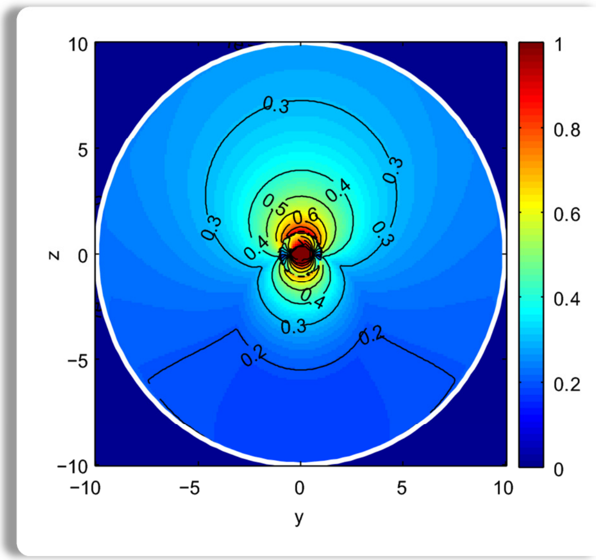
HAMER ENVIRONMENTAL
Innovative Solutions to Natural Resource Issues

AVIAN RISK OF COLLISION MODEL

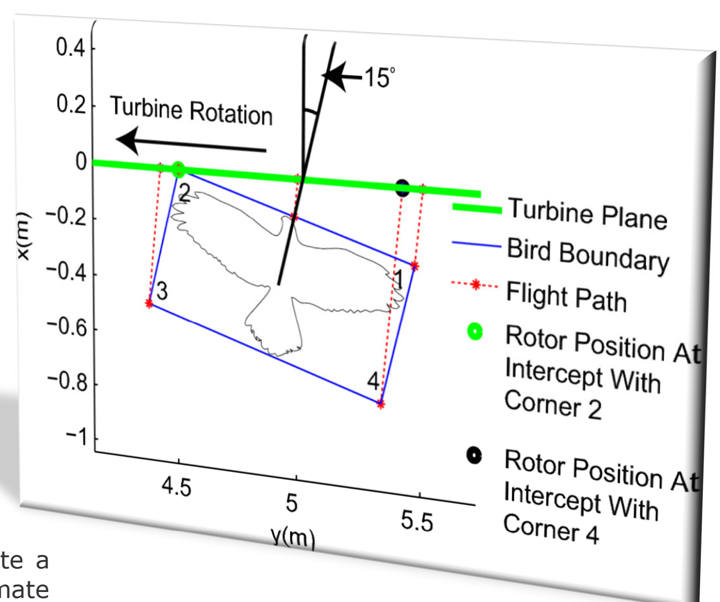
Applications for Proposed and Existing Wind Power Projects



Wind power is quickly becoming an attractive renewable energy source, resulting in exponential growth in the number of wind turbines deployed across the globe. However, wind turbines can sometimes pose a threat to bird populations resulting from collisions with wind turbine blades and turbine towers. Due to the potential impact on endangered and protected species, it is becoming common to assess the risk of collision and resulting impacts to local and migratory bird populations from wind developments prior to their construction.

Hamer Environmental has developed a model based approach for the estimation of this collision risk. Our state-of-the-art model was developed by Ph.D. level biologists and modeling experts and is designed to account for a number of inputs that have a significant effect on bird mortality, including observed flight and wind data, turbine characteristics, wind farm layout, and estimated avoidance rates.

Using site specific avian data collected with our ornithological radar systems and audio visual survey techniques, we iteratively simulate the passage of individual birds through the modeled wind resource area under typical wind conditions. Each flight path is analyzed for possible interactions with either the stationary components (tower and nacelle) or the rotor blades of the wind turbines.



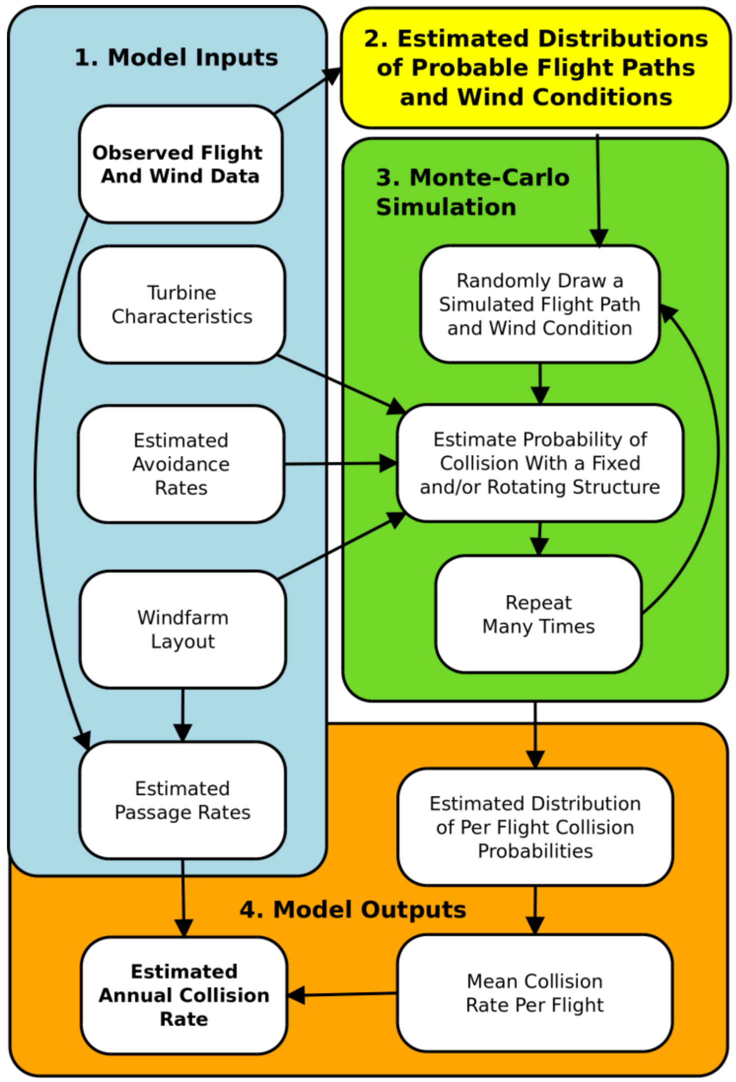
For flight paths that intersect the rotor planes, we use a kinematic model to estimate the probability of collision with a moving rotor which accounts for arbitrary angles of avian approach (relative to downwind) in addition to the shape, pitch, and angular velocity of the 3-D rotors.

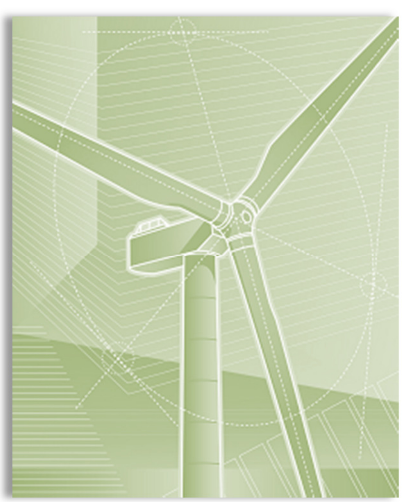
Using Monte Carlo sampling techniques, we simulate a large number (>1 million) of flight paths to estimate the mean collision probability of individual birds. This is then used in conjunction with observed passage rates to estimate the annual risk of collision.

Our Model

The Hamer Risk of Collision Model accounts for:

- Natural variation using Monte Carlo simulations of probable bird flight paths to estimate mean collision risk
- Different turbine avoidance and wind park displacement rates
- Turbine model characteristics including blade radius, 3 dimensional blade characteristics, number of blades, monopole dimensions, hub & turbine height, & nacelle dimensions
- Rotor speed and rotor pitch as a function of wind speed; including cut-in & cut-out speeds
- Precise point of entry into the rotor plane
- Site specific variation in wind speed & direction over time
- Number of wind turbines & their spatial configuration
- Bird body dimensions & variation in bird flight direction including all oblique angles of approach
- Variation in bird flight speeds & flight heights





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