
Overview

The two maps shown in main manuscript were created by assembling vector format data layers and overlaying a 50 × 50 km tile grid for summarizing the data. We calculated the relative proportion of each source of mortality occurring in each grid square as a function of direct or indirect measures of intensity of each mortality source. The estimated kill for each source was then allocated across the applicable grid tile according to the proportional intensity of the mortality source calculated. The tile grid was used to summarize the overall bird mortalities occurring across Canada based on the following seven data layers representing eight sources of terrestrial mortality:

- Roads
- Communication Towers
- Terrestrial Oil and Gas
- Forestry
- Agriculture
- Population Density (used as an index of building and cat distribution)
- Wind Farms.

These were the only sources for which suitable data were available for mapping. A detailed summary of data sources, manipulations, and a map for each mortality source is provided in this appendix. All work was done in ArcGIS 10.0 and area calculations were done in Albers Equal Area Conic projection. Specific procedures/functions are noted to encourage replication or improvement.

The general approach for each layer followed this example: The total amount of disturbance for each mortality source was calculated for all of Canada (e.g. km of roads or km² of oil and gas disturbance). Grid tiles overlapping that mortality source were identified. For instance, if 137 grid tiles had oil and gas activity, the total area of oil and gas disturbance was taken from the previous calculation and the proportion of disturbance in each tile was derived by simple division. The proportional kill for that entire mortality source was then assigned to each applicable tile. If a single tile had 5% of the total national disturbance, the total kill for oil and gas was multiplied by 0.05 and assigned to that tile. Therefore the units for each mortality source are in birds or nests taken as per the original research paper. Standardized values from our manuscript Table 3 were not used because they were not calculated at the same geographic level of specificity (e.g. kills for agriculture were converted nationally, not at the BCR level).

Grid totals (number of kills) were created by summing the values for the eight mortality sources above. Each map was coloured in a colour ramp of 10 classes and the natural breaks (Jenks) classification method was applied for all datasets (http://en.wikipedia.org/wiki/Jenks_natural_breaks_optimization). Note that this classifier does not produce equal width classes, but does optimize the splits for presentation.

As noted generally in the manuscript text, the following caveats apply:

- The map is a gross approximation only and we acknowledge that none of the sources/sectors above would be expected to have kill exactly proportional to their intensity. Technically we
consider it to be a map of potential risk that remains unrealized until the sources of mortality interact with birds and result in deaths.

- Actual kill in any given tile would depend on many factors that cannot be mapped with currently available national data: the density of birds, the specific interaction of the source/sector with those birds in each environment (i.e. traffic volume, height of roadside verges, local features attracting birds), the seasonal timing of the activity, and even local weather conditions in any given year.
- In certain cases, such as forestry, a realistic calculation should be based on the location of actual cutting in Canada rather than the entire area available for cutting. This would be similar for farming; the location and spatially explicit footprint of each crop or farm type would ideally be known nationally. Such data are not available.
- In spite of these caveats, it remains self-evident that kills occur where the source/sector operates and, as a generalization, more activity by a given source/sector would result in some incremental increase in kill. We have constrained the scale of the map and smoothed the final product to minimize the perceived precision of the mapping classes.

Each section below contains the data source for each source of mortality, how we derived the maps and sector-specific maps that are not presented in the main paper.

Bird-vehicle Collisions

- Ellipsoid Name: GRS80 (Geodetic Reference System 1980)
- Total kill figure used: Kills per km/day of road, by ecotype, from Table 3 in Bishop and Brogan 2013.

The National Road Network (NRN) is produced, updated, and distributed (with the support of GeoConnections) through collaborative agreements between Natural Resources Canada, Statistics Canada, and the provincial and territorial governments. A detailed summary of the product is here:


**Methodology:**

A roads layer was created from the NRN which displayed only 1 and 2 lane paved roads that occurred outside of urban areas using a ‘select by attributes’ query and did not contain Ramp features. A ‘create layer from selected features’ was then used to create a new layer containing only these selected features. The query used to extract this data was: ("NBRLANES" <3 AND ("PAVSTATUS" = 'Paved' OR "PAVSTATUS" = '2Paved' OR "PAVSTATUS" = 'Paved') AND "ROADCLASS" <> 'Ramp').

Roads were separated by ecozone type following the methods in Bishop and Brogan (2013); ecozone types consisted of: Broadleaf and Mixed Forest (classified as one ecozone), Coniferous High Volume (1%), Coniferous Low Volume (99%), Cropland, 90% Rangeland Area, 10% Rangeland Area and Wetlands. Each ecozone type was assigned a kill value for the number of birds killed per kilometre of road based on Table 3 in Bishop and Brogan (2013).
Roads were separated into each individual 50 km tile by using the ‘Intersect’ tool. The intersect output contained numerous road segments and types by tile; each ecotype total was multiplied by the value for birds killed per kilometre per day corresponding to the ecotype classification of that segment and then multiplied by the number of days (122) and adjusted for scavenging by multiplying by 2.97 (Table 3, Bishop and Brogan 2013).

The ‘merge’ tool was then used to join all 7 ecozone types together with all of their final road values for the number of birds killed by unique tile ID. The ‘Dissolve’ tool was then run to dissolve all roads by Tile ID and sum the total number of birds killed annually for all 7 ecozones.

The result of the road analysis is shown in Fig. A4.1.

![Figure A4.1](image)

**Fig. A4.1** – Approximated distribution of bird-vehicle collisions in Canada on road types considered by Bishop and Brogan (2013).

**Communication Towers**

- Source: NAVCAN database of tower locations. License paid for by Environment Canada for EC use as specified in agreement. Substantial corrections on the original data were performed by Beau MacDonald (The Urban Wildlands Group, Los Angeles, CA, USA) for use in Longcore et al. (2012).
- Spatial Reference: n/a
- Ellipsoid Name: n/a
- Total kill figure used: ~221,000 (Table 7, Longcore et al. 2012).
Methodology

NavCan tower data were provided in a proofread and cleaned format. The equation from Fig. 3 of Longcore et al. (2012) was used to calculate predicted tower mortality for each tower. Longcore et al. (2012) used a probability-based reduction of totals at the BCR level to account for towers that were guyed or not and steadily lit or not. We applied a BCR-specific static adjustment to each tower kill value such that our BCR total matched those from Longcore et al (2012) because we calculated mortality at the individual tower level. Only towers > 60m tall were considered in our analysis, the same restriction used by Longcore et al. (2012).

The 50 × 50 km tile grid was overlaid with the communications tower point layer and a spatial join was performed to link each point to the proper tile that it fell within. The Dissolve tool was then run to sum the number of kills by tile ID using the statistics function.

The results of our communication towers analysis is shown in Fig. A4.2

![Fig. A4.2 – Approximated distribution of kills from birds colliding with communication towers >60 m in Canada.](image)

Terrestrial Oil and Gas (wells, seismic lines, pipelines)

Total kill figures are from the mean value column of Table 3 (number of nests) in Van Wilgenburg et al. (2013). Those data are split in each province into boreal areas and prairie areas.

Manitoba
• Source: Manitoba Innovation, Energy and Mines
  http://www.gov.mb.ca/iem/petroleum/gis/index.html
• Spatial Reference: North American 1983 CSRS UTM Zone 14N
• Ellipsoid Name: GRS 80
• Total kill figure used: Boreal: 211, Prairie: 92

Metadata are not provided with the wells file on the above noted website.

The data was displayed by township (6 mile by 6 mile square area polygons) which contained the number of wells within each township.

Saskatchewan
• Source: Saskatchewan Energy and Resources oil and gas information viewer,
  http://www.infomaps.gov.sk.ca/website/SIR_Oil_And_Gas_Wells/viewer.htm
• Spatial Reference: North American 1983 UTM Zone 13N
• Ellipsoid Name: GRS 80
• Total kill figure used: Boreal: 284, Prairie: 2602

Metadata are available at https://www.geosask.ca by entering the Spatial Gallery, searching for the data layer “wells” and using the metadata viewer.

The data was displayed by township (6 mile by 6 mile squares) which contained the number of wells within each township.

Alberta
• Source: Energy Resources Conservation Board (http://www.ercb.ca/) data subscription for well data to Environment Canada.
• Spatial Reference: North American 1983 UTM Zone 10N
• Ellipsoid Name: GRS 80
• Total kill figure used: Boreal: 1125, Prairie: 5677

The data were in point format and each point contained a value for the number of wells at that specific location.

Metadata are provided via Environment Canada’s digital subscription (i.e. not on the ERCB website) and are available by contacting the authors.

British Columbia
• Source: British Columbia Oil and Gas Commission,
  ftp://www.bcogc.ca/outgoing/OGC_Data/Wells/
• Spatial Reference: BC Albers, NAD83
• Ellipsoid Name: GRS 80
• Total kill figure used: Boreal: 1125, Prairie: n/a

In addition to the short metadata associated with the above link, more information on the data is available here:
ftp://www.bcogc.ca/outgoing/OGC_Data/ePASS_Documents/ePASS_Standards_Requirements.pdf
Methodology

We restricted our analysis to the area covered by Van Wilgenburg et al. (2013). Raw well data for Manitoba and Saskatchewan were processed by S. Van Wilgenburg and overlaid with the official township grid for those provinces. The township grid (polygon data) for Manitoba and Saskatchewan were placed into one dataset by using the ‘Merge’ tool to place all townships into one dataset (containing the number of wells by township).

No township data was available without an associated fee for British Columbia and Alberta so a 6 × 6 mile tiled grid was created using the Fishnet tool in order to represent the size of townships within Alberta and British Columbia (Taylor 1975). The 6 × 6 mile tiled grid was then overlaid with the point layer that was provided for AB and BC in order to assign a well count value to each township grid using a spatial join. The output was a polygon vector that contained numerous point data (many points) to one township. The dissolve tool was used to sum up the total count value of wells by township. The township polygon for AB and BC was then added to the MB and SK township dataset using the ‘Merge’ tool.

Using the Bird Conservation Regions (BCR) layer (http://www.nabci-us.org/bcrs.htm) the townships were classified as Boreal or Prairie based on which larger proportion of the township fell within the specified BCR (11 for prairie, 6 for boreal).

We calculated the area in each township disturbed by seismic line and pipelines using the following formulas from Appendix 1 of Van Wilgenburg et al. (2013) based on the well count value.

- The percent of township disturbed by seismic lines in the Boreal Plain Ecozone can be estimated as: \( \% = (0.974 + 0.807 \times \log(\text{wells}))^2 \)
- The percent of a township disturbed by seismic lines in the Grassland Natural Region (Prairie) can be estimated as: \( \% = (0.430 + 0.006 \times \log(\text{wells}))^2 \)
- The percent of a township disturbed by pipeline right-of-ways in the Boreal Plain Ecozone can be estimated as: \( \% = (0.699 + 1.866 \times \log(\text{wells}))^2 \)
- The percent of a township disturbed by pipeline right-of ways in the Grassland Natural Region (Prairie) can be estimated as: \( \% = (0.655 + 1.811 \times \log(\text{wells}))^2 \)

We had to convert well count to well area within each township. A value of 20,000 m² (2 ha) was assigned to each well based on written advice from the Canadian Association of Petroleum Producers as used in Van Wilgenburg et al. (2013). The sum of the area disturbance by seismic lines, pipelines and the total well areas by township were summed to obtain the overall area of disturbance by township.

Townships were intersected with the 50 × 50 km tile grid. An area calculation was done on the divided (intersected) townships in order to determine the proportion of that township that fell within each tile. The proportion value was then multiplied by the overall area of disturbance by township (sum of Seismic, Pipeline and Well area) in order to determine the total area of disturbance within each tile. The ‘Dissolve’ tool was run to dissolve all townships by tile and the statistics field was used to ‘SUM’ the area of disturbance values for each portion of the townships that fell within each individual tile.

The BCR layer was then overlaid with the 50 × 50 km tiled disturbance area layer and each tile was reclassified as ‘Boreal’ or ‘Prairie’. Whichever larger portion (>50%) of the cell fell within the specified BCR then that tile was classified as that region.
The proportion value for each tile was calculated from the final disturbance value depending on which province and part of a province (boreal or prairie) the tile fell into. Total disturbance value by each provincial region was calculated. In areas where tiles overlapped with provinces and/or prairie/boreal regions, the proportion of each had to be calculated using the area field and multiplying those proportions based off of the total tile area of 2500 km$^2$; in all other cases the tile had a value of 100% for the province/region intersect.

The proportion of each 50 × 50 km tile disturbed were then multiplied by the kill values listed above for each of the 7 intersections of province and habitat. Calculations were all performed within the Field Calculator.

The result of our oil and gas analysis is shown in Fig. A4.3.

![Bird Mortalities By Tile Total Kills By Oil and Gas](image)

**Fig. A4.3** – Approximated distribution of nests destroyed from the oil and gas sector in the western Canadian sedimentary basin as enumerated by Van Wilgenburg et al. (2013).

**Forestry**

- Spatial Reference: Lambert Conformal Conic
- Ellipsoid Name: Clarke 1866
- Total kill figures (nests) from Hobson et al. (2013, Table 6) by averaging the low PIF estimate and the high BAM estimate (see Table A4.1)
A brief description of the data from Global Forest Watch Canada is: “A compilation of the basic forest tenure/concession data from all of the provinces. [It] includes companies in order of allowable annual cut (where applicable/available). Tenures/concession polygons will contain areas restricted to logging and other resources extraction activities by protected areas legislation and by other legislative and policy restrictions. We attempted to include only crown lands and exclude all private lands where the data was available (e.g., New Brunswick), but other jurisdictions may have inadvertently included private lands.”

Metadata: http://www.gloabalforestwatch.ca/data/tenure.spatial/CANADA/canada_tenures.txt

**Table A4.1 – Estimated nests destroyed by forestry from Hobson et al. (2013).**

<table>
<thead>
<tr>
<th>Province</th>
<th>Estimated nests destroyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>387,926</td>
</tr>
<tr>
<td>AB</td>
<td>62,210</td>
</tr>
<tr>
<td>SK</td>
<td>15,316</td>
</tr>
<tr>
<td>MB</td>
<td>6039</td>
</tr>
<tr>
<td>ON</td>
<td>255,832</td>
</tr>
<tr>
<td>QC</td>
<td>372,680</td>
</tr>
<tr>
<td>NB</td>
<td>126,316</td>
</tr>
<tr>
<td>NS</td>
<td>88,924</td>
</tr>
<tr>
<td>PEI</td>
<td>6938</td>
</tr>
<tr>
<td>NF</td>
<td>15,576</td>
</tr>
<tr>
<td>NT, YK, NU</td>
<td>0 (no forest tenure map data available, no tenures, or no forestry in the region)</td>
</tr>
</tbody>
</table>

**Methodology**

The forestry tenure data (Fig. A4.4) was dissolved and overlaid with the $50 \times 50$ km tile grid and clipped by tile. Tiles were broken down by province and the proportion of forestry tenure that occurred within each tile, within a province was determined. The proportion of forestry by tile by province was then multiplied by the kill values (above) by province in order to determine the total kills by tile. This value represents the number of nests destroyed by tile.
Fig. A4.4: Forestry tenures across Canada as mapped by Global Forest Watch. Data are current to 2004.

The result of our forestry analysis is shown in Fig. A4.5.

Fig. A4.5 - Approximated distribution of nests destroyed from the forestry sector in Canada as enumerated by Hobson et al. (2013).
Agriculture

- Spatial Reference: n/a
- Ellipsoid Name: n/a
- Total kill figures (nestlings or eggs) taken from data appendices of Tews et al. (2013):

Table A4.2 – Total kills of nestlings/eggs for five species from data appendix of Tews et. al. (2013) broken down by BCR and type of farming. BCR and grand totals match Table 3 of Tews et al. (2013).

<table>
<thead>
<tr>
<th>BCR</th>
<th>Grain</th>
<th>Haying</th>
<th>Vegetable</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>209,913</td>
<td>0</td>
<td>209,915</td>
</tr>
<tr>
<td>6</td>
<td>5,276</td>
<td>167,061</td>
<td>0</td>
<td>172,337</td>
</tr>
<tr>
<td>8</td>
<td>2,345</td>
<td>43,778</td>
<td>2810</td>
<td>48,933</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>7,460</td>
<td>0</td>
<td>7,461</td>
</tr>
<tr>
<td>10</td>
<td>31</td>
<td>36,602</td>
<td>0</td>
<td>36,633</td>
</tr>
<tr>
<td>11</td>
<td>12,075</td>
<td>610,821</td>
<td>0</td>
<td>622,897</td>
</tr>
<tr>
<td>12</td>
<td>5,079</td>
<td>155,270</td>
<td>1,672</td>
<td>162,021</td>
</tr>
<tr>
<td>13</td>
<td>22,777</td>
<td>618,698</td>
<td>49,252</td>
<td>690,727</td>
</tr>
<tr>
<td>14</td>
<td>41,568</td>
<td>203,789</td>
<td>13,119</td>
<td>258,477</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>89,155</strong></td>
<td><strong>2,053,393</strong></td>
<td><strong>66,853</strong></td>
<td><strong>2,209,401</strong></td>
</tr>
</tbody>
</table>


Methodology

Tabular agricultural data from the 2006 Agricultural Census was manually combined with the Canadian Census Subdivision (CD) data (http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2011-eng.cfm). The number of each farm types that were present within that CD was entered from the Agriculture Census Data tables.
Fig. A4.6 – Census divisions (CDs) of Canada from Statistics Canada. Note that the northern portion of most provinces and all of the territories have very large divisions. The CD labeled with a ‘1’ is Kenora and is discussed in the text as an example of how the large divisions were problematic.

Below is the list of farm types that have been identified in the Agriculture Census Data. The number in front of each is how we classified them into the aggregate groups following the main list:

2 Hay Farming
3 Fruit and vegetable combination farming
3 All other miscellaneous crop farming
3 Floriculture Production
3 Tobacco Farming
3 Other food crops grown under cover
5 Nursery and tree production
3 Fruit and tree nut farming
3 Mushroom Production
6 Livestock combination farming
4 All other miscellaneous animal production
4 Horse and other equine production
4 Fur bearing animal and rabbit production
6 Goat Farming
5 Apiculture
4 Other poultry production
6 Sheep farming
4 Poultry Hatcheries
3 Potato Farming
3 Other Vegetables (except potatoes) and melon farming
1 Corn farming
1 Other grain farming
1 Dry pea and bean farming
1 Wheat Farming
1 Soybean Farming
1 Oilseed (except soybean) farming
4 Combination poultry and egg production
4 Broiler and other meat type chicken production
4 Turkey Production
4 Hog Pig Farming
4 Chicken Egg Production
4 Dairy Cattle Milk Production
6 Beef Cattle Ranching Farming Feedlots
Aggregated Groups:
1 – annual grain type cropping
2 – hay farming
3 – fruit, vegetable, other miscellaneous farming
4 – animal farming, not big grazers
5 – farming without regular harvesting (bees, tree growing)
6 – livestock/grazers

Tews et al. (2013) only calculated mortality estimates for the first 3 groups above. Mortality from grazing was calculated by Btaho et al. (2013) separately and is not mapped.

Methodology

Since there were no geospatial files available with this agricultural data, the CD’s geospatial data was downloaded from Statistics Canada in order to link the unique CD ID’s with the CD ID’s from the 2006 Census of Agriculture dataset. The datasets were merged by using the ‘join’ operation based on the CD Unique ID’s.

CDs in Canada are not equally sized (Fig. A4.6), nor particularly representative of areas of the country where agriculture occurs (Fig. A4.7). This creates a problem as the number and type of farms is only summarized at the CD level. For large CDs with very little agriculture (such as Kenora in Fig. A4.6), we initially had uniformly distributed the farm count across all of our 50 × 50 km tiles covering the entire CD. The result of that process was that it appeared as though hay farming occurred everywhere at a low level in Ontario, from the US border right to James Bay.

To fix this problem we constrained our 50 × 50 km tile grid by the extent of agriculture land in Canada. The tile layer was intersected with the agriculture lands layer (Fig. A4.7), producing a much smaller potential tile grid in Canada. This is identical to the process used to display forestry in Canada where our tile grid was constrained by the forestry tenure layer. The result is that large and/or northern CDs like Kenora now only had grid tiles where agriculture occurs (in this case at the extreme southern end).
Fig. A4.7 – Distribution of agricultural land in Canada. Data provided by T. Rounce, Agriculture and Agri-Food Canada. Original derivation is from the Census of Agriculture interpolated variable called ‘PERAGR’ which is the percent of agriculture within a Soil Landscape of Canada (v3.1) polygon.

Agricultural data was displayed by CD across Canada. In order to determine the total percentage of each farm type that occurs by tile across Canada we did the following:

- Census Divisions were intersected to each 50 × 50 km tile. The sub-area for each divided CD (CDs crossing tile boundaries) was calculated and the area value was then used to calculate the percentage of each CD’s that fell within each tile (assumes population is homogenously distributed in each CD, likely not true).
- The number of each farm type within each CD (Grain, Haying, Vegetables) was multiplied by the proportion of each CD that fell within each unique tile ID in order to obtain the number of farms within each tile for each farm type.
  - The ‘Dissolve’ tool was then used so that all CD’s were dissolved by each 50 × 50 km tile and the statistics field was used to ‘SUM’ the number of farms within each tile. This was done separately for each of the 3 farm types.
  - Ideally we need the area of each farm type in each CD. However, Statistics Canada does not provide the area associated with each farm or in aggregate, so all we have is a count of farms by type in each CD.
- Equally distribute the quotient to each tile.

A map of Bird Conservation Regions (BCRs) was then overlaid on the tile grid with all the farming data. The two layers were intersected and each tile was assigned to its respective BCR (overlap cases were put into the BCR which contained the greater proportion of the tile area). The total number of farms of each type for all tiles in each BCR was calculated and the proportion in each tile was then derived.

Kills by farm type and BCR (Table A4.2) were then multiplied by the proportion of that farm type in that BCR for each 50 × 50 km tile. This represents the total nestlings or eggs killed per tile.
The results of our agriculture analysis are shown in Fig. A4.8: Grain Cropping, Fig. A4.9: Haying, and Fig. A4.10: Vegetable Cropping.

**Fig. A4.8** – Approximated distribution of nestlings and eggs destroyed from the grain cropping in Canada as enumerated by Tews et al. (2013).
**Fig. A4.9** - Approximated distribution of nestlings and eggs destroyed from the haying in Canada as enumerated by Tews et al. (2013).

**Fig. A4.10** – Approximated distribution of nestlings and eggs destroyed from the vegetable (and fruit) cropping in Canada as enumerated by Tews et al. (2013). Agriculture Census data had entries fruit and vegetable farms in western Canada (as expected), but the species analyzed and results from Tews et al.
(2013) had zero deaths for the western BCRs (such as BCRs 5 and 9 covering the lower mainland of BC).

Cats and Buildings (based on Population Density)

- Spatial Reference: n/a
- Ellipsoid Name: n/a
- Total kill figure used: Cats: 204 million (median value, Blancher 2013); Buildings: 24,900,000 (total average values from Table 5 in Machants et al. (2013).

The 2006 Census Population Density data for Canada was used to display the data by Census Division (CD). The Census Division data was not spatially represented so the geospatial file containing the Census Divisions for Canada were also obtained from Statistics Canada in order to acquire the desired results.

Methodology

Human population density was used as a proxy for the spatial distribution of both cats and buildings across Canada. We provide rationale below for using population data as the proxy for the two sources of mortality.

Cats: Per capita pet ownership in Canada was tabulated by Leger Marketing (http://www.legermarketing.com/documents/SPCLM/020617eng.pdf) and varied somewhat across Canada. In the absence of spatial data on pet ownership however, we calculated ≤ 2% difference between the proportion of cats per province (number of households × % cat ownership) and the % of total human population per province (Table A4.3). Although the results are autocorrelated from using population to calculate cats, this exercise demonstrates that the regional variation in cat ownership rates is a trivial deviation from simply approximating ownership by population. We recognize that if the number of cats per household varies radically across the country that it would introduce another inaccuracy into our map (Perrin [2009] indicates an average of 1.76 cats per owner). We expected unowned cat numbers to be associated with owned cats in some unknown, but constant ratio (fewer people in rural settings, fewer pet cats total, and fewer feral cats, with the opposite in cities). We did not explicitly extrapolate the unowned cats into the totals below. Because we assumed a constant ratio between the two types, and allocated the total kill of all cats to the proportional representation of population, no mapping differences would appear from calculating unowned cats in the table below.

Table A4.3: Comparison of geographic distribution of population by province and calculated owned cats per province.

<table>
<thead>
<tr>
<th>Prov</th>
<th>Population (2011)</th>
<th>Proportional Population</th>
<th>People/Household</th>
<th>2002 Cats Ownership Rate</th>
<th>Number of Owned Cats</th>
<th>Proportional Cat Population</th>
<th>Difference (% Human - %Cat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>4,400,057</td>
<td>13%</td>
<td>2.5</td>
<td>32%</td>
<td>991,245</td>
<td>15%</td>
<td>-2%</td>
</tr>
<tr>
<td>AB</td>
<td>3,645,257</td>
<td>11%</td>
<td>2.6</td>
<td>31%</td>
<td>764,943</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>SK</td>
<td>1,033,381</td>
<td>3%</td>
<td>2.4</td>
<td>21%</td>
<td>159,141</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

16
<table>
<thead>
<tr>
<th>Province</th>
<th>Population (2011)</th>
<th>Proportional Population</th>
<th>People/Household</th>
<th>2002 Cats Ownership Rate</th>
<th>Number of Owned Cats</th>
<th>Proportional Cat Population</th>
<th>Difference (% Human - %Cat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB</td>
<td>1,208,268</td>
<td>4%</td>
<td>2.5</td>
<td>21%</td>
<td>178,630</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>ON</td>
<td>12,851,821</td>
<td>38%</td>
<td>2.6</td>
<td>28%</td>
<td>2,435,914</td>
<td>36%</td>
<td>2%</td>
</tr>
<tr>
<td>QC</td>
<td>8,080,550</td>
<td>24%</td>
<td>2.3</td>
<td>26%</td>
<td>1,607,678</td>
<td>24%</td>
<td>0%</td>
</tr>
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<td>2.5</td>
<td>37%</td>
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Notes:
1. People/household is from 2006 Population Census, statistics Canada.
2. Average cat ownership rate was higher (about 36% compared to 31% here) in Perrin (2009) as cited by Blancher (2013), but we could not get updated geographic breakdowns of ownership rate and therefore used the 2002 figures from the Leger survey. Therefore the sum of the column “number of cats” is lower than the estimated number of pet cats given in Blancher (2013).

Buildings: The number of people per household in Canada varies little (2.3 - 2.6 persons per household for all major provinces [2006 Census data]), and since each household should be a unit represented in the analysis of Machtans et al. (2013), the proxy of population for buildings is gross (not 1:1), but suitable for broad scale mapping. This relationship would be confounded slightly since high rise apartments have many households in them and are technically counted in the high rise buildings section of Machtans et al. (2013). However, we did not break out the three categories of buildings separately in the mapping exercise so this confounding would be largely inconsequential. We did not have data to correlate the number of low-rise commercial buildings to population but assumed it was a linear relationship so proportional population could represent the kills from this class.

The number of tall buildings is highly correlated with log(population) in cities but is not completely log-linear (Fig. A4.11). We ignored both the logarithmic curve function and its inflection given that of the ~25M birds killed by buildings in Canada, only 1% in total is ascribed to tall buildings and slight adjustments for the proportion of buildings in each city in Canada in each 50 × 50 km tile would not be visible in the final map. While technically this would have been a better map of tall building density, Machtans et al. (2013) provides evidence that the number of buildings alone is a poor predictor of tall building bird-collision deaths (geography seems very important).
Fig. A4.11 – The relationship between city population and number of high-rise buildings in Canada. High-rise data from http://skyscraperpage.com/cities/?s=0&c=2&p=0&r=50&10=0

Population data were exported from Statistics Canada and merged together for all CD’s in Canada. Tabular data were joined with the CD shapefile which contained the polygons for each CD. The join was performed based on the unique ID’s from the CD’s ID field. Using the ‘Field Calculator’, the area for each CD was calculated.

Census Divisions were intersected to each 50 × 50 km tile. The sub-area for each divided CD (CDs crossing tile boundaries) was calculated and the area value was then used to calculate the percentage of each CD’s that fell within each tile (assumes population is homogenously distributed in each CD, likely not true). The result was multiplied by the 2006 Population Density for each unique CD based on the percentage of the CD’s that fall within each individual tile.

Census Divisions were dissolved by each 50 × 50 km tile and population densities were summed. Proportion of the total national population in each 50 × 50 km tile was calculated.

Proportional population in each tile was multiplied by the kill values for cats and buildings separately to produce the two data layers. The problem with large census divisions explained in the Agriculture section was also encountered for the population layer. We arbitrarily removed all tiles with population densities of < 100 people per tile (0.04/km²). We then reinserted only the tiles that contained communities.

The results of our analyses (Fig. A4.12: cats; Fig. A4.13: buildings) appear identical because the 10 colours chosen for each class are identical and the underlying population distribution is the same. Note the different estimate of take per tile in the legends however.
Fig. A4.12 – Approximated distribution of birds killed by cats in Canada from values in Blancher (2013).

Fig. A4.13 – Approximated distribution of birds killed by colliding with windows in buildings in Canada from values in Machtans et al. (2013). Note that the legend values are different than in the similarly coloured Fig. A4.12.
Wind Power

- Source: Canadian Wind Energy Association (http://www.canwea.ca/farms/wind-farms_e.php) web table and on-line map
- Spatial Reference: n/a
- Ellipsoid Name: n/a
- Total kill figure used: 5.9 birds per turbine from Zimmerling et al. (2013).

We created our own point layer shapefile by deriving coordinates for each wind farm from the above noted source. We entered the provided data for each wind farm (number of turbines and type) in the attribute file.

Methodology

Each point in our wind farm layer (one wind farm) was assigned a total kills by multiplying the number of turbines at that facility by the average kills per turbine noted above. The 50 × 50 km tile grid was overlaid with the wind farm point layer and a spatial join was performed in order to assign a tile ID to each wind farm point location. The Dissolve tool was then run to sum all kills within each unique tile ID using the statistics filed within the dissolve tool.

The result of our analysis on wind farms is in Fig. A4.14.

![Bird Mortalities By Tile](image)

**Fig. A4.14:** Approximated distribution of kill of birds by wind farm operation in Canada based on average kill per turbine in Zimmerling et al. (2013).
Combined layers used in main paper

The final analysis involves summing all tile values for each of the specified mortality sources. Two maps were created. First, a map summing all layers was made. However, since so much kill in Canada is attributed to cats, bird-building collisions, and bird-vehicle collisions, a second map without these three sources was created.

The results of the summed layers for all mortality sources are shown in Fig. A4.15 and the results without the three sources noted above are in Fig. A4.16. Finally, the distribution of total mortality from only the top three sources (cats, bird-building collisions and bird-vehicle collisions) is presented in Fig. A4.17.

![Map of Canada with mortality data]

**Fig. A4.15** – Approximated distribution of all bird mortalities across all sources considered.
**Fig. A4.16**: Approximated distribution of all bird mortalities for all sources except cats, bird-building collisions and bird-vehicle collisions.

**Fig. A4.17** – Approximated distribution of all bird mortalities from cats, bird-building collisions and bird-vehicle collisions only.
Literature Cited (Appendix 4)


