Applications and Limitations of Fatality Models for Wind Energy Developments : Lessons Learned from Modeling Efforts for Marbled Murrelets

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Essentially, all models are wrong, but some are useful.

—George E.P. Box (1919–present)

Overview

- Basic concepts of fatality models and common assumptions
- Potential sources of uncertainty in fatality models
- Next steps

Fatality modeling of listed seabird species

Photo courtesy of Mike Danzenbaker

Marbled Murrelet
Hawaiian Petrel
Newell's Shearwater

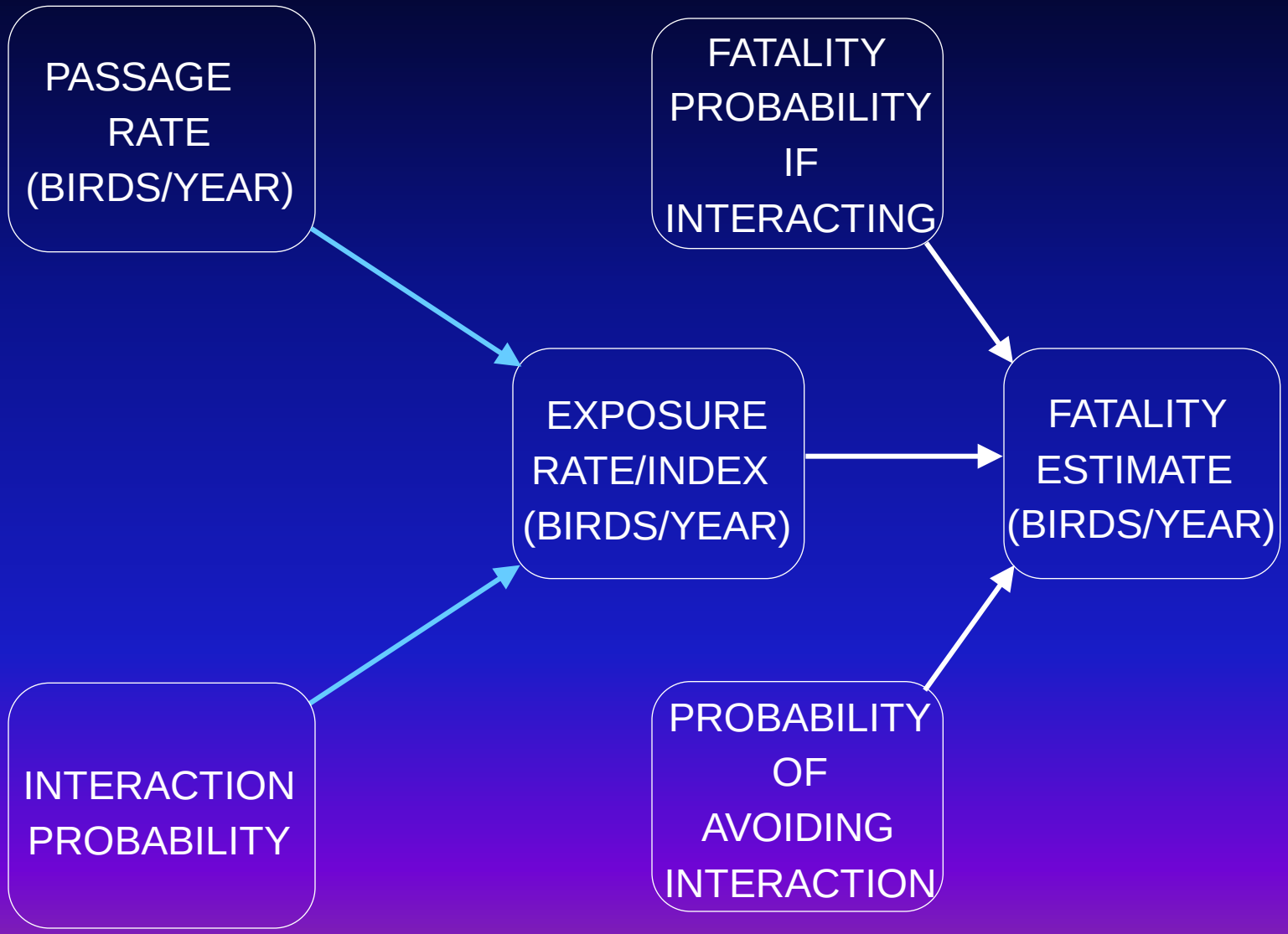
Photos courtesy of Jim Denny

Numbers of birds present

?

Numbers of birds killed

Steps Toward Estimating Fatality Rates



Exposure Rates (= No. MAMU exposed to turbines each year)

Begin with passage rates observed on radar

= Hourly passage rates X hours/day X days/season

Potential Sources of Variation in Passage Rate

- Inclusion of non-murrelets (e.g., shorebirds, waterfowl)
- Among-day variation
- Within-year and among-year variation

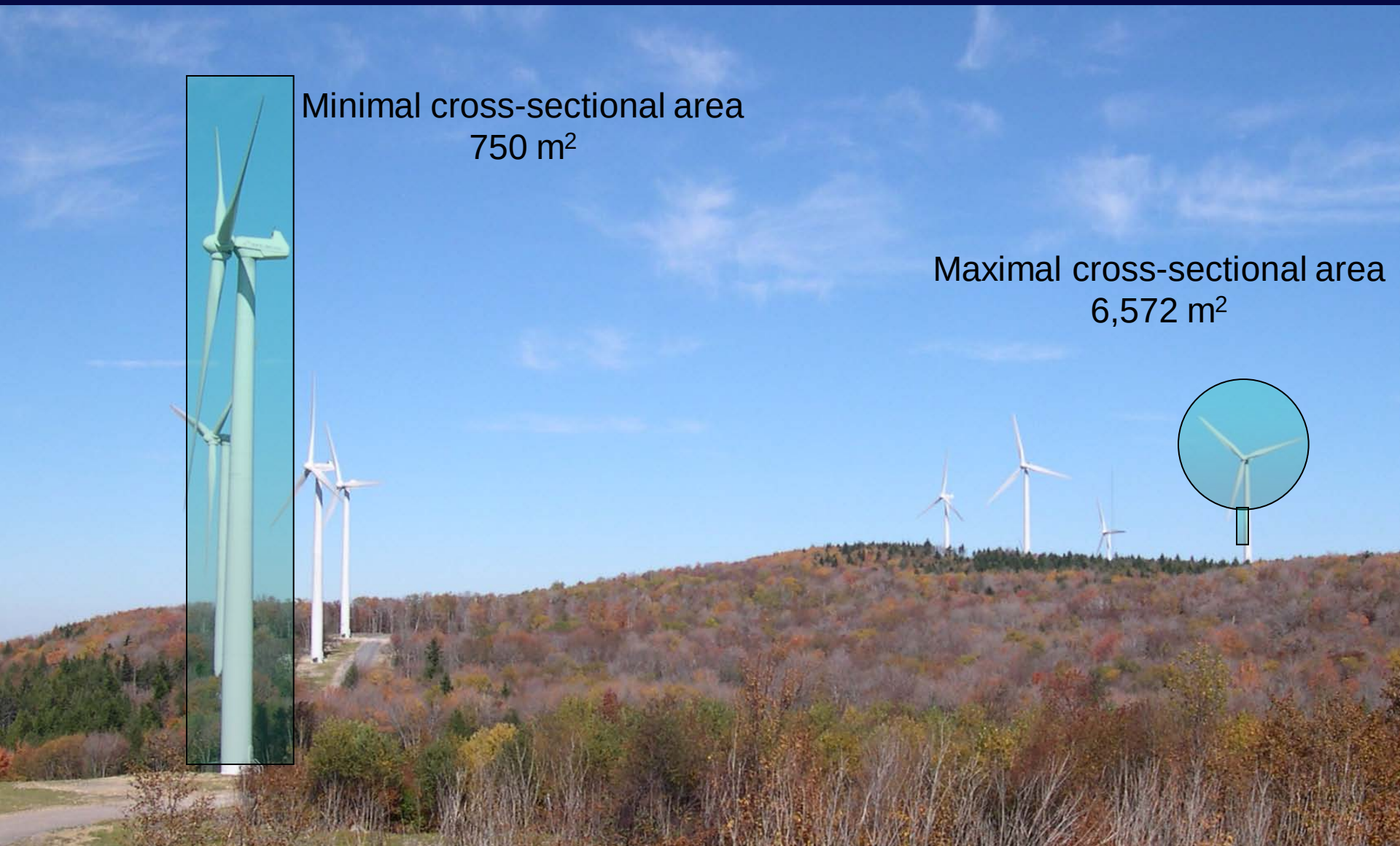
Vertical interaction probabilities:

What proportion of targets are flying low enough to potentially encounter turbines?

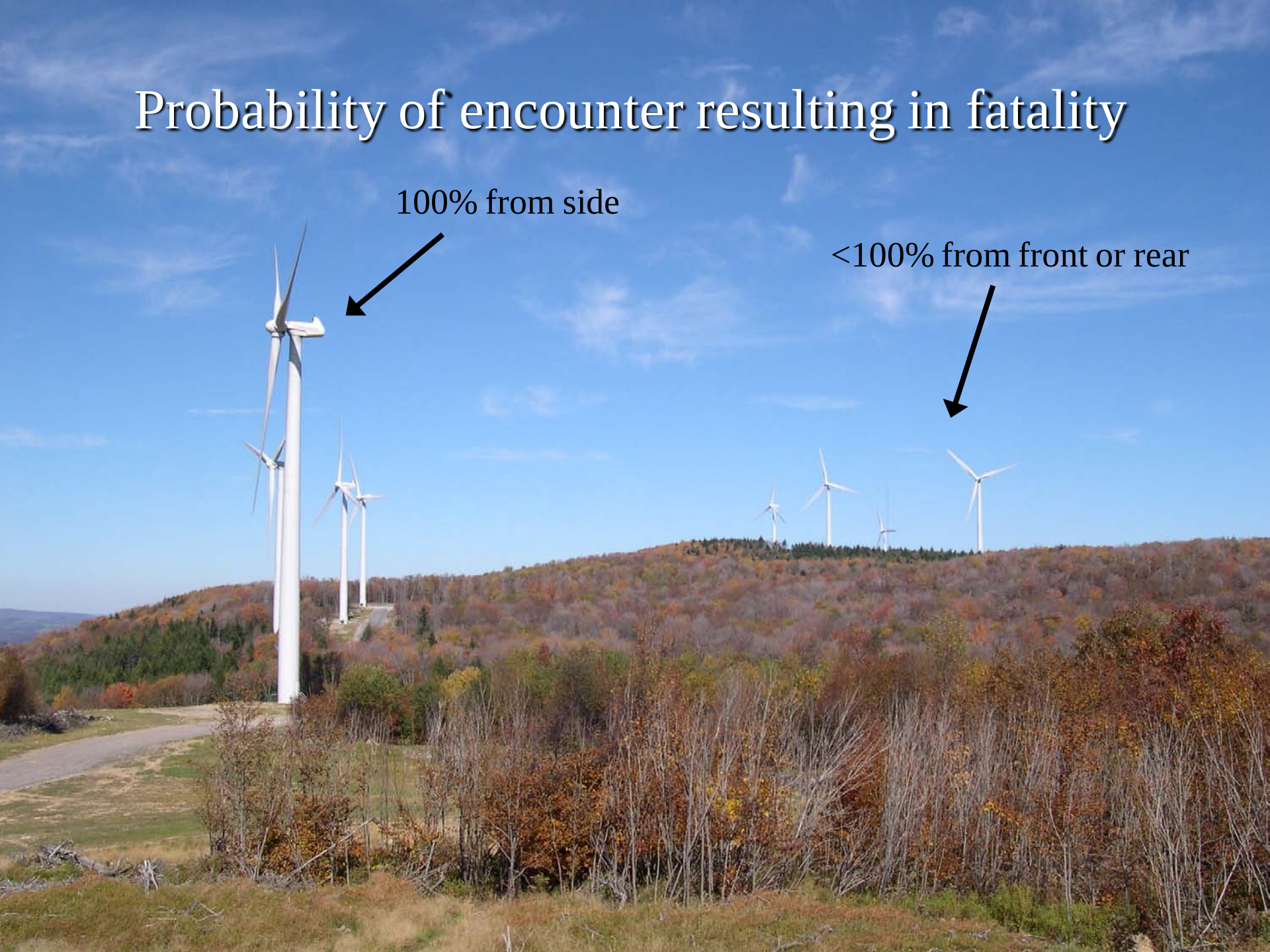
Potential Sources of Variation in Flight Altitude Data

- Among-site variation
- Variation due to weather, visibility, etc.?

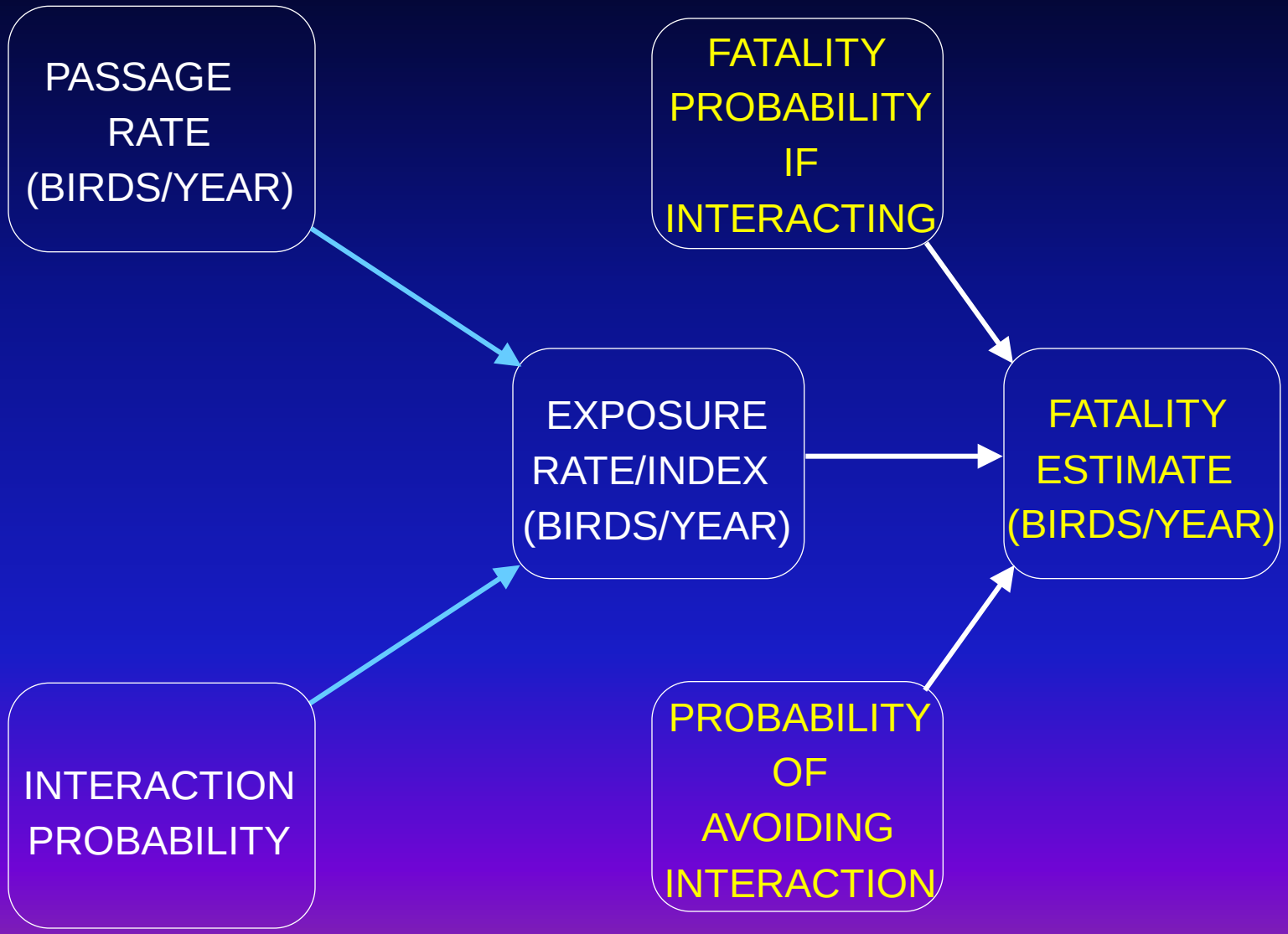
Horizontal interaction probabilities:
For birds flying below the maximal turbine height, what is the probability of encountering a turbine?



Probability of encounter resulting in fatality



Steps Toward Estimating Fatality Rates



Avoidance Rates

- Probability birds will detect and alter flight paths to avoid collision
- Largely unknown, although available data suggest avoidance is high (>90%) under average conditions
- Therefore, fatality estimates often presented for range of avoidance probabilities
- Avoidance rates have a large effect on model outcome

Example: Influence of Avoidance Factor on Murrelet Fatality Rates (hypothetical)

Percentage of birds exhibiting collision avoidance behavior	Fatality rate (birds/year)	
	Minimum	Maximum
0%	10	20
90%	1	2
99%	0.1	0.2

Additional Factors that are Difficult to Quantify for Inclusion in the Models

	Change
Sampling without replacement	↓
Population changes during life of project	↓
Climate-related variation in passage rates	↕
Light Attraction	↑
Turbulence ('prop wash')	↑

One model validation to date; more needed!

Next Steps

- Model validation studies
- Comparison of different fatality model estimates
- Avoidance studies

Questions?