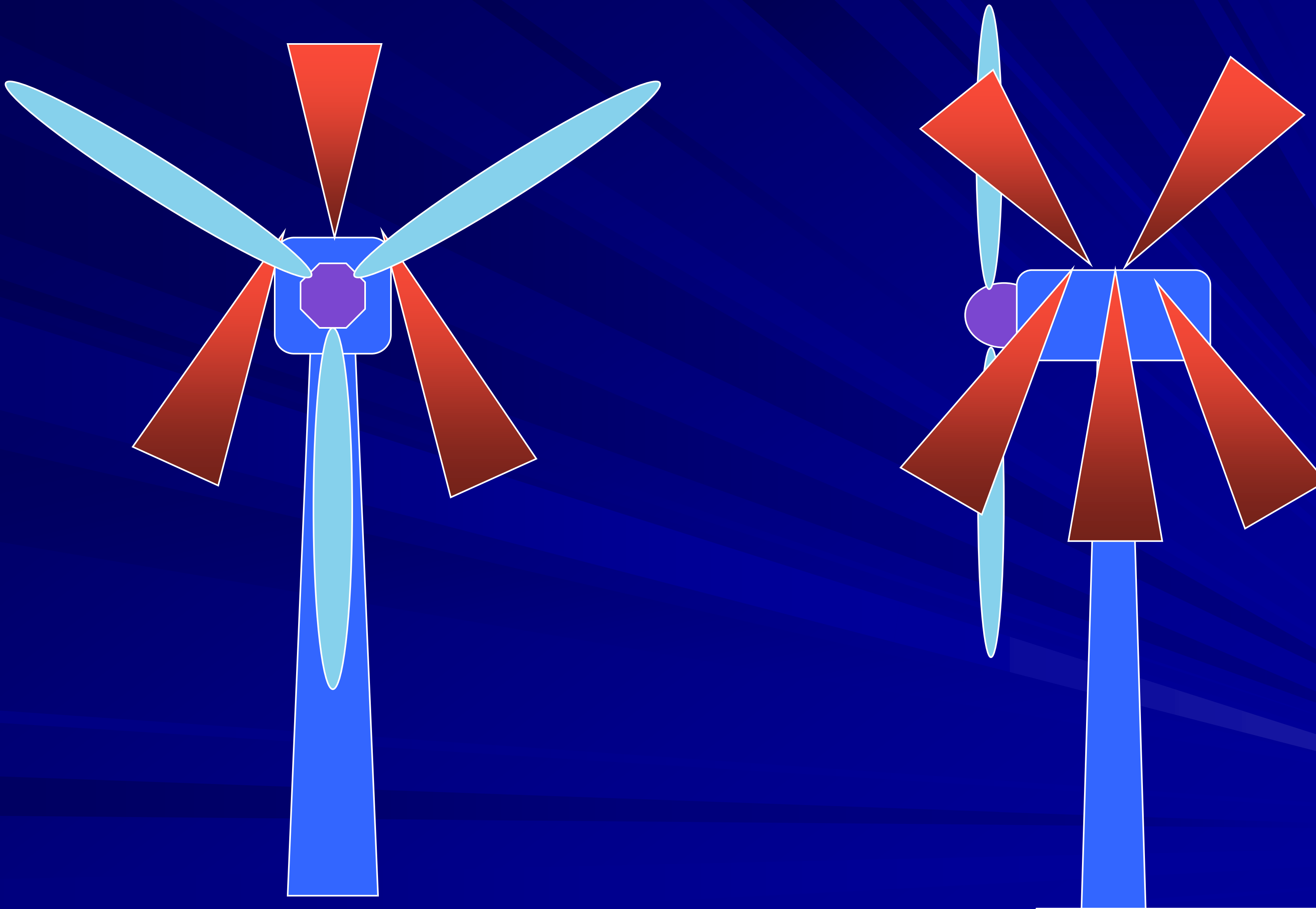
- Significant Reductions in Bat Fatality
- Conduct Similar Studies…
  - Other Sites…Other Species
  - Time of Night
  - Cut-in Speeds
  - Incorporate Temperature or Other Variables

Deterrent Studies

Can we generate a disorienting or uncomfortable airspace around turbines that will deter bats and reduce fatalities?



Deterrent Placement



BAT CONSERVATION INTERNATIONAL
www.batcon.org

Deterrent Results

- We found a significant reduction in bat fatalities at Deterrent Turbines for both years.
- Some evidence of a species specific response to Deterrents
  - Fewer fatalities of low-frequency calling bats at Deterrent Turbines.

Humidity Matters!

Calculated Decibel Level at Distance and Frequency (Assumes 20° C at 10% relative humidity and pressure of 101.325 kPa)									
	Frequency (kHz)								
Distance (m)	20	30	40	50	60	70	80	90	100
1	102	107	112	122	122	117	114.5	114.5	117
5	87.0	91.6	96.2	105.6	104.7	99.1	95.7	94.5	95.8
10	79.7	83.9	87.9	96.6	94.4	88.1	83.7	81.0	80.8
15	74.8	78.7	82.0	90.1	86.7	79.7	74.2	70.0	68.3
20	71.0	74.5	77.2	84.6	80.0	72.3	65.7	60.0	56.8
25	67.8	70.8	73.0	79.6	73.9	65.4	57.7	50.6	45.8
30	64.9	67.5	69.1	75.0	68.1	58.9	50.2	41.6	35.3
35	62.3	64.5	65.5	70.7	62.6	52.6	42.8	32.7	24.9
40	59.8	61.6	62.0	66.5	57.2	46.5	35.7	24.1	14.8
45	57.5	58.8	58.7	62.5	52.0	40.6	28.6	15.6	4.7
50	55.3	56.2	55.5	58.6	46.9	34.8	21.7	7.2	-5.2
55	53.2	53.7	52.4	54.7	41.8	29.0	14.9	-1.1	-15.0
60	51.1	51.2	49.3	51.0	36.9	23.3	8.1	-9.4	-24.8

Humidity Matters!

Calculated Decibel Level at Distance and Frequency

(Assumes 20º C at 40% relative humidity and pressure of 101.325 kPa)

	Frequency (kHz)								
Distance (m)	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	102	107	112	122	122	117	114.5	114.5	117
5	85.7	89.3	93.2	102.0	100.8	94.9	91.3	90.1	91.4
10	76.8	78.5	81.2	88.4	85.8	78.7	73.8	71.0	70.9
15	70.4	70.3	71.7	77.3	73.3	65.0	58.8	54.5	52.9
20	65.0	63.1	63.2	67.2	61.8	52.4	44.8	38.9	35.9
25	60.1	56.4	55.2	57.8	50.8	40.3	31.3	23.9	19.4

Humidity Matters!

Calculated Decibel Level at Distance and Frequency

(Assumes 20° C at 80% relative humidity and pressure of 101.325 kPa)

	Frequency (kHz)								
Distance (m)	20	30	40	50	60	70	80	90	100
1	102	107	112	122	122	117	114.5	114.5	117
5	86.5	89.9	93.2	101.2	98.8	92.4	88.1	86.3	87.0
10	78.6	80.0	81.2	86.6	81.3	73.2	66.6	62.6	61.0
15	73.2	72.6	71.7	74.6	66.3	56.5	47.6	41.3	37.5
20	68.8	66.2	63.2	63.5	52.3	40.8	29.6	21.1	15.0
25	64.9	60.4	55.2	53.1	38.8	25.6	12.1	1.4	-7.0
30	61.4	55.0	47.7	42.9	25.8	10.8	-4.9	-17.9	-28.5
35	58.2	49.8	40.3	33.1	12.9	-3.7	-21.8	-36.9	-49.9
40	55.1	44.7	33.2	23.4	0.3	-18.1	-38.4	-55.8	-71.0
45	52.2	39.8	26.1	13.8	-12.3	-32.3	-55.0	-74.6	-92.1
50	49.4	35.0	19.2	4.4	-24.7	-46.5	-71.4	-93.2	-113.0
55	46.7	30.3	12.4	-5.0	-37.0	-60.5	-87.7	-111.8	-133.8
60	44.0	25.7	5.6	-14.3	-49.3	-74.5	-104.0	-130.2	-154.6

Bat Conservation International
www.batcon.org

Next Steps

- Develop Next Generation Deterrent.
- Examine different placement designs/Resonance Frequencies
- Determine costs of purchasing/installing/maintaining devices.

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Technology has a way of advancing quickly…

Changes in technology could make many of today's concerns obsolete… and could create a new suite of unforeseen issues

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Cooperation is CRITICAL!!!

BAT CONSERVATION INTERNATIONAL
www.batcon.org

Many thanks to:

www.batsandwind.org

Deaton Engineering

Manuela Huso, Oregon State University
Michael Schirmacher & Michael Baker, Bat Conservation International
Joe Szewczak, Humboldt State University

Iberdrola Renewables (Andy Linehan, Lee VanHorn, Don Rogers, Jerry Roppe, Dave DeCaro, and Senior Management for their support)

Field crews!!!

Funding provided by:
American Wind Energy Association – member companies
American Wind and Wildlife Institute
Bat Conservation International
Department of Energy and NREL
National Renewable Energy Lab
Iberdrola Renewables
US Fish and Wildlife Service

BWEC bats and wind energy cooperative

Bat Conservation International
www.batcon.org

Questions?

BAT CONSERVATION INTERNATIONAL
www.batcon.org