Advances in Post-Construction Monitoring

Manuela Huso

Research Statistician

Forest & Range Ecosystem Science Center

U.S. Department of the Interior
U.S. Geological Survey

How to Advance Post-Construction Monitoring

Manuela Huso

Research Statistician

Forest & Range Ecosystem Science Center

U.S. Department of the Interior
U.S. Geological Survey

Why monitor post-construction?

- Detect Impact to wildlife
  - Estimate fatality
  - Detect displacement
  - Detect change in population viability
  - Estimate cumulative impacts

USGS

Why monitor post-construction?

- Inform operations
  - Adaptive management
  - Curtailment
  - Collision Risk
  - Model avoidance and/or attraction

USGS

Tools

- Deterministic Models with Incorporated Stochasticity
- Statistical Models
  - Predictive Models
  - Relational Models
  - Causal Models

USGS

How to Advance

Develop strong conceptual model

↓

Design sampling to reflect conceptual model

↓

Develop statistical model that reflects conceptual model and all sources of variation due to sampling design

USGS

How to Advance

- Strong conceptual model developed by biologists, statisticians and field technicians
- Conceptual model drives the statistical model
- Conceptual model establishes inferential scope and guides sampling
- Conceptual model guides interpretation

USGS

Sampling to reflect conceptual model

Conceptual model based on risk

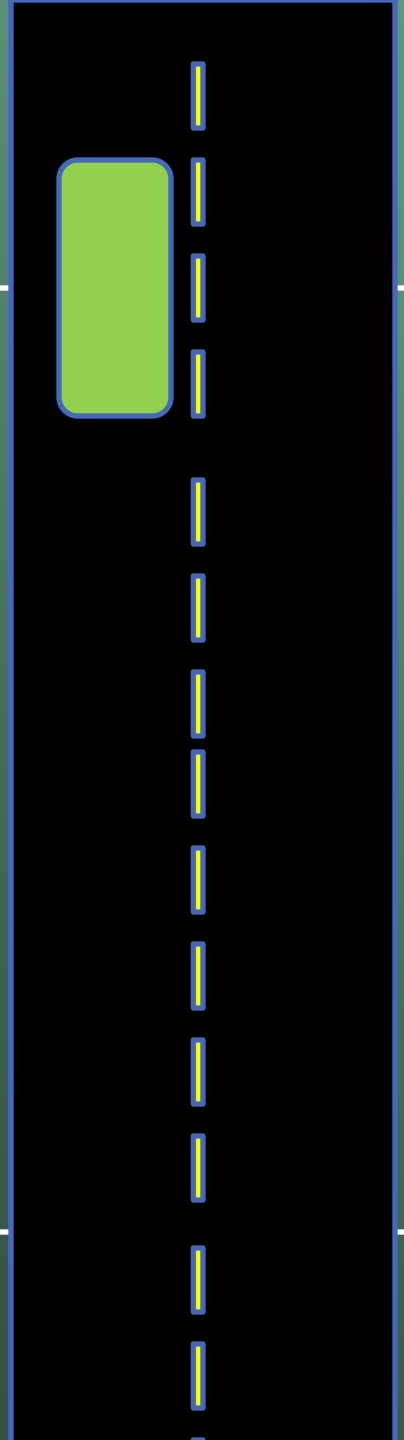
More activity => more chance of accident

But activity of what, where and when and how do we measure it?

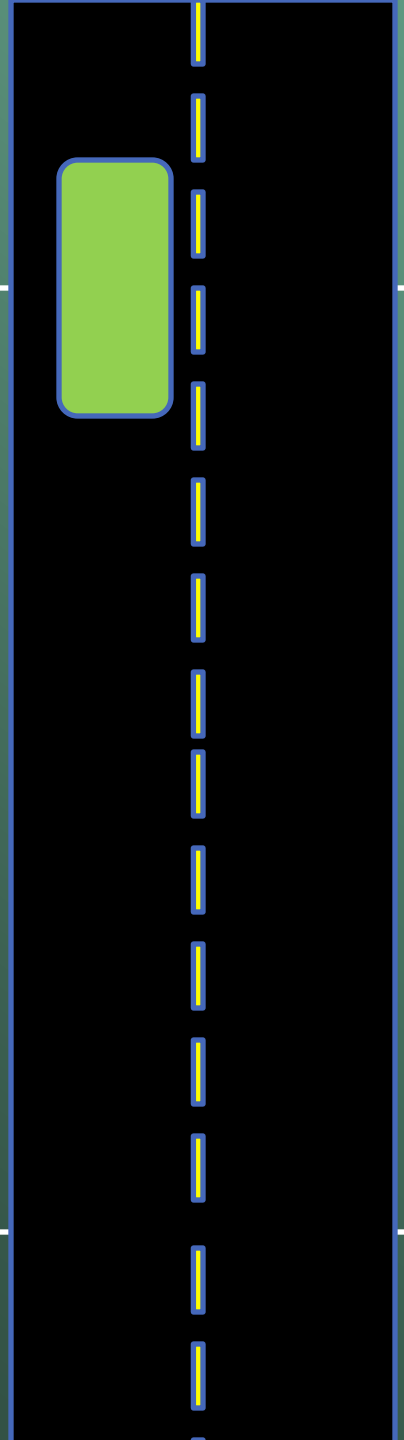
Radar monitoring of air space

Acoustic monitors on turbines or at locations of future turbines

USGS

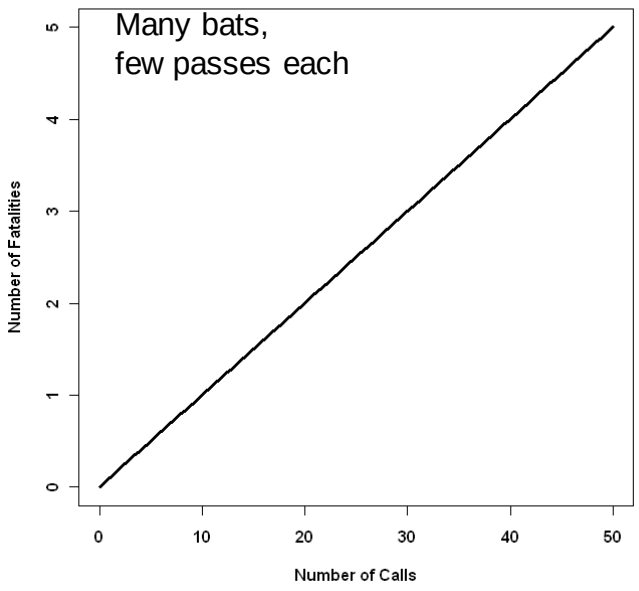


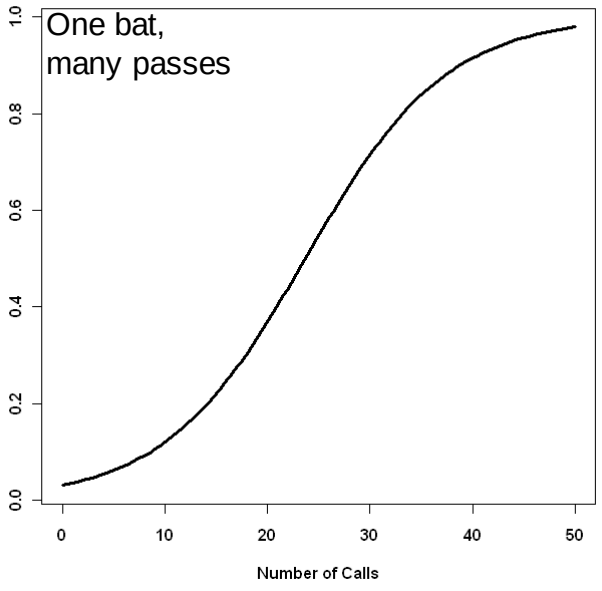
USGS

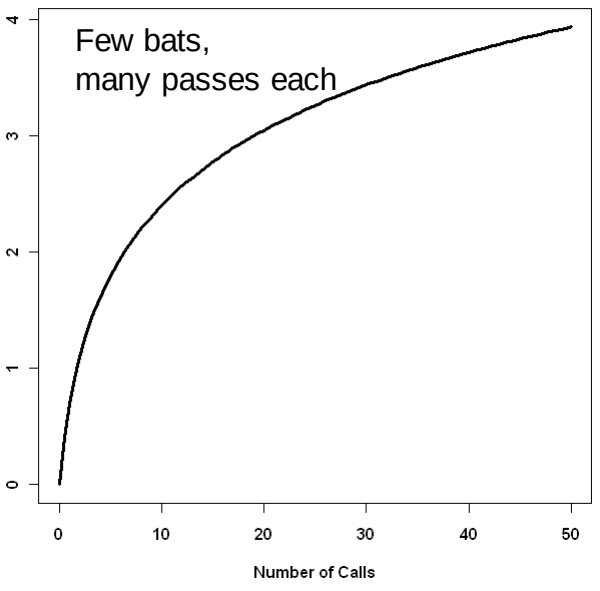


USGS

Conceptual Model Drives Statistical Model







USGS

Conceptual Model Drives Statistical Model

- What we measure is NOT consistent with conceptual model
- Change Conceptual Model:
  - Fatality is correlated with a <u>surrogate of activity</u>
- Change what we measure to accurately reflect our model

How to Advance

Conceptual model establishes inferential limits and guides interpretation of statistical models

Strong relationship of fatality to activity measured below RSZ => GREAT!

Weak or no relationship ≠> none exists

Maybe surrogate is not appropriate

USGS

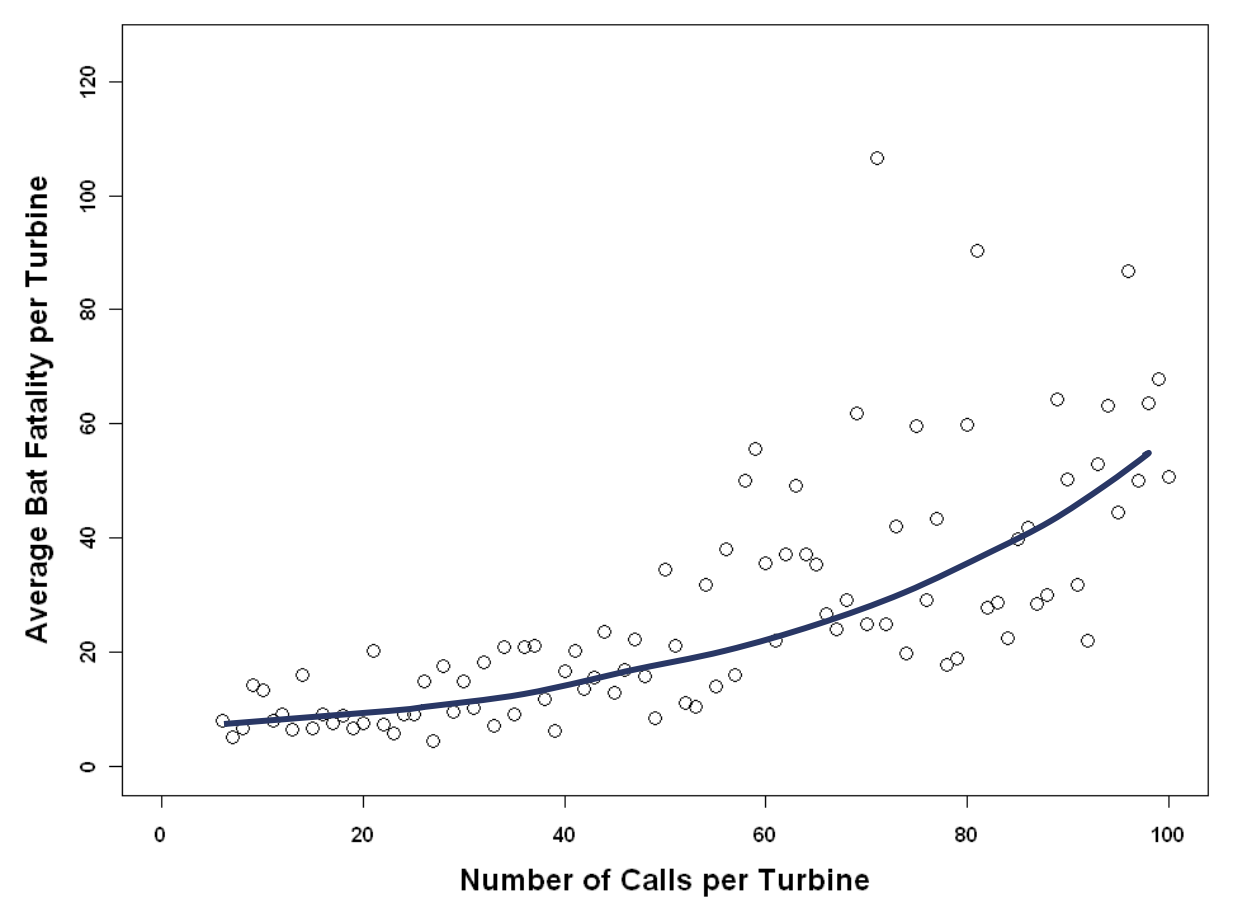
Predictive Models

Can bat fatality be predicted from activity at the nacelle?

Can we use models to predict future fatality from current activity?

USGS

Predictive Models



USGS

Statistical Model and Inference

- Take $\log_e$ transform to linearize and stabilize variance
- Fit linear model

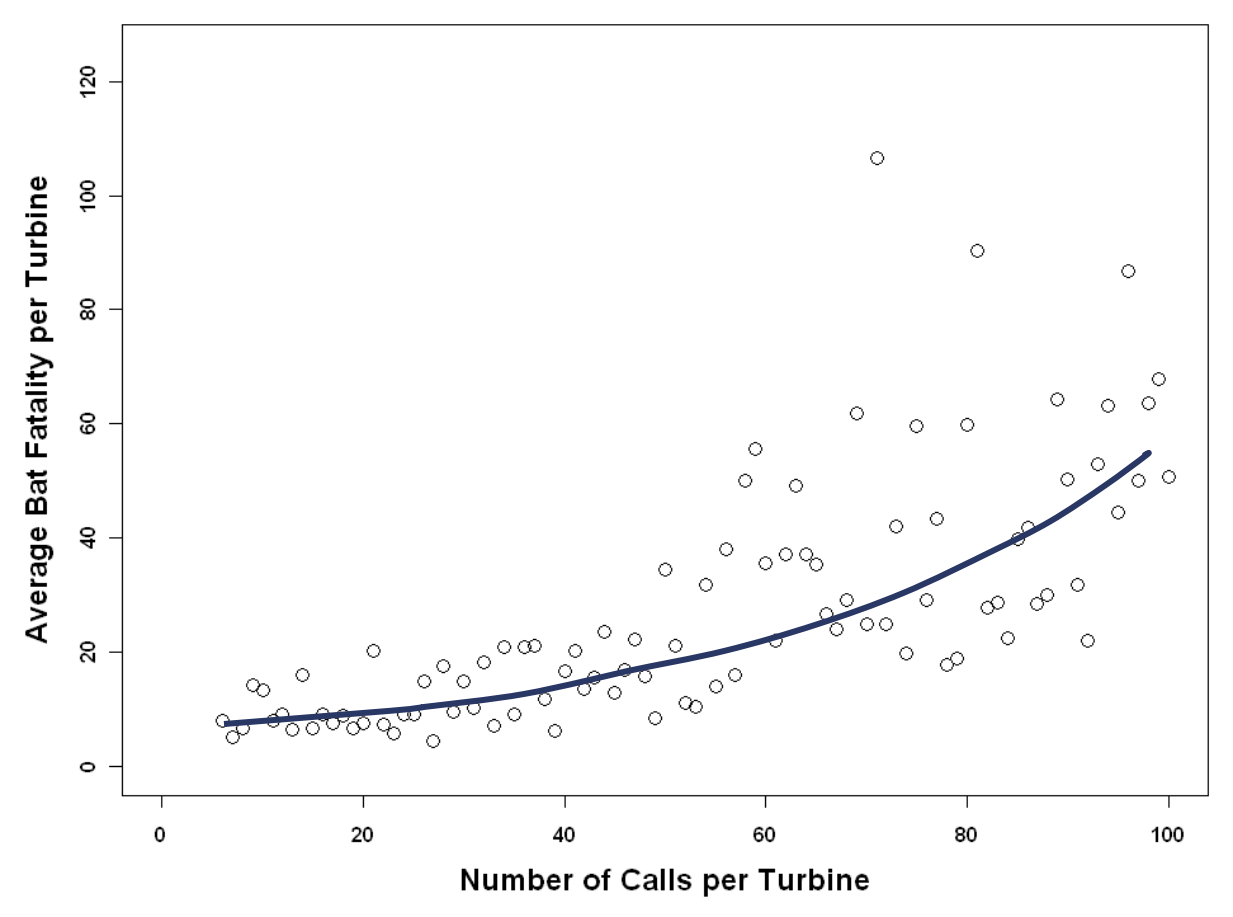
  $R^2 = 0.66$

  $\beta_1 = 0.022$, SE=0.00166, $p<0.001$
- Make predictive statements

  "For every increase of 10 calls per turbine, average bat fatality per turbine is expected to increase 25% (95%CI: 21.2, 29.4)."

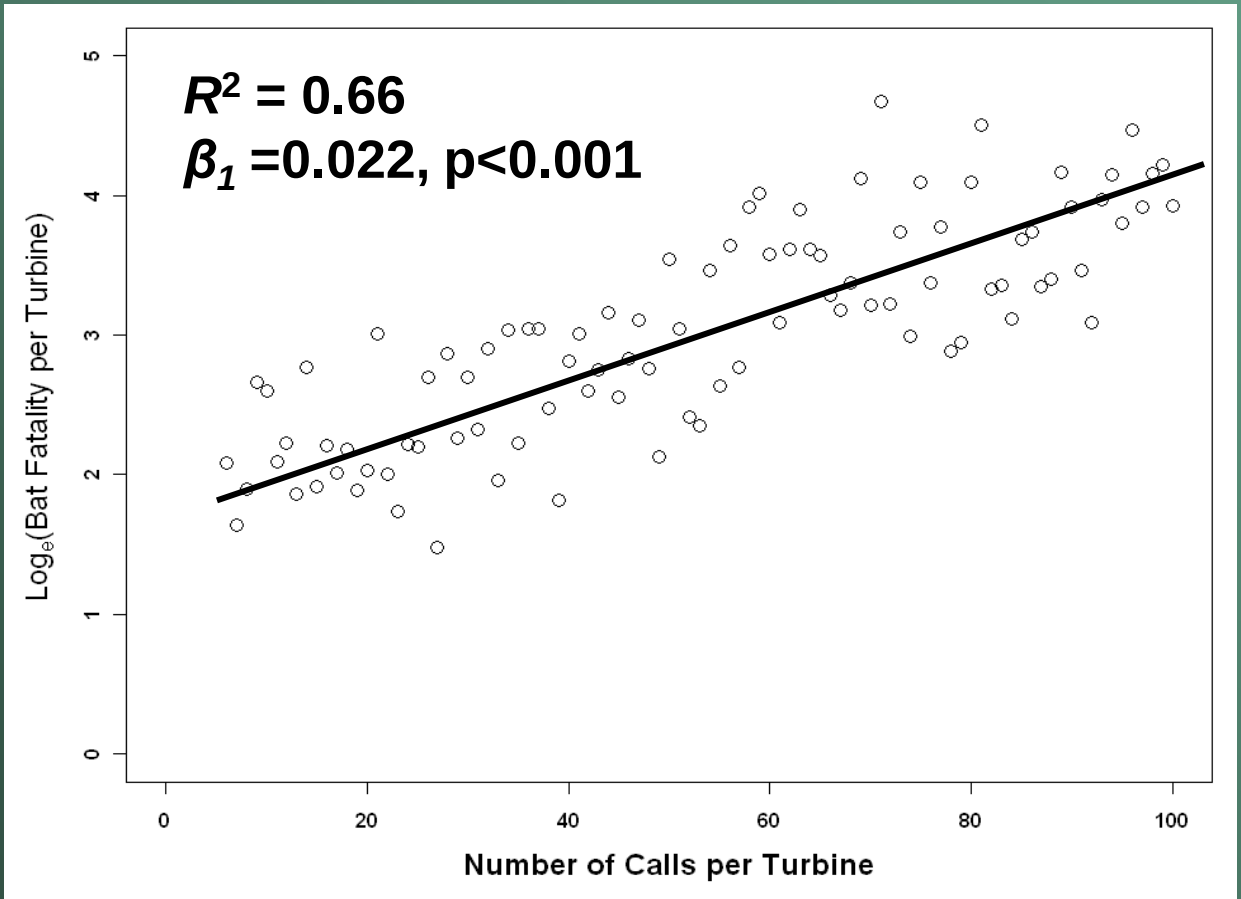
USGS

Predictive Models



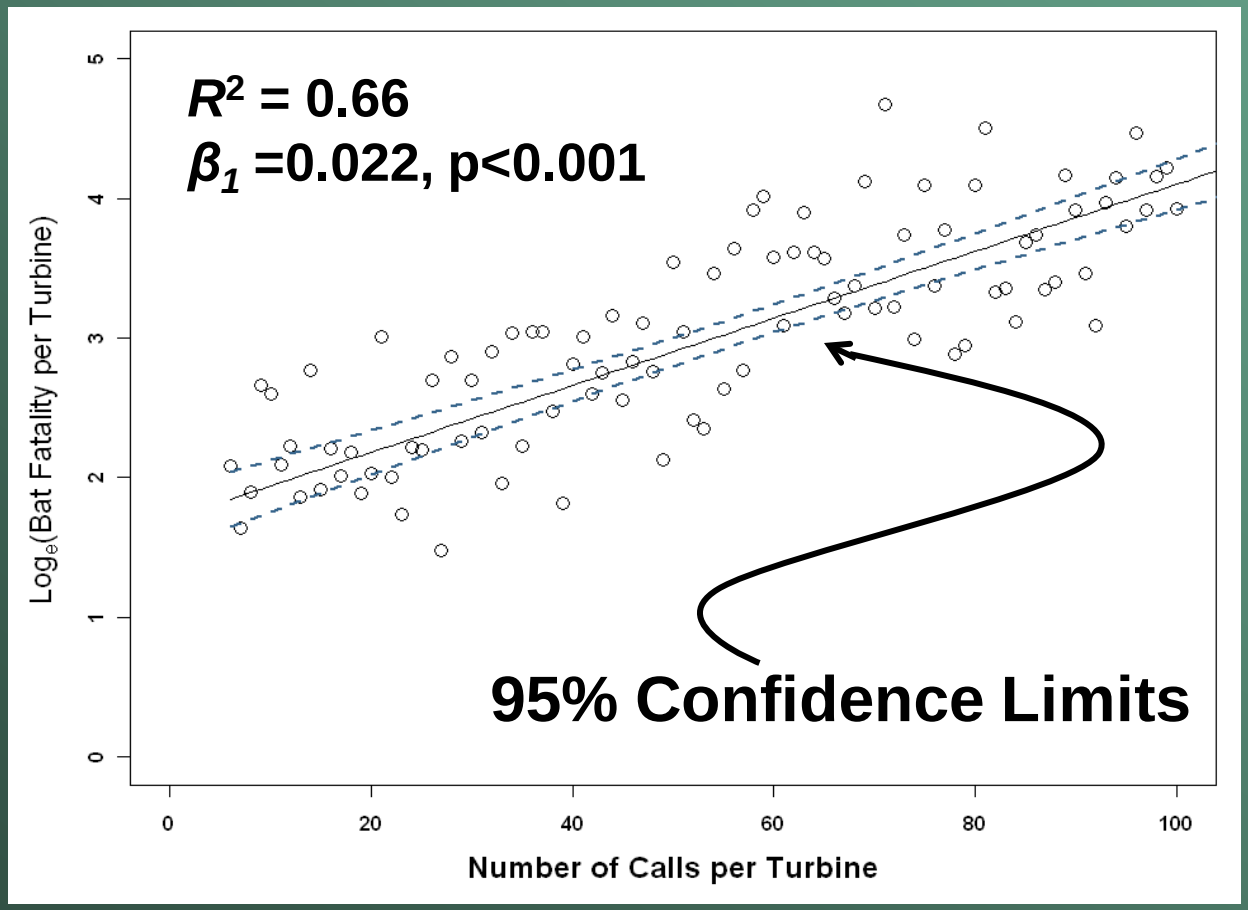
USGS

Predictive Models



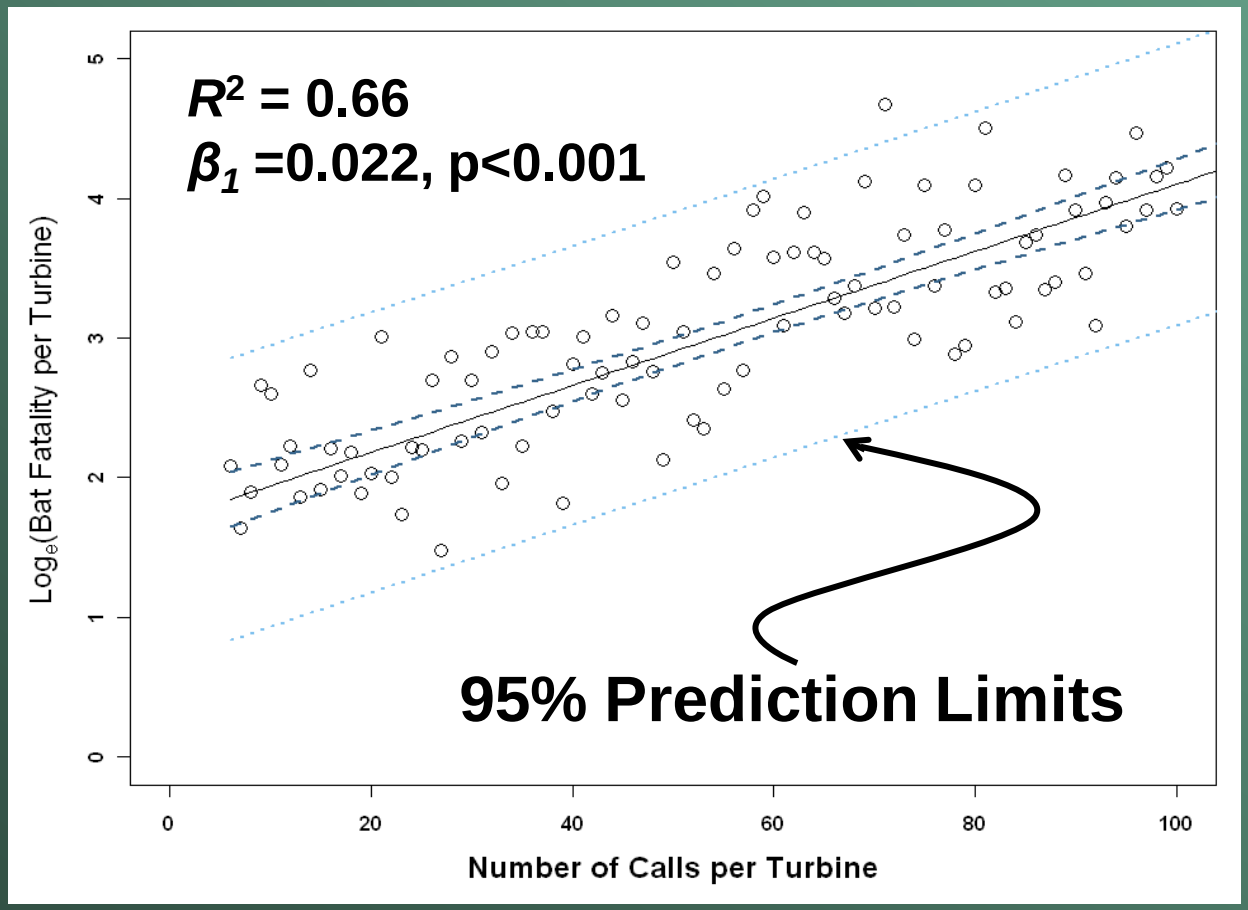
USGS

Predictive Models



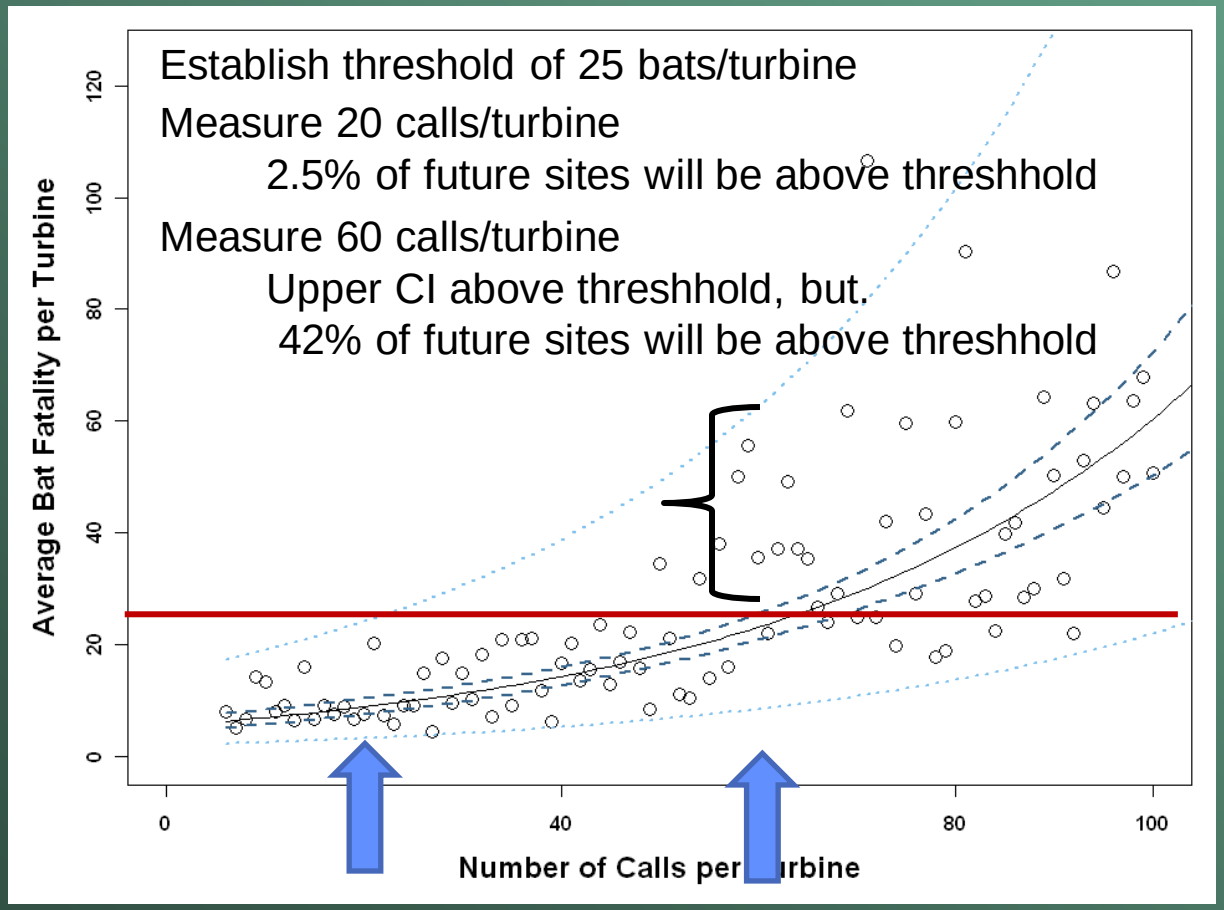
USGS

Predictive Models



USGS

Predictive Models



USGS

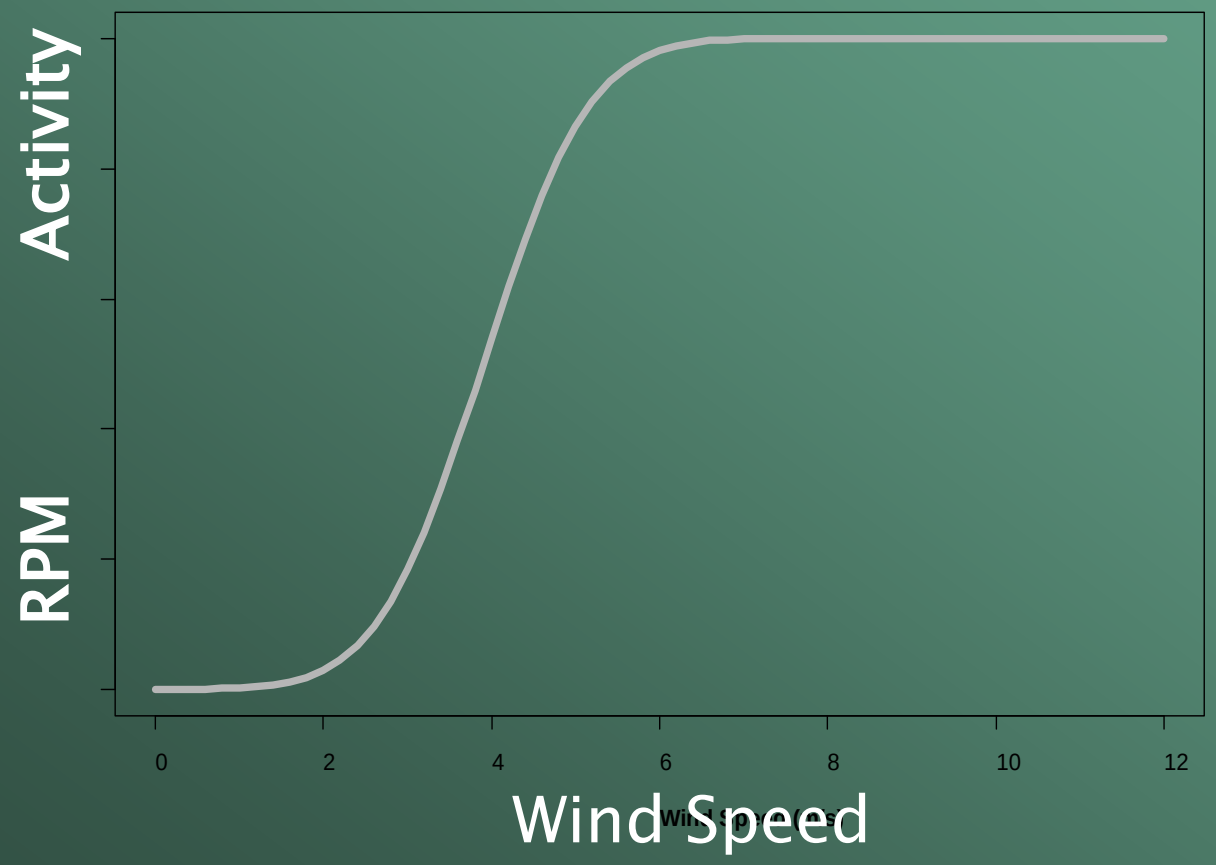
Relational Models

Is bat activity related to wind speed?

Simple regression?

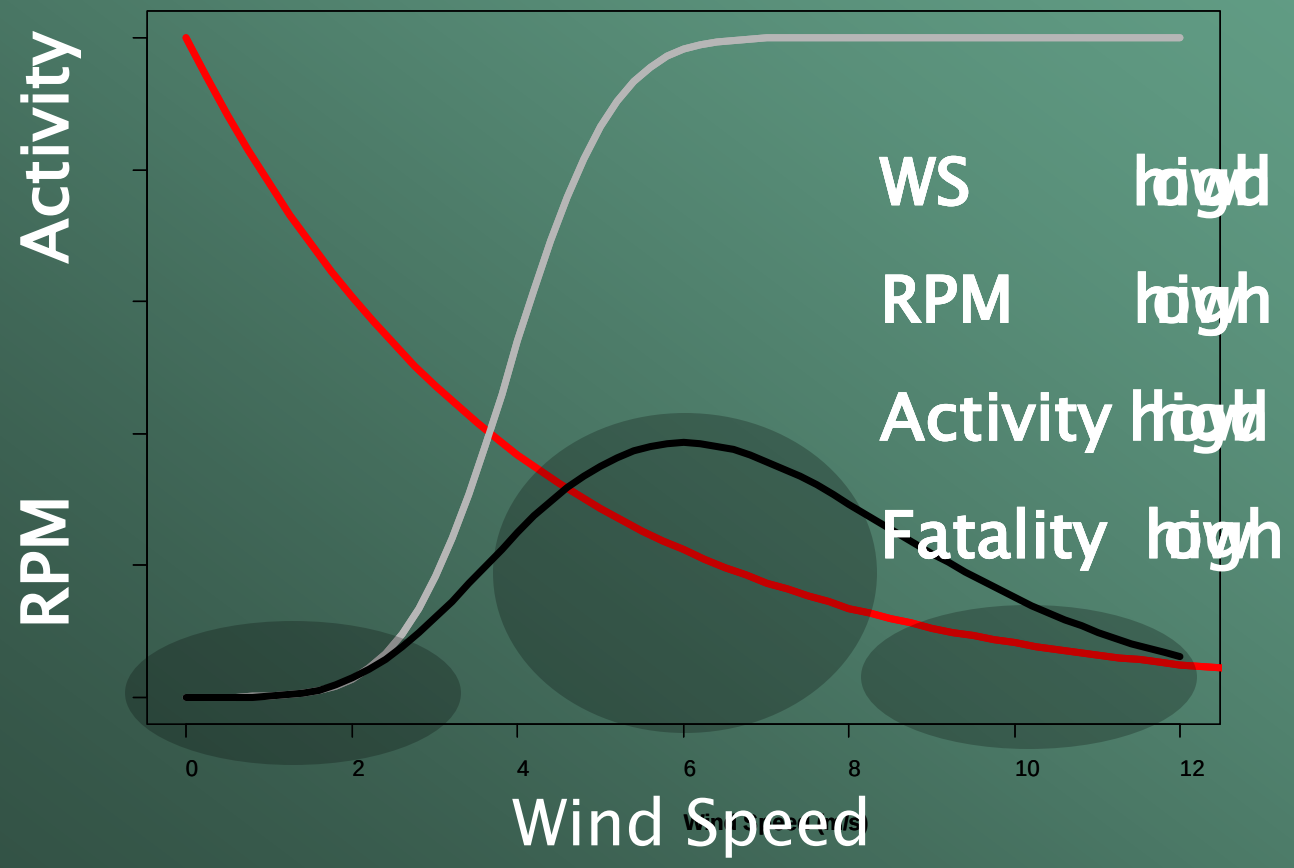
USGS

Relational Models



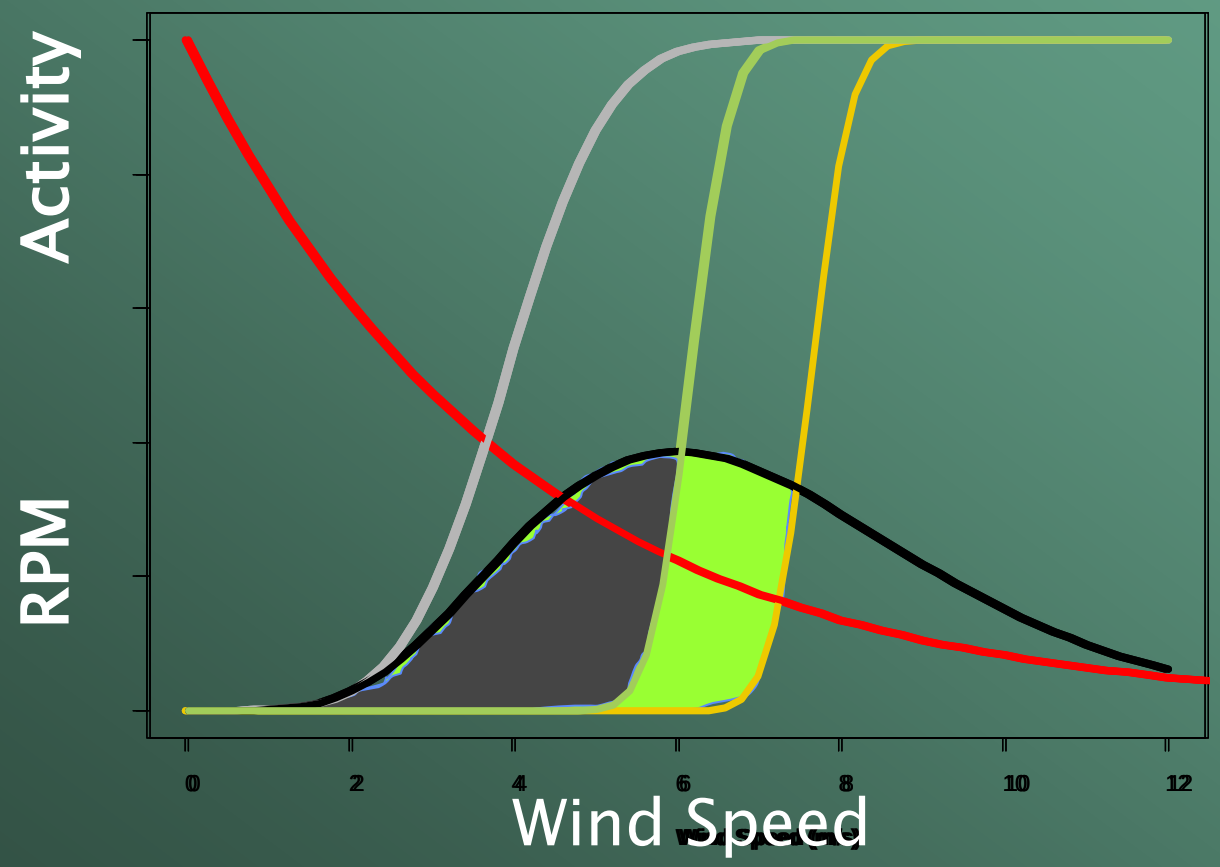
USGS

Consider curved relationship



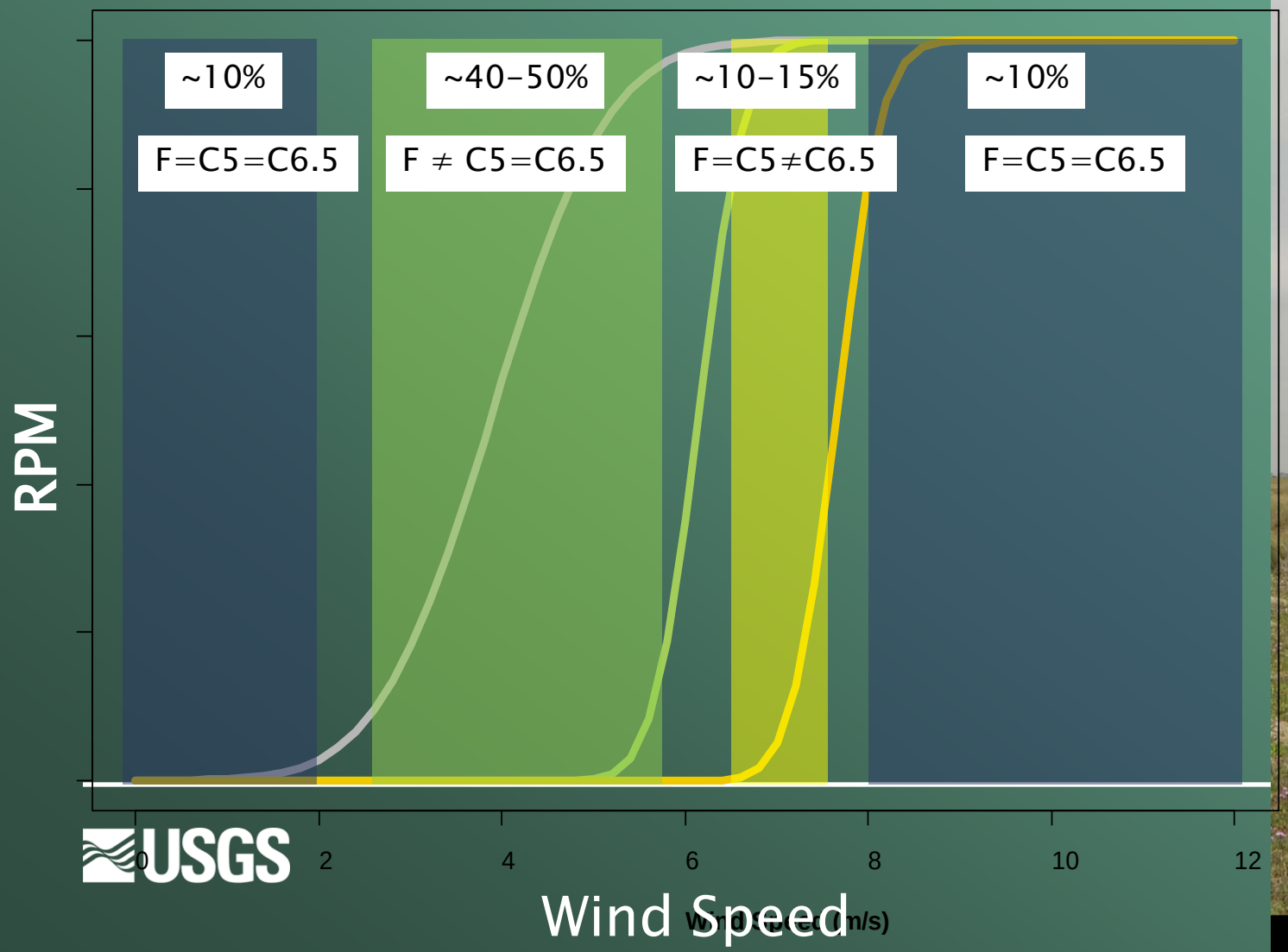
USGS

Causal Models



USGS

Causal Models



Statistical Model and Inference

Conceptual model drives statistical model

- Fatality non-linearly related to wind speed

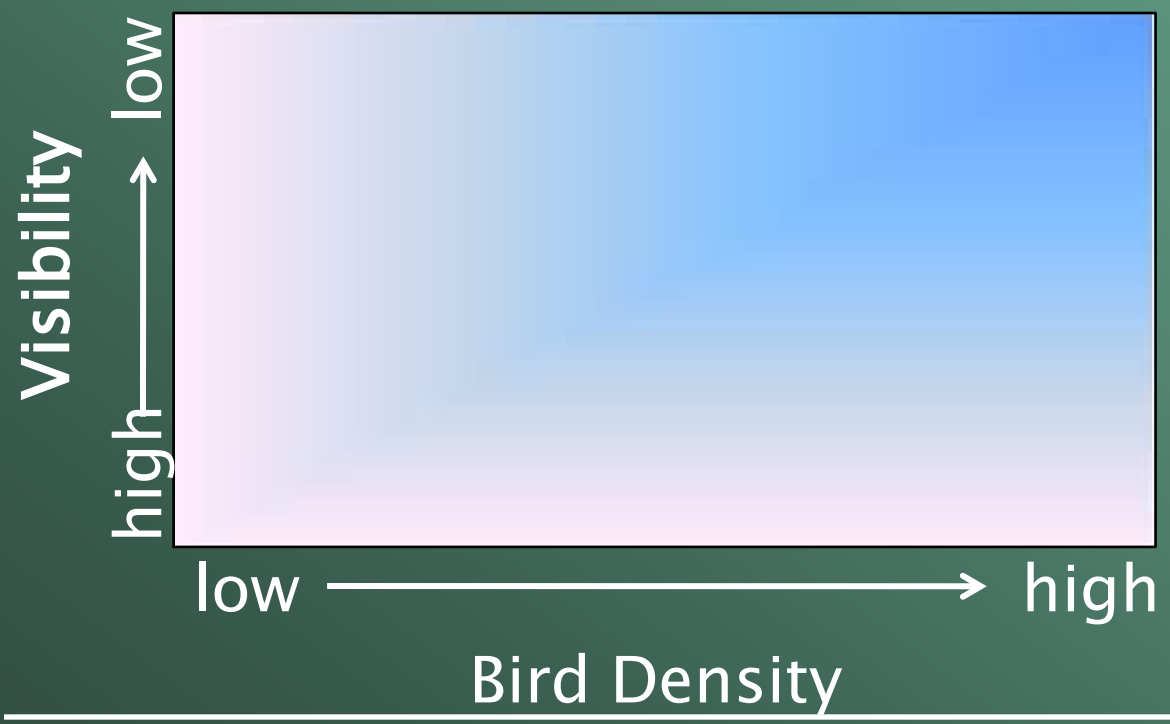
Conceptual model establishes inferential limits and guides interpretation of statistical models

- C5 and C6.5 treatments very rarely distinguishable in actual implementation
- no difference ≠> none exists
- Implementation of treatments didn’t allow detection

USGS

Conceptual Model Drives Statistical Model
Radar monitoring to trigger shutdown

$$\text{Fatality} = \beta_0 + \beta_1\text{visibility} + \beta_2\text{density} + \beta_3\text{visibility*density}$$



USGS

Conclusions

- Well developed conceptual model should underlie all our research and management
  - Critical evaluation of assumptions informs conceptual models
  - Conceptual model drives statistical model
  - Conceptual model establishes inferential limits and guides interpretation of statistical models

USGS

Recommendations

- Clearly describe conceptual model
  - How does what we measured reflect our model?
  - What are the possible outcomes of our model?
  - How will we interpret various outcomes?
- Conceptual model is hardest but most important
- Construct a statistical model that reflects conceptual model
- Fitting statistical model is a piece of cake!

USGS

Thank you!

And remember…

“Statisticians are friends, not foes!”

USGS

USGS