1. PROJECT INFORMATION

<table>
<thead>
<tr>
<th>Title</th>
<th>Predicting waterbird nest distributions on the Yukon-Kuskokwim Delta of Alaska</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project ID</td>
<td>WA2012_22</td>
</tr>
<tr>
<td>Project Period</td>
<td>July 1, 2012 to June 30, 2014</td>
</tr>
<tr>
<td>Report submission date</td>
<td>14 November 2014</td>
</tr>
<tr>
<td>Author(s) of Report</td>
<td>Sarah T. Saalfeld, Julian B. Fischer, Robert A. Stehn, Robert Platte, and Stephen Brown</td>
</tr>
<tr>
<td>Key words</td>
<td>Alaska, Arctic, eider, geese, nest density, predicted density surface, random forests, waterbirds, waterfowl, Yukon-Kuskokwim Delta</td>
</tr>
</tbody>
</table>

Principal Investigator(s), Co-Principal Investigators and Recipient Organization(s):
Sarah Saalfeld, Manomet Center for Conservation Sciences, ssaalfeld@manomet.org
Julian Fischer, Division of Migratory Bird Management, U.S. Fish and Wildlife Service, julian_fischer@fws.gov
Thomas Ravens, University of Alaska Anchorage, tomravens@uaa.alaska.edu
Stephen Brown, Manomet Center for Conservation Sciences, sbrown@manomet.org

2. PROJECT OVERVIEW

a. Briefly (4-5 sentences) describe both the research purpose and the underlying need for this research.

The Yukon-Kuskokwim Delta of Alaska is the largest intertidal wetland in North America, providing globally important habitat for numerous avian species including millions of nesting and migrating waterfowl and shorebirds. Within the Yukon-Kuskokwim Delta, waterbird nest densities are greatest within coastal fringe habitats, with some species only occurring within these habitat types. The landforms and these habitats depend on coastal estuarine processes including tidal erosion, deposition of sediments, storm-tide flooding, and salt intrusion. Thus, predicted changes related to climate (e.g., sea level rise, increased frequency and intensity of coastal storms, changes in seasonal patterns of storminess, reduction in permafrost) have the potential to dramatically alter waterbird nesting habitat in the near future. A first step in evaluating the potential impacts of climate-mediated changes on waterbird species within the Yukon-Kuskokwim Delta is to determine the
current location of important nesting areas and understand the importance of environmental
variables associated with nest density.

b. List the objective(s) of the project, exactly as described in your Statement of Work.
Create and map predictive surfaces of waterbird nest densities on the Yukon-Kuskokwim Delta of
Alaska using landscape habitat features and U.S. Fish and Wildlife Service’s nest survey data
collected between 1985 and 2013.

3. PROJECT SUMMARY
Ground surveys were conducted during 29 years from 1985 to 2013 as part of the U. S. Fish and
Wildlife Service’s annual waterbird monitoring program. During this time, 2,318 plots were surveyed,
with fifteen species detected in ≥10% of these plots. We developed nest density models for these 15
species, using relevant landscape habitat features including mean elevation, percentage of plot
containing different vegetation classifications (e.g., % coastal dwarf shrub, % coastal dwarf shrub/pond
mosaic, % lower coastal salt marsh, % upper coastal brackish meadow, % coastal graminoid, %
sandbar/mudflat, and % upland), percentage of plot containing potential nesting habitat (i.e., all
vegetated areas), mean density of water bodies within the plot, percentage of plot identified containing
water bodies, percentage of plot containing rivers, total length of water body shoreline within the plot,
water body shoreline complexity in the plot, total length of riverine and tidal sloughs within the plot,
distance to coast, distance to inland mudflats, and year. To model waterbird nest density, we used
random forests, an ensemble regression tree approach. For each species, we determined the percent
variance explained by the model, as well as variable importance values and partial dependence plots to
estimate the relative effect of each environmental variable on nest densities. We then mapped
predicted nest densities across the Yukon-Kuskokwim Delta central coastal zone for each species to
reveal spatially explicit areas of high and low densities.

The percentage of total variance explained by the random forests models varied widely among
species, ranging from 0–69% (Table 1). Model performance tended to be better for geese and eiders,
with subpar performance for the remainder of the species. Variable importance plots illustrated that
distance to coast was an important explanatory variable for all geese and eider species, with Black Brant
and Common Eider showing sharp declines in nest density as distance to coast increased, while Cackling
Goose, Emperor Goose, and Spectacled Eider illustrated more gradual declines. Conversely, nest density
of Greater White-fronted Goose was greatest at intermediate levels. Most geese and eider species also
tended to select greater percentages of lowland habitat types. For example, greater nest densities of
Cackling Goose, Spectacled Eider, and Common Eider occurred when the percentage of coastal
graminoid land cover class was greater, while the percentage of lower coastal salt marsh was positively
related to nest densities of Emperor Goose and Common Eider. Percentage of mudflats was also
important for Black Brant and Common Eider, with greater nest densities occurring in areas with more
coastal mudflats. In addition to environmental variables, mean survey year was highly important for
Cackling Goose, Greater White-fronted Goose, and Spectacled Eider, with all three of these species
exhibiting increases in nest densities in the mid 1990’s. Predicted nest densities mapped across the
Yukon-Kuskokwim Delta coastal zone for each species of geese and eiders revealed spatially explicit
areas of high and low densities (Figure 1).
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of nests found</th>
<th>Nest density (nests/km²)</th>
<th>% variance explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater White-fronted Goose</td>
<td>12,119</td>
<td>10.1 0.5 0-69.5</td>
<td>68.8</td>
</tr>
<tr>
<td>Cackling Goose</td>
<td>33,264</td>
<td>25.8 1.4 0-177.7</td>
<td>52.5</td>
</tr>
<tr>
<td>Emperor Goose</td>
<td>9,328</td>
<td>9.0 0.4 0-57.8</td>
<td>41.1</td>
</tr>
<tr>
<td>Spectacled Eider</td>
<td>2,254</td>
<td>1.7 0.1 0-18.5</td>
<td>39.7</td>
</tr>
<tr>
<td>Glaucous Gull</td>
<td>2,427</td>
<td>2.1 0.2 0-45.8</td>
<td>16.6</td>
</tr>
<tr>
<td>Black Brant</td>
<td>10,898</td>
<td>13.0 2.4 0-507.9</td>
<td>16.4</td>
</tr>
<tr>
<td>Common Eider</td>
<td>835</td>
<td>0.8 0.1 0-33.9</td>
<td>12.5</td>
</tr>
<tr>
<td>Tundra Swan</td>
<td>901</td>
<td>0.9 0.1 0-6.2</td>
<td>12.4</td>
</tr>
<tr>
<td>Loons</td>
<td>1,532</td>
<td>1.6 0.1 0-10.8</td>
<td>12.4</td>
</tr>
<tr>
<td>Northern Pintail</td>
<td>728</td>
<td>0.7 0.1 0-8.2</td>
<td>12.3</td>
</tr>
<tr>
<td>Sandhill Crane</td>
<td>941</td>
<td>1.1 0.1 0-9.3</td>
<td>6.1</td>
</tr>
<tr>
<td>Mew Gull</td>
<td>1,494</td>
<td>1.2 0.1 0-30.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Arctic Tern</td>
<td>676</td>
<td>0.6 0.1 0-18.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Greater Scaup</td>
<td>315</td>
<td>0.3 0.0 0-6.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Sabine’s Gull</td>
<td>1,098</td>
<td>1.0 0.1 0-35.7</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Figure 1. Predicted nest density (i.e., number of nests/km²) for Cackling Goose, Emperor Goose, Black Brant, Greater White-fronted Goose, Spectacled Eider, and Common Eider on the Yukon-Kuskokwim Delta of Alaska, USA, 1985–2013. Areas with no predictions (e.g., unclassified habitat was >10% in predictive grid cells) are in white.
4. PRODUCTS

a. Publications, conference papers, and presentations.
   We have presented results on predicting waterbird nest distributions on the Yukon-Kuskokwim Delta of Alaska at the Alaska Chapter of the Wildlife Society in Anchorage, Alaska, as well as at a Western Alaska Landscape Conservation Cooperative Webinar.

b. Education and outreach.
   We have distributed our report on predicting waterbird nest distributions on the Yukon-Kuskokwim Delta to interested parties including staff from the Yukon-Delta National Wildlife Refuge.

c. Other products resulting from the project.
   We have produced spatially explicit models of waterbird nest density for the six waterbird species with reasonable accuracy (i.e., Cackling Goose, Emperor Goose, Black Brant, Greater White-fronted Goose, Spectacled Eider, and Common Eider). These raster layers depicting predicted nest densities will be available following publication of these data.