A Visual Method of Evaluating Migratory Golden Eagle Behaviour at a Pre-operational Wind Farm in the Canadian Rocky Mountains

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We documented migratory golden eagle (Aquila chrysaetos) flight tracks at a wind farm in the Hart Range of northeast British Columbia, Canada. In fall 2009 and spring 2010 we conducted visual surveys to define 3-D flight tracks of birds, which were integrated into GIS for analysis on factors that influenced the altitudes of eagles entering a proposed turbine string area on a ridge (risk-zone). Of the 412 eagles detected in the fall, 6% entered the risk zone –3% of which were at rotor swept height. Fall heights increased with increasing wind speed; were lower under head-winds compared to cross-winds; and, were lower over sloped compared to flat areas of the ridge. Spring counts were lower (N =104) than the fall and most birds entering the risk zone (26%) did so under weak wind conditions. Spring heights were positively correlated with wind speed, and were higher in the hours immediately after midday. Although post-construction avoidance rates are likely to be high, a cumulative impact assessment for the region is needed to account for the potential effects on eagle migration. Our data collection technique could be used to identify areas of raptor use and document the occurrence of avoidance behavior post-construction.
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Background

• Birds of prey are at lower risk of collision mortality during migration – when not hunting for food (de Lucas et al. 2007; Drewitt & Langston 2008)
• Concern exists along major migration routes where birds are funnelled (Steinen et al. 2007)
• Few collision risk studies exist along golden eagle (GOEA) migration routes (exception: Whitfield 2009)
  • Findings indicate fewer turbine approaches than expected based on a `Band’ Collision Risk Model (Whitfield 2009)
Much has yet to be learned regarding golden eagle avoidance behaviour to turbines or wind farms during migration.

Western NA has the greatest concentration of migratory GOEAs along the Rocky Mountains.

My study is the first for an area in BC heavily slated for wind farm development – which is also along a significant GOEA migration route (approx. 1000+ individuals fall; 300 individuals spring)
Griffon Vulture Flight Behaviour

- Low wing loading
- Rely on soaring flight

Photo: Mario modesto

Photo: Jerry Ting
Griffon vulture Research - Spain

• In Spain, Barrios & Rodriguez (2004) found griffon vulture collision risk increased as wind speed decreased, particularly over gentle slopes (Barrios & Rodriguez 2004)

• Collision risk was higher for vultures that used circle-soaring flight (“Thermalling”) near turbines
  • For proposed wind farm developments in mountainous areas, it will be important to identify the ridge-top areas used by GOEAs, in addition to the weather conditions that reduce flight altitudes
Research Question

• **Fall migration**: Are any weather variables, ridge-top topography features and/or flight behaviors associated with golden eagle flight altitudes over the ridge-top (also the proposed turbine string)?
Study Site

North Dokie
Hart Range
Front Range
Methods - Field

• Surveyed between September 13 to October 24th, 2009
• Surveyed for 6 hours/day, between 900-1530 hrs
• 3 observation sites
  • Surveyed 2/day (3 hours each)
  • Rotated between sites to cover different time blocks (am/pm)
Methods - Field

• Collected 3D points of bird locations
  • Compass for direction
  • Clinometer for altitude relative to observer
  • Horizontal distance estimation
    • Horizontal distance using maps with known distance rings
• Used same experienced observers (Band et al. 2007)
• Focused the collection of points for eagles that approached the ridge-top
Methods – Data Handling

- Simple trigonometry to create bird locations
- Imported 3D points into GIS
  - ET Geowizard to create tracks and obtain flight heights (above ground level) (Tchoukanski 2003)
- Obtained flight heights upon entry to a risk-zone (100m buffer of proposed turbine string)
- Statistical analysis using R
- Onset™ weather station collected weather variables at 2 m above ground (1215 m)
Ridge-Top Topography
sloped versus flat sections

Sloped: grade 18-24; Flat: grade 1-2
Wind Direction Categories

Wind Speed by Direction – Fall 2009

- Tail-Wind
- Cross-Wind West
- Head-Wind

Wind Speed (Km/hr)

- Zero values - 1.48%
- >0 - 6
- >6 - 12
- >12 - 18
- >18 - 24
- >24

Cross-Wind East
Statistical Analysis

• Mixed-effects model to determine what variables, if any, were associated with heights of eagles as they entered the risk-zone.
  • **Variables**: *Weather* (wind speed and direction, temperature, relative humidity, cloud cover, and cloud ceiling height); *topography* (sloped or flat areas); *flight behavior* (circle-soaring, soaring or powered-flight); *date*; *time* (am/pm); and *age* (adult-looking, juvenile-looking, unknown).
  • Observation site = random effect
Results - Overview

• Of the 417 golden eagles detected within 2km of the study ridge, approximately 20% \((n = 81)\) entered the risk-zone (100 metres from the turbine string)

• Of the 81 birds, 12% \((n = 10)\) entered the risk-zone at rotor swept height \((\leq 150 \, m)\) and at winds above turbine cut-in speed \((14 \, km/hr)\)
  • This represents 2.5% of birds detected within 2km
Results – Statistical Model

Heights for eagles that entered the risk-zone:

• Positively correlated with wind speed \(F_{1,74} = 4.446, P = 0.038\)

• Lower under head-winds compared to cross- and tail-winds \(F_{2,74} = 8.402, P \leq 0.001; \text{ Tukey } (|t| = 4.065, P \leq 0.001)\)

• Lower over sloped topography features compared to flat areas \(F_{1,74} = 8.627, P = 0.004\)
### Results - Wind Direction

<table>
<thead>
<tr>
<th>Wind Speed (Km/hr)</th>
<th>Risk-Zone Entry Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>200</td>
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<tr>
<td>10</td>
<td>400</td>
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<tr>
<td>15</td>
<td>600</td>
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<tr>
<td>20</td>
<td>800</td>
</tr>
<tr>
<td>25</td>
<td>1000</td>
</tr>
</tbody>
</table>

**West Cross-Wind**

**Head-Wind**

**Tail-wind**

- **Cross-Wind**
- **Head-Wind**
- **Rotor Swept Height** ($\leq 150m$)

**Turbine Cut-in Speed** (14 km/hr)
Results - Topography Type

Wind Speed (Km/hr)
0 5 10 15 20 25 30
Risk-Zone Entry Height (m)
0 200 400 600 800 1000
Flat Areas
Slopes

Turbine Cut-in Speed
14 km/hr

Flat Areas
Sloped areas

Rotor Swept Height (150m)
Results – Flight Behavior

- Wind Speed (Km/hr):
  - 0
  - 5
  - 10
  - 15
  - 20
  - 25
  - 30

- Risk-Zone Entry Height (m):
  - 0
  - 200
  - 400
  - 600
  - 800
  - 1000

- Flight Behavior:
  - Powered Flight
  - Soaring Flight
  - Thermalling Flight

- Turbine Cut-in Speed: 14 km/hr

- Rotor Swept Height: 150m
Conclusions

• GOEA flight heights as they entered the risk-zone were **lower under head-winds regardless of wind speed**
• Heights were **lower over sloped topography**
• Circle-soaring flight not observed within RSH at winds above turbine cut-in speed
• Post-operation observations needed to quantify avoidance behaviours
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