

Supplemental Information

The information and data presented herein serve as the supplement to the report, "Spatial Integration of Biological and Social Objectives to Identify Priority Landscapes for Waterfowl Habitat Conservation." The purpose of this supplemental material is to encourage exploration of the methods used to develop the spatially explicit products presented in the report. The in depth step-by-step methodology is complemented with a geodatabase (Supplement 8) to facilitate future refinement of the model as new information becomes available in the future. To repeat the process of developing the spatially explicit products (or to create other composite spatial products by varying objectives and weights), follow the methodology described herein. Spatial data available for download include 34 layers (20 waterfowl breeding and non-breeding objectives layers, 9 social objectives layers, and 5 raster mixed model layers), which can be accessed at <https://doi.org/10.5066/P9L7J5U4>. All sources of raw data are provided and should be cited accordingly. For availability of intermediate spatial products and other data included in the geodatabase (Supplement 8), contact the corresponding author. For further inquiries or comments about the products or results, contact the corresponding author.

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Legend

Red text = shapefiles and spatial data
Green text = excel worksheets and .csv files
Blue text = ArcGIS functions and tools

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Supplement 1.

Developing Spatial Layers of Continental Density and Abundance for Breeding Ducks

Breeding Range

Mallard (*Anas platyrhynchos*)

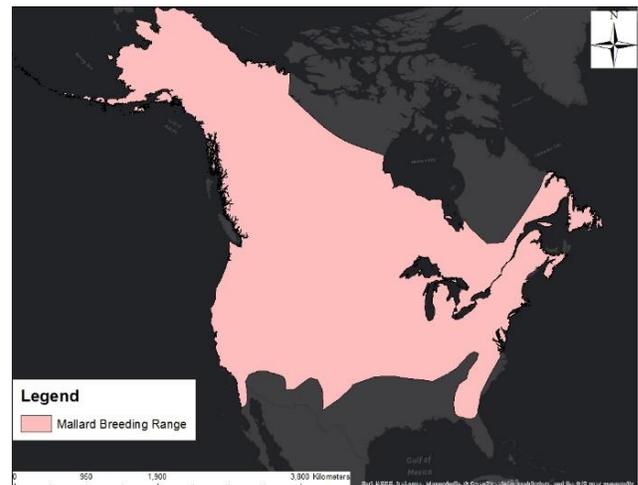
Species Account for Habitat Conservation Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Mallard during the breeding season. Data from several surveys were used, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Traditional Survey Area

Date Range: 2001-2015

Provinces: Manitoba, Saskatchewan, Alberta, and Northwest Territories

States: Alaska, North Dakota, and South Dakota

TSA Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The average Mallard population estimate was assigned to its respective stratum.

Waterfowl Breeding Population and Habitat Survey Eastern Survey Area

Date Range: 2001-2015

Provinces: Ontario, Quebec, Newfoundland and Labrador, New Brunswick, Prince Edward Island, and Nova Scotia

States: Maine

ESA Strata: 51, 52, 53, 54, 55, 56, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Missing Data:

2001-2015 for strata 57, 58, 59

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The average Mallard population estimate (excluding missing data) was assigned to its respective stratum

Atlantic Flyway Plot Survey

Date Range: 2001-2015

States: Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Virginia

BBS Strata: 3, 4, 9, 10, 11, 12, 13, 16, 18, 22, 23, 24, 26, 27, 28, 99, 24.1, 24.2, 24.3

Missing Data:

2006 DE for strata 4, 10, 99

2009 MA for stratum 27

2013, 2014 MD for stratum 24

2014 NH for stratum 99

Spatial boundary for DE 10 did not exist in the spatial strata

Methods: for each state/stratum (i.e., CT12, MD4, etc.), the average population estimate was calculated for 2001-2015. The average Mallard population estimate (excluding missing data) was assigned to its respective stratum.

Upper Mississippi River and Great Lakes Region Joint Venture Surveys

Date Range: 2006-2015

States: Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Iowa, Arkansas, Kansas, and Nebraska

BCR Strata: 12, 13, 22, 23, 24

Missing Data: NONE

Methods: For each Bird Conservation Region (BCR) stratum, the average population estimate was calculated for 2006-2015. The average Mallard population estimate was assigned to its respective BCR stratum.

British Columbia Central Interior Waterfowl Aerial Survey Program

Date Range: 2006-2017

Provinces: British Columbia

Eco-sections Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, and 10-Cariboo Basin

Missing Data: NONE

Methods: For each Eco-section stratum, the average population estimate was calculated for 2006-2017. The average Mallard population estimate was assigned to its respective stratum.

Minnesota Waterfowl Breeding Population Survey

Date Range: 2001-2015

States: Minnesota

Strata: 1-high density of wetlands, 2- medium density of wetlands, and 3- low density of wetlands

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The average Mallard population estimate was assigned to its respective stratum.

Washington State Breeding Waterfowl Population Survey

Data Range: 2010-2017

States: Washington

Strata: Chehalis Valley, Hood Canal, South Puget Lowlands, North Puget Lowlands, Dungeness, Irrigated, Potholes, and Highlands

Missing Data:

2010-2011 for Highlands stratum

Methods: For each stratum, the average population estimate was calculated for 2010-2017. The average Mallard population estimate (excluding missing data) was assigned to its respective stratum.

Oregon State Breeding Waterfowl Population Survey

Data Range: 2002-2016

States: Oregon

Strata: Forested Wetlands, Lower Columbia River, Northeast Seasonal Marsh, Southeast Seasonal Marsh, and Willamette Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2002-2016. The average Mallard population estimate was assigned to its respective stratum.

California Waterfowl Breeding Population Survey

Date Range: 2001-2017

States: California

Strata: 1-Sacramento Valley, 2-Delta, 3-San Joaquin Desert, 4-San Joaquin Grasslands, 5-Suisun Marsh, 6-Napa (w/ Santa Rosa), 9-Northeastern, 10-East Valley, and 11-West Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2017. The average Mallard population estimate was assigned to its respective stratum.

Nevada Waterfowl Breeding Survey

Date Range: 2010-2016

States: Nevada

Strata: Agriculture and Marsh

Missing Data: NONE

Methods: The survey includes 4 strata: Agriculture, Marsh, Lake/Reservoir, and River. Only two of the strata and their population estimates were used in this analysis due to technical difficulties with strata shapefiles in ArcGIS. For each stratum, the average population estimate was calculated for 2010-2016. The average Mallard population estimate was assigned to its respective stratum

Utah Breeding Duck Aerial Survey

Date Range: 2001-2015

States: Utah

Strata: Box Elder, Cache, Davis, Rich, Weber, and GLS total (Counties)

Missing Data: NONE

Methods: The survey is conducted using fixed-wing aircraft. The Visibility Correction Factor (VCF) is based on a 1977-1979 study. The survey reports an estimate of Indicated Breeding Birds (IBB) which is then corrected by a species specific VCF of 11.364 and an 'All Species Factor' of 5.06. Population estimates for each year and stratum were calculated using original IBB value \times VCF \times Species Factor. For each stratum, the average population estimate was then calculated for 2001-2015. The average Mallard population estimate was assigned to its respective stratum.

Nebraska Sandhills Survey

Date Range: 2003-2005

States: Nebraska

Strata: Sandhills

Missing Data: NONE

Methods: For one stratum (Sandhills) the average population estimate was calculated for the 2003-2005. The average Mallard population estimate was then assigned to the stratum.

Arctic Coastal Plain Waterfowl Population Survey

Date Range: 2008-2017

States: Alaska

Strata: Stratum 1, Stratum 2, Stratum 3, and Stratum 4

Missing Data: NONE

Methods: Survey results are reported at Indicated Total Birds per stratum annually. Population estimates at the stratum level were calculated by applying the Hodges and others (1996) species specific VCFs for Tundra (Mallard VCF = 4.01). For each stratum, the average population estimate was then calculated for 2008-2017. The average Mallard population estimate was assigned to its respective stratum.

*Original data and calculations can be found in the [MALL_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Mallard Density and Abundance Spatial Layers

- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in

[MALL_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.

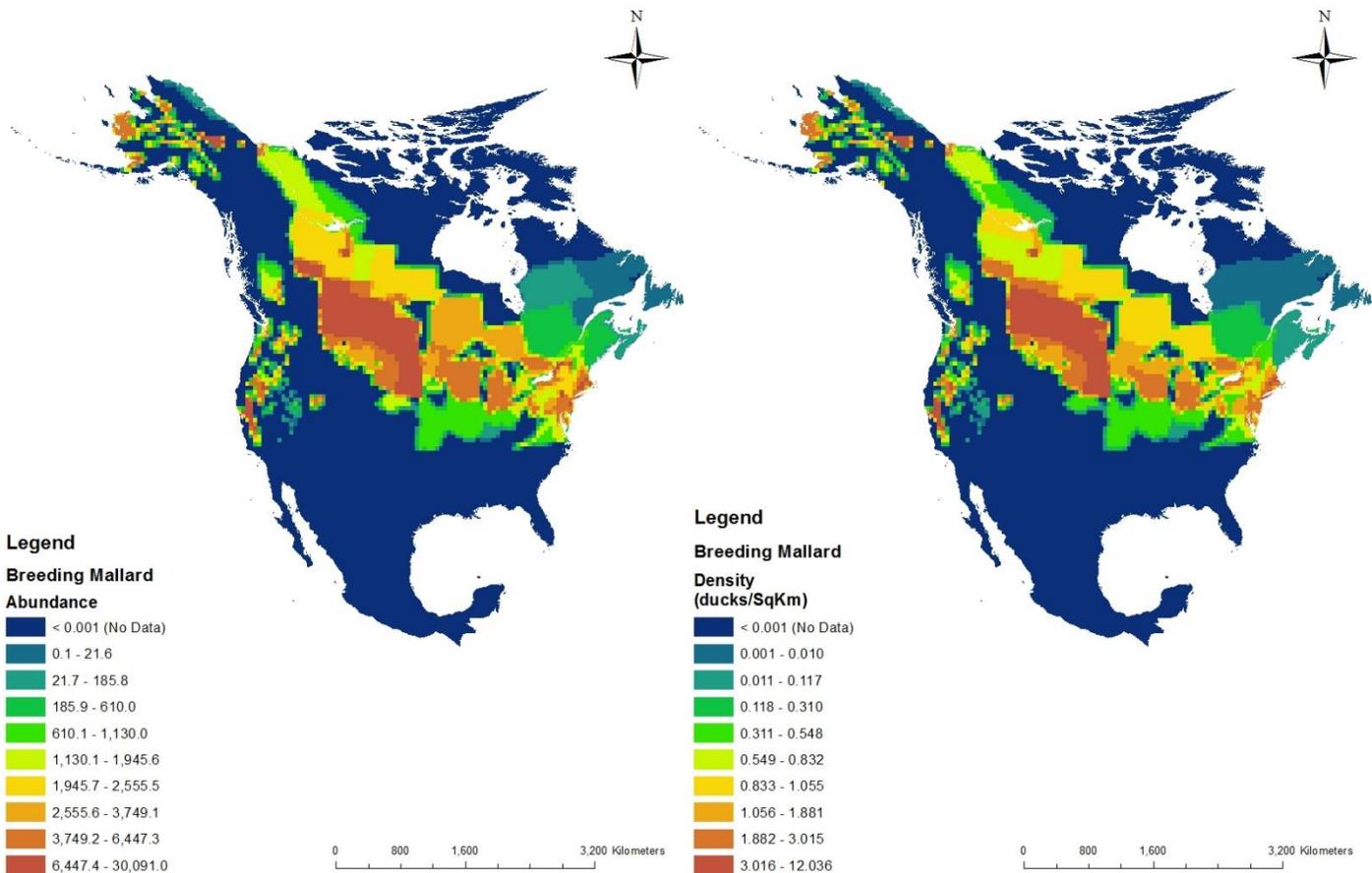
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [MALL_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/strata specific) associated with each point estimate, however, we feel that given the scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Mallard.
- 3) Each spatial shapefile of strata where Mallard population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Mallards were counted, [AFS_Strata.shp](#), [ESA_Strata.shp](#), [TSA_Strata.shp](#), [BC_Strata.shp](#), [WA_Strata.shp](#), [OR_Strata.shp](#), [CA_Strata.shp](#), [NV_Strata.shp](#), [UT_Strata.shp](#), [MN_Strata.shp](#), [Sandhills_Strata.shp](#), [ACP_Strata.shp](#) and [BCR_Strata.shp](#) were merged into file [MALL_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [MALL_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'MALL' (with 'Float' as field type), and 'MALL_Dens' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Mallard breeding population for the temporal range analyzed within that stratum, and Mallard density, respectively).
 - a. Total area of each 'STRATA' was calculated using [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'MALL' field from [Strata_Averages](#) tab in the [MALL_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'MALL' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'MALL' = 0 and 'MALL_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [MALL_Breeding_Dens_n_Abun.shp](#), can be used to display density of Mallards per square km in each stratum (using the 'MALL_Dens' field of the attribute table) or abundance of Mallards per stratum (using the 'MALL' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, 100×100, and 10×10 km grid scales were explored. Mallard density and abundance estimates at these scales are available as supplemental information upon request).

- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Mallards need to be added as a ‘NoData’ value in the ‘STRATA’ field.
- 9) We used the **Erase** function to erase the areas covered in the survey (**MALL_Breeding_Dens_n_Abun.shp**) from the shapefile outline of North America (inclusive of Canada and Mexico; **North_America_Boundary.shp**) to create a new shapefile, **North_America2.shp**.
- 10) We then merged **North_America2.shp** with **MALL_Breeding_Dens_n_Abun.shp** to create a new file, **MALL_Breeding_Dens_n_Abun2.shp**, encompassing continental North America.
- 11) We used the **Edit** tool to input ‘NoData’ in the ‘STRATA’ field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the **Calculate Geometry** function.
- 12) A 50×50 km grid fishnet (**Fishnet_50.shp**) was created using the **Create Fishnet** tool and then clipped to the boundaries of **North_America_Boundary.shp** using the **Clip** tool.
- 13) We then used the **Intersect** tool to intersect **Fishnet_50.shp** and **MALL_Breeding_Dens_n_Abun2.shp** files to create **50_MALL_Breeding.shp**. Two new fields were added to the attribute table, ‘Area_new’ (with a ‘Float’ type) and ‘Abundance’ (with a ‘Float’ type). Area was recalculated using the **Calculate Geometry** function in the ‘Area_new’ field.
- 14) Abundance was calculated by multiplying the ‘Area_new’ field by the ‘MALL_Dens’ field using the **Field Calculator** tool.
- 15) Next, **50_MALL_Breeding.shp** was dissolved by ‘FID_Fishne’ field using the **Dissolve** tool to create a new file **50_MALL_Breeding2.shp**.
 - a. Statistics for ‘Area_new’ and ‘Abundance’ fields were summed.
 - b. New field for ‘Density’ was created and density was recalculated at the 50×50 km grid using **Field Calculator** and dividing field ‘SUM_Abunda’ by field ‘SUM_Area_n’
- 16) The final product, **50_MALL_Breeding2.shp** can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Mallard distribution and density during the breeding season for the Eastern Survey Area, Traditional Survey Area, Atlantic Flyway Survey Area, Minnesota, and Utah Breeding Waterfowl Surveys.
2. 2006-2015 time period reflects current Mallard distribution and density during the breeding season for the Upper Mississippi River and Great Lakes Region Joint Venture.
3. 2006-2017 time period reflects current Mallard distribution and density during the breeding season for the British Columbia Breeding Waterfowl Survey.
4. 2010-2017 time period reflects current Mallard distribution and density during the breeding season for the Washington Breeding Waterfowl Survey.
5. 2002-2016 time period reflects current Mallard distribution and density during the breeding season for the Oregon Breeding Waterfowl Survey.
6. 2001-2017 time period reflects current Mallard distribution and density during the breeding season for the California Breeding Waterfowl Survey.

7. 2010-2016 time period reflects current Mallard distribution and density during the breeding season for the Nevada Breeding Waterfowl Survey.
8. 2003-2005 time period reflects current Mallard distribution and density during the breeding season for the Nebraska Sandhills Survey.
9. 2008-2017 time period reflects current Mallard distribution and density during the breeding season for the Arctic Coastal Plain Survey.
10. All surveys and population estimates are consistent across years and strata within a survey.
11. Missing data will not significantly skew results.
12. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
13. High density and high abundance regions represent geographies of continental significance to breeding Mallard.



American Black Duck (*Anas rubripes*)

Species Account for Habitat Conservation Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution) *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to American Black Duck during the breeding season. Data from several surveys were used, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Eastern Survey Area

Date Range: 2001-2015

Provinces: Ontario, Quebec, Newfoundland and Labrador, New Brunswick, Prince Edward Island, and Nova Scotia

States: Maine

ESA Strata: 51, 52, 53, 54, 55, 56, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Missing Data:

2001-2015 for strata 57, 58, 59

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The average American Black Duck population estimate (excluding missing data) was assigned to its respective stratum.

Atlantic Flyway Plot Survey

Date Range: 2001-2015

States: Maine, Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Virginia

BBS Strata: 3, 4, 9, 10, 11, 12, 13, 16, 18, 22, 23, 24, 26, 27, 28, 99, 24.1, 24.2, 24.3

Missing Data:

2006 DE 4, 10, 99 strata

2013, 2014 MD 24 stratum

2014 NH 99 stratum

Spatial boundary for DE 10 stratum did not exist in the spatial strata

Methods: for each state/stratum (i.e., CT12, MD4, etc.), the average population estimate was calculated for 2001-2015. The average American Black Duck population estimate (excluding missing data) was assigned to its respective stratum.

Upper Mississippi River and Great Lakes Region Joint Venture Surveys

Date Range: 2003-2007

States: Minnesota, Wisconsin, and Michigan

BCR Strata: 12, 23

Missing Data: NONE

Methods: Estimates for American Black Duck breeding populations for BCR 12 and 23 were derived directly from referenced report (Table 4; Soulliere and others, 2007). Expert opinion from biologists in the JV indicated that Minnesota and Wisconsin should not be included as there are very few American Black Ducks breeding in these regions (G. Soulliere, personal communication). The American Black Ducks that do breed in WI and MN, are generally thought of as incidental pairs. Therefore, we excluded MN and WI from the final range map of American Black Duck densities and abundance. American Black Duck average population estimate from 2003-2007 was then assigned to its respective stratum.

*Original data and calculations can be found in the [ABDU_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing American Black Duck Density and Abundance Spatial Layers

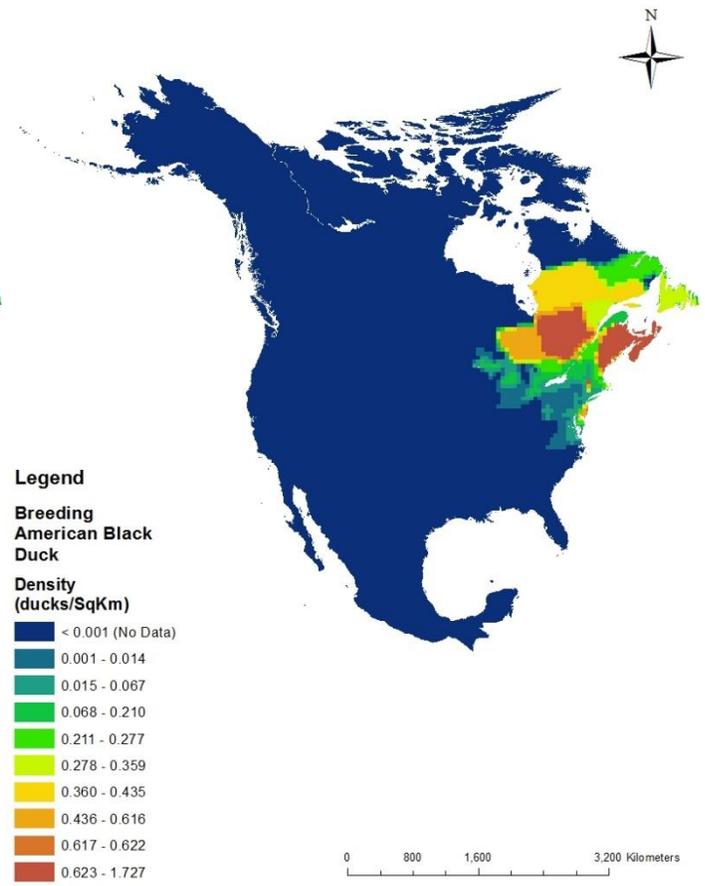
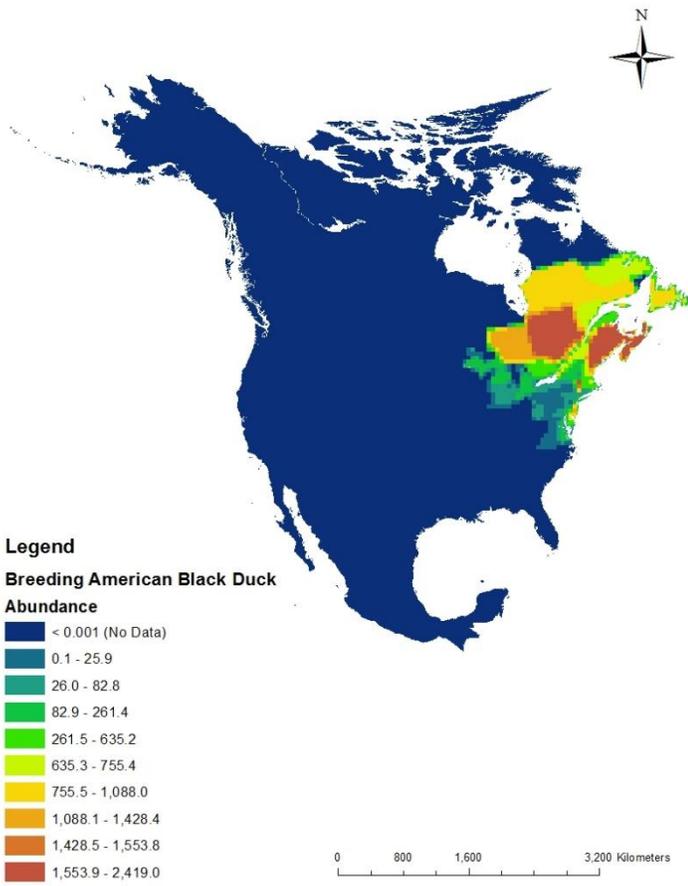
- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [ABDU_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [ABDU_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/strata specific) associated with each point estimate, however, we feel that given the scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding American Black Duck.
- 3) Each spatial shapefile of strata where American Black Duck population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic:

- GCS_North_American_1983). Shapefiles of strata associated with surveys where Black Ducks were counted, [AFS_Strata.shp](#), [ESA_Strata.shp](#), and [BCR_12_23_Strata.shp](#) were merged into file [ABDU_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [ABDU_Breeding_Dens_n_Abun.shp](#), fields ‘Area_sqkm’ (with ‘Float’ as field type), ‘ABDU’ (with ‘Float’ as field type), and ‘ABDU_Dens’ (with ‘Float’ as field type) were added. (These represent, area of strata in square kilometers, average American Black Duck breeding population for the temporal range analyzed within that stratum, and American Black Duck density, respectively).
 - a. Total area of each ‘STRATA’ was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the ‘ABDU’ field from [Strata_Averages](#) tab in the [ABDU_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing ‘ABDU’ field by ‘Area_sqkm’ field.
 - 5) All rows in the attribute table where ‘ABDU’ = 0 and ‘ABDU_Dens’ = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
 - 6) The resulting spatial layer, [ABDU_Breeding_Dens_n_Abun.shp](#), can be used to display density of American Black Ducks per square km in each stratum (using the ‘ABDU_Dens’ field of the attribute table) or abundance of American Black Duck per stratum (using the ‘ABDU’ field of the attribute table).
 - 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, 100×100, and 10×10 km grid scales were explored. American Black Duck density and abundance estimates at these scales are available as supplemental information upon request).
 - 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding American Black Ducks need to be added as a ‘NoData’ value in the ‘STRATA’ field.
 - 9) We used the [Erase](#) function to erase the areas covered in the survey ([ABDU_Breeding_Dens_n_Abun.shp](#)) from the shapefile outline of North America (inclusive of Canada and Mexico; [North_America_Boundary.shp](#)) to create a new shapefile, [North_America2.shp](#).
 - 10) We then merged [North_America2.shp](#) with [ABDU_Breeding_Dens_n_Abun.shp](#) to create a new file, [ABDU_Breeding_Dens_n_Abun2.shp](#), encompassing continental North America.
 - 11) We used the [Edit](#) tool to input ‘NoData’ in the ‘STRATA’ field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
 - 12) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.

- 13) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [ABDU_Breeding_Dens_n_Abun2.shp](#) files to create [50_ABDU_Breeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
- 14) Abundance was calculated by multiplying the 'Area_new' field by the 'ABDU_Dens' field using the [Field Calculator](#) tool.
- 15) Next, [50_ABDU_Breeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_ABDU_Breeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
- 16) The final product, [50_ABDU_Breeding2.shp](#) can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current American Black Duck distribution and density during the breeding season for the Atlantic Flyway Survey and the Easter Survey Area.
2. 2003-2007 time period reflects current American Black Duck distribution and density during the breeding season in Michigan.
3. All surveys and population estimates are consistent across years and strata within a survey.
4. Methodology used to derive population estimates (UMRGLRJV Waterfowl Habitat Conservation Strategy 2007; Appendix F) are appropriate and verified as standard methodology by experts in the region.
5. Missing data or not surveyed strata will not significantly skew results.
6. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
7. High density and high abundance regions represent geographies of continental significance to breeding American Black Duck.



Northern Pintail (*Anas acuta*)

Species Account for Habitat Conservation Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Northern Pintail during the breeding season. Data from several surveys were used to determine geographies of greatest continental significance to breeding Northern Pintail, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Traditional Survey Area

Date Range: 2001-2015

Provinces: Manitoba, Saskatchewan, Alberta, and Northwest Territories

States: Alaska, North Dakota, and South Dakota

TSA Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The average Northern Pintail population estimate was assigned to its respective stratum.

British Columbia Central Interior Waterfowl Aerial Survey Program

Date Range: 2006-2017

Provinces: British Columbia

Eco-sections Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, and 10-Cariboo Basin

Missing Data: NONE

Methods: For each Eco-section stratum, the average population estimate was calculated for 2006-2017. The average Northern Pintail population estimate was assigned to its respective stratum.

Minnesota Waterfowl Breeding Population Survey

Date Range: 2001-2015

States: Minnesota

Strata: 1-high density of wetlands, 2- medium density of wetlands, and 3- low density of wetlands

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The average Northern Pintail population estimate was assigned to its respective stratum.

Washington State Breeding Waterfowl Population Survey

Data Range: 2010-2017

States: Washington

Strata: Chehalis Valley, Hood Canal, South Puget Lowlands, North Puget Lowlands, Dungeness, Irrigated, Potholes, and Highlands

Missing Data:

2010-2011 for Highlands stratum

Methods: For each stratum, the average population estimate was calculated for 2010-2017. The average Northern Pintail population estimate (excluding missing data) was assigned to its respective stratum.

Oregon State Breeding Waterfowl Population Survey

Data Range: 2002-2016

States: Oregon

Strata: Forested Wetlands, Lower Columbia River, Northeast Seasonal Marsh, Southeast Seasonal Marsh, and Willamette Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2002-2016. The average Northern Pintail population estimate was assigned to its respective stratum.

California Waterfowl Breeding Population Survey

Date Range: 2001-2017

States: California

Strata: 1-Sacramento Valley, 2-Delta, 3-San Joaquin Desert, 4-San Joaquin Grasslands, 5-Suisun Marsh, 6-Napa (w/ Santa Rosa), 9-Northeastern, 10-East Valley, and 11-West Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2017. The average Northern Pintail population estimate was assigned to its respective stratum.

Nevada Waterfowl Breeding Survey

Date Range: 2010-2016

States: Nevada

Strata: Agriculture and Marsh

Missing Data: NONE

Methods: The survey includes 4 strata: Agriculture, Marsh, Lake/Reservoir, and River. Only two of the strata and their population estimates were used in this analysis due to technical difficulties with strata shapefiles in ArcGIS. For each stratum, the average population estimate was calculated for 2010-2016. The average Northern Pintail population estimate was assigned to its respective stratum.

Utah Breeding Duck Aerial Survey

Date Range: 2001-2015

States: Utah

Strata: Box Elder, Cache, Davis, Rich, Weber, and GLS total (Counties)

Missing Data: NONE

Methods: The survey is conducted using fixed-wing aircraft. The visibility correction Factor is based on a 1977-1979 study. The survey reports an estimate of Indicated Breeding Birds (IBB) which is then corrected by a species specific VCF of 8.05 and an 'All Species Factor' of 5.06. Population estimates for each year and strata were calculated using original IBB value \times VCF \times Species Factor. For each stratum, the average population estimate was then calculated for 2001-2015. The average Northern Pintail population estimate was assigned to its respective stratum.

Nebraska Sandhills Survey

Date Range: 2003-2005

States: Nebraska

Strata: Sandhills

Missing Data: NONE

Methods: For one stratum (Sandhills), the average population estimate was calculated for the 2003-2005. The average Northern Pintail population estimate was then assigned to the stratum.

Arctic Coastal Plain Waterfowl Population Survey

Date Range: 2008-2017

States: Alaska

Strata: Stratum 1, Stratum 2, Stratum 3, and Stratum 4

Missing Data: NONE

Methods: Survey results are reported at Indicated Total Birds per strata annually. Population estimates at the strata level were calculated by applying the Hodges and others (1996) species specific VCFs for Tundra (Northern Pintail VCF = 3.05). For each stratum, the average population estimate was then calculated for 2008-2017. The average Northern Pintail population estimate was assigned to its respective stratum.

*Original data and calculations can be found in the [NOPI_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Northern Pintail Density and Abundance Spatial Layers

- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [NOPI_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [NOPI_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/strata specific) associated with each point estimate, however, we feel that given the scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Northern Pintail.
- 3) Each spatial shapefile of strata where Northern Pintail population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Northern Pintail were counted, [TSA_Strata.shp](#), [BC_Strata.shp](#), [WA_Strata.shp](#), [OR_Strata.shp](#), [CA_Strata.shp](#), [NV_Strata.shp](#), [UT_Strata.shp](#), [MN_Strata.shp](#), [Sandhills_Strata.shp](#), and [ACP_Strata.shp](#) were merged into file [NOPI_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [NOPI_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'NOPI' (with 'Float' as field type), and 'NOPI_Dens' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Northern Pintail breeding population for the temporal range analyzed within that stratum, and Northern Pintail density, respectively).
 - a. Total area of each 'STRATA' was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'NOPI' field from [Strata_Averages](#) tab in the [NOPI_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'NOPI' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'NOPI' = 0 and 'NOPI_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [NOPI_Breeding_Dens_n_Abun.shp](#), can be used to display density of Northern Pintail per square km in each stratum (using the 'NOPI_Dens' field of the attribute table) or abundance of Northern Pintail per stratum (using the 'NOPI' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, and 10×10 km grid scales were explored. Northern Pintail

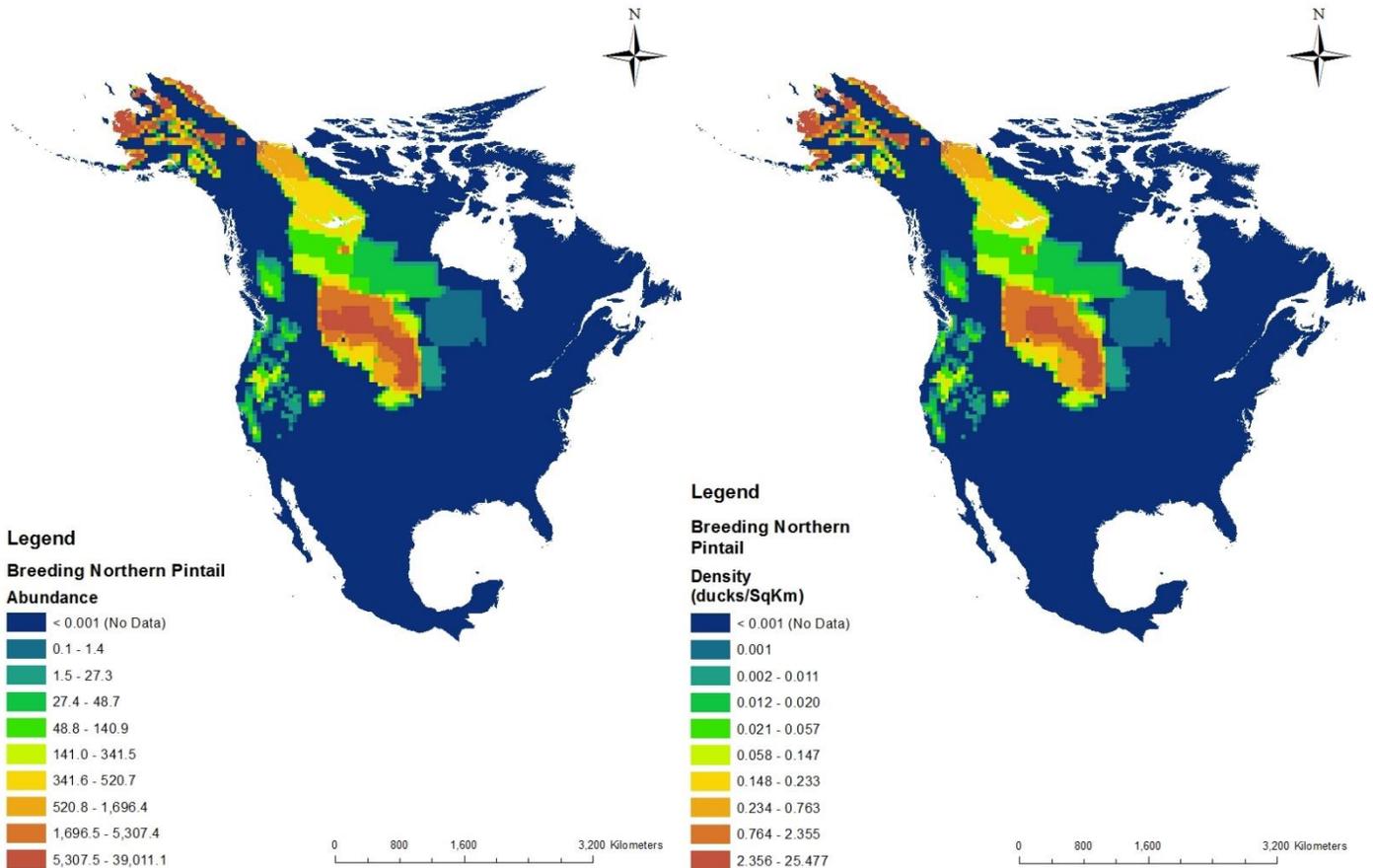
density and abundance estimates at these scales are available as supplemental information upon request).

- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Northern Pintail need to be added as a 'NoData' value in the 'STRATA' field.
- 9) We used the [Erase](#) function to erase the areas covered in the survey ([NOPI_Breeding_Dens_n_Abun.shp](#)) from the shapefile outline of North America (inclusive of Canada and Mexico; [North_America_Boundary.shp](#)) to create a new shapefile, [North_America2.shp](#).
- 10) We then merged [North_America2.shp](#) with [NOPI_Breeding_Dens_n_Abun.shp](#) to create a new file, [NOPI_Breeding_Dens_n_Abun2.shp](#), encompassing continental North America.
- 11) We used the [Edit](#) tool to input 'NoData' in the 'STRATA' field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 12) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 13) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [NOPI_Breeding_Dens_n_Abun2.shp](#) files to create [50_NOPI_Breeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
- 14) Abundance was calculated by multiplying the 'Area_new' field by the 'NOPI_Dens' field using the [Field Calculator](#) tool.
- 15) Next, [50_NOPI_Breeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_NOPI_Breeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
- 16) The final product, [50_NOPI_Breeding2.shp](#) can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Northern Pintail distribution and density during the breeding season for the Traditional Survey Area, Minnesota, and Utah Breeding Waterfowl Surveys.
2. 2006-2017 time period reflects current Northern Pintail distribution and density during the breeding season for the British Columbia Breeding Waterfowl Survey.
3. 2010-2017 time period reflects current Northern Pintail distribution and density during the breeding season for the Washington Breeding Waterfowl Survey.
4. 2002-2016 time period reflects current Northern Pintail distribution and density during the breeding season for the Oregon Breeding Waterfowl Survey.
5. 2001-2017 time period reflects current Northern Pintail distribution and density during the breeding season for the California Breeding Waterfowl Survey.

6. 2010-2016 time period reflects current Northern Pintail distribution and density during the breeding season for the Nevada Breeding Waterfowl Survey.
7. 2003-2005 time period reflects current Northern Pintail distribution and density during the breeding season for the Nebraska Sandhills Survey.
8. 2008-2017 time period reflects current Northern Pintail distribution and density during the breeding season for the Arctic Coastal Plain Survey.
9. All surveys and population estimates are consistent across years and strata within a survey.
10. Missing data will not significantly skew results.
11. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
12. High density and high abundance regions represent geographies of continental significance to breeding Northern Pintail.



Wood Duck (*Aix sponsa*)

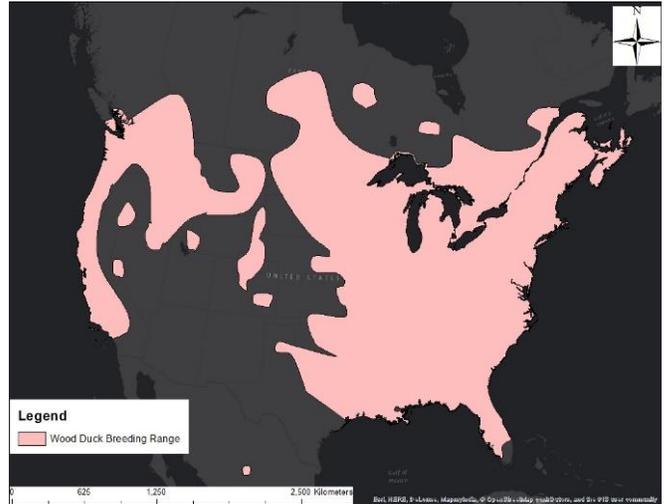
Species Account for Habitat Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Wood Duck during the breeding season. Data from several surveys were used to determine geographies of greatest continental significance to breeding Wood Duck, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Atlantic Flyway Plot Survey

Date Range: 2001-2015

States: Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Virginia

BBS Strata: 3, 4, 9, 10, 11, 12, 13, 16, 18, 22, 23, 24, 26, 27, 28, 99, 24.1, 24.2, 24.3

Missing Data:

2006 DE 4, 10, 99 strata

2009 MA 27 stratum

2013, 2014 MD 24 stratum

2014 NH 99 stratum

Spatial boundary for DE 10 stratum did not exist in the spatial strata

Methods: for each state/stratum (i.e., CT12, MD4, etc.), the average population estimate was calculated for 2001-2015. The average Wood Duck population estimate (excluding missing data) was assigned to its respective stratum.

Washington State Breeding Waterfowl Population Survey

Data Range: 2010-2017

States: Washington

Strata: Chehalis Valley, Hood Canal, South Puget Lowlands, North Puget Lowlands, Dungeness, Irrigated, Potholes, and Highlands

Missing Data:

2010-2011 for Highlands stratum

Methods: For each stratum, the average population estimate was calculated for 2010-2017. The average Wood Duck population estimate (excluding missing data) was assigned to its respective stratum.

Oregon State Breeding Waterfowl Population Survey

Data Range: 2002-2016

States: Oregon

Strata: Forested Wetlands, Lower Columbia River, Northeast Seasonal Marsh, Southeast Seasonal Marsh, and Willamette Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2002-2016. The average Wood Duck population estimate was assigned to its respective stratum.

California Waterfowl Breeding Population Survey

Date Range: 2001-2017

States: California

Strata: 1-Sacramento Valley, 2-Delta, 3-San Joaquin Desert, 4-San Joaquin Grasslands, 5-Suisun Marsh, 6-Napa (w/ Santa Rosa), 9-Northeastern, 10-East Valley, and 11-West Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2017. The average Wood Duck population estimate was assigned to its respective stratum.

British Columbia Central Interior Waterfowl Aerial Survey Program

Date Range: 2006-2017

Provinces: British Columbia

Eco-sections Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, 10-Cariboo Basin

Missing Data: NONE

Methods: For each Eco-section stratum, the average population estimate was calculated for 2007-2015. The average Wood Duck population estimate was assigned to its respective stratum. There were very few accounts of Wood Duck in strata 2, 3, and 10. The other strata had no Wood Duck accounts, in the years they were surveyed.

Nevada Waterfowl Breeding Survey

Date Range: 2010-2016

States: Nevada

Strata: Agriculture and Marsh

Missing Data: NONE

Methods: The survey includes 4 strata: Agriculture, Marsh, Lake/Reservoir, and River. Only two of the strata and their population estimates were used in this analysis due to technical difficulties with strata shapefiles in ArcGIS. For each stratum, the average population estimate was calculated for 2010-2016. The average Wood Duck population estimate was assigned to its respective stratum.

Upper Mississippi River and Great Lakes Region Joint Venture Surveys

Date Range: 2006-2015

States: Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Iowa, Arkansas, Kansas, and Nebraska

BCR Strata: 12, 13, 22, 23, 24

Missing Data: NONE

Methods: For each BCR stratum the average population estimate was not calculated. Instead the Soulliere and others (2017) report provided density estimates for each of the BCR strata. These reported density estimates were calculate based on survey data from 2006-2015. These values were multiplied by BCR strata area to determine average population estimates of breeding Wood Duck for 2006-2015. The average Wood Duck population estimate was assigned to its respective BCR stratum.

Breeding Bird Survey

Date Range: 2001-2015

States: *Continental road side surveys

Strata: BBS strata

Missing Data: NONE

Methods: Population estimates of Wood Duck for regions where this species is not surveyed systematically were provided by Guthrie Zimmerman. For detail on how population estimates were calculated using the BBS data and the Atlantic Flyway Survey data see Zimmerman and others (2017).

*Original data and calculations can be found in the [WODU_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Wood Duck Density and Abundance Spatial Layers

- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [WODU_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [WODU_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/strata specific) associated with each point estimate, however, we feel that given the scale (i.e.,

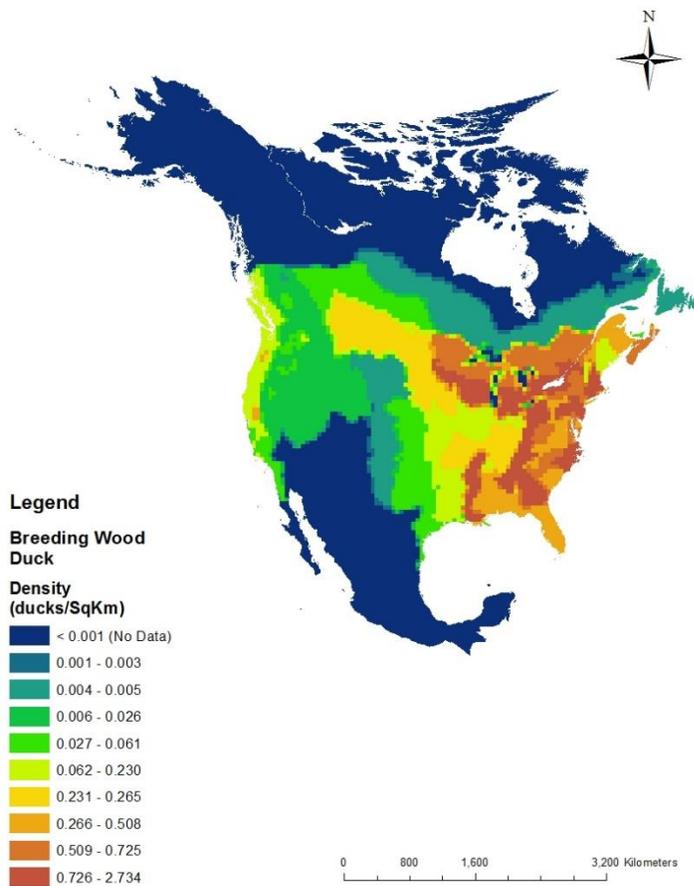
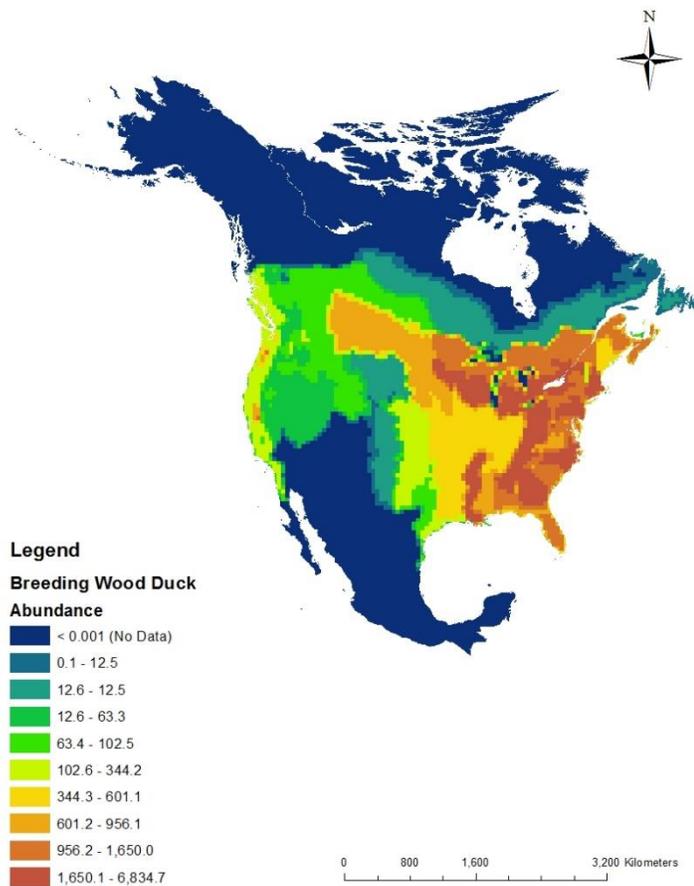
continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Wood Duck.

- 3) Each spatial shapefile of strata where Wood Duck population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Wood Ducks were counted, [AFS_Strata.shp](#), [BC_Strata.shp](#), [WA_Strata.shp](#), [OR_Strata.shp](#), [CA_Strata.shp](#), [NV_Strata.shp](#), [BCR_Strata](#), and [BCR_State_Province_Strata.shp](#) were merged into file [WODU_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [WODU_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'WODU' (with 'Float' as field type), and 'WODU_Dens' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Wood Duck breeding population for the temporal range analyzed within that stratum, and Wood Duck density, respectively).
 - a. Total area of each 'STRATA' was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'WODU' field from [Strata_Averages](#) tab in the [WODU_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'WODU' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'WODU' = 0 and 'WODU_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [WODU_Breeding_Dens_n_Abun.shp](#), can be used to display density of Wood Duck per square km in each stratum (using the 'WODU_Dens' field of the attribute table) or abundance of Wood Duck per stratum (using the 'WODU' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, and 10×10 km grid scales were explored. Wood Duck density and abundance estimates at these scales are available as supplemental information upon request).
- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Wood Ducks need to be added as a 'NoData' value in the 'STRATA' field.
- 9) We used the [Erase](#) function to erase the areas covered in the survey ([WODU_Breeding_Dens_n_Abun.shp](#)) from the shapefile outline of North America (inclusive of Canada and Mexico; [North_America_Boundary.shp](#)) to create a new shapefile, [North_America2.shp](#).
- 10) We then merged [North_America2.shp](#) with [WODU_Breeding_Dens_n_Abun.shp](#) to create a new file, [WODU_Breeding_Dens_n_Abun2.shp](#), encompassing continental North America.

- 11) We used the [Edit](#) tool to input 'NoData' in the 'STRATA' field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 12) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 13) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [WODU_Breeding_Dens_n_Abun2.shp](#) files to create [50_WODU_Breeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
- 14) Abundance was calculated by multiplying the 'Area_new' field by the 'WODU_Dens' field using the [Field Calculator](#) tool.
- 15) Next, [50_WODU_Breeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_WODU_Breeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
- 16) The final product, [50_WODU_Breeding2.shp](#) can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Wood Duck distribution and density during the breeding season for the Atlantic Flyway Survey Area.
2. 2006-2015 time period reflects current Wood Duck distribution and density during the breeding season for the Upper Mississippi River and Great Lakes Region Joint Venture.
3. 2006-2017 time period reflects current Wood Duck distribution and density during the breeding season for the British Columbia Breeding Waterfowl Survey.
4. 2010-2017 time period reflects current Wood Duck distribution and density during the breeding season for the Washington Breeding Waterfowl Survey.
5. 2002-2016 time period reflects current Wood Duck distribution and density during the breeding season for the Oregon Breeding Waterfowl Survey.
6. 2001-2017 time period reflects current Wood Duck distribution and density during the breeding season for the California Breeding Waterfowl Survey.
7. 2010-2016 time period reflects current Wood Duck distribution and density during the breeding season for the Nevada Breeding Waterfowl Survey.
8. BBS data are accurate and analysis performed by G. Zimmerman is consistent with example from Zimmerman and others (2017).
9. All surveys and population estimates are consistent across years and strata within a survey.
10. Missing data will not significantly skew results.
11. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
12. High density and high abundance regions represent geographies of continental significance to breeding Wood Duck.



Scaup Spp. (*Aythya affinis*, *Aythya marila*)

Species Account for Habitat Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution of both species).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Scaup during the breeding season. Data from several surveys were used to determine geographies of greatest continental significance to breeding Scaup, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Traditional Survey Area

Date Range: 2001-2015

Provinces: Manitoba, Saskatchewan, Alberta, and Northwest Territories

States: Alaska, North Dakota, and South Dakota

TSA Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The survey does not differentiate between Scaup species. The average Scaup population estimate was assigned to its respective stratum.

British Columbia Central Interior Waterfowl Aerial Survey Program

Date Range: 2006-2017

Provinces: British Columbia

Eco-sections Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, and 10-Cariboo Basin

Missing Data: NONE

Methods: For each Eco-section stratum, the average population estimate was calculated for 2006-2017. The survey does not differentiate between Scaup species. The average Scaup population estimate was assigned to its respective stratum.

Minnesota Waterfowl Breeding Population Survey

Date Range: 2001-2015

States: Minnesota

Strata: 1-high density of wetlands, 2- medium density of wetlands, and 3- low density of wetlands

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2015. The survey does not differentiate between Scaup species. The average Scaup population estimate was assigned to its respective stratum.

Washington State Breeding Waterfowl Population Survey

Data Range: 2010-2017

States: Washington

Strata: Chehalis Valley, Hood Canal, South Puget Lowlands, North Puget Lowlands, Dungeness, Irrigated, Potholes, and Highlands

Missing Data:

2010-2011 for Highlands stratum

Methods: For each stratum, the average population estimate was calculated for 2010-2017. The survey does not differentiate between Scaup species. The average Scaup population estimate (excluding missing data) was assigned to its respective stratum.

Oregon State Breeding Waterfowl Population Survey

Data Range: 2002-2016

States: Oregon

Strata: Forested Wetlands, Lower Columbia River, Northeast Seasonal Marsh, Southeast Seasonal Marsh, and Willamette Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2002-2016. The survey does not differentiate between Scaup species. The average Scaup population estimate was assigned to its respective stratum.

California Waterfowl Breeding Population Survey

Date Range: 2001-2017

States: California

Strata: 1-Sacramento Valley, 2-Delta, 3-San Joaquin Desert, 4-San Joaquin Grasslands, 5-Suisun Marsh, 6-Napa (w/ Santa Rosa), 9-Northeastern, 10-East Valley, and 11-West Valley

Missing Data: NONE

Methods: For each stratum, the average population estimate was calculated for 2001-2017. Lesser Scaup is the only species surveyed, Greater Scaup is not included in the survey. The average Scaup population estimate was assigned to its respective stratum.

Nevada Waterfowl Breeding Survey

Date Range: 2010-2016

States: Nevada

Strata: Agriculture and Marsh

Missing Data: NONE

Methods: The survey includes 4 strata: Agriculture, Marsh, Lake/Reservoir, and River. Only two of the strata and their population estimates were used in this analysis due to technical difficulties with strata shapefiles in ArcGIS. For each stratum, the average population estimate was calculated for 2010-2016. Lesser Scaup is the only species surveyed, Greater Scaup is not included in the survey. The average Scaup population estimate was assigned to its respective stratum.

Utah Breeding Duck Aerial Survey

Date Range: 2001-2015

States: Utah

Strata: Box Elder, Cache, Davis, Rich, Weber, and GLS total (Counties)

Missing Data: NONE

Methods: The survey is conducted using fixed-wing aircraft. The visibility correction Factor is based on a 1977-1979 study. The survey reports an estimate of Indicated Breeding Birds (IBB) which is then corrected by a species specific VCF of 3.0 and an 'All Species Factor' of 5.06. Population estimates for each year and strata were calculated using original IBB value \times VCF \times Species Factor. For each stratum, the average population estimate was then calculated for 2001-2015. The survey does not differentiate between Scaup species. The average Scaup population estimate was assigned to its respective stratum.

Arctic Coastal Plain Waterfowl Population Survey

Date Range: 2008-2017

States: Alaska

Strata: Stratum 1, Stratum 2, Stratum 3, and Stratum 4

Missing Data: NONE

Methods: Survey results are reported at Indicated Total Birds per strata annually. Population estimates at the strata level were calculated by applying the Hodges and others (1996) species specific VCFs for Tundra (Scaup VCF = 1.93). For each stratum, the average population estimate was then calculated for 2008-2017. The survey does not differentiate between Scaup species. The average Scaup population estimate was assigned to its respective stratum.

*Original data and calculations can be found in the [SCAU_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Scaup Density and Abundance Spatial Layers

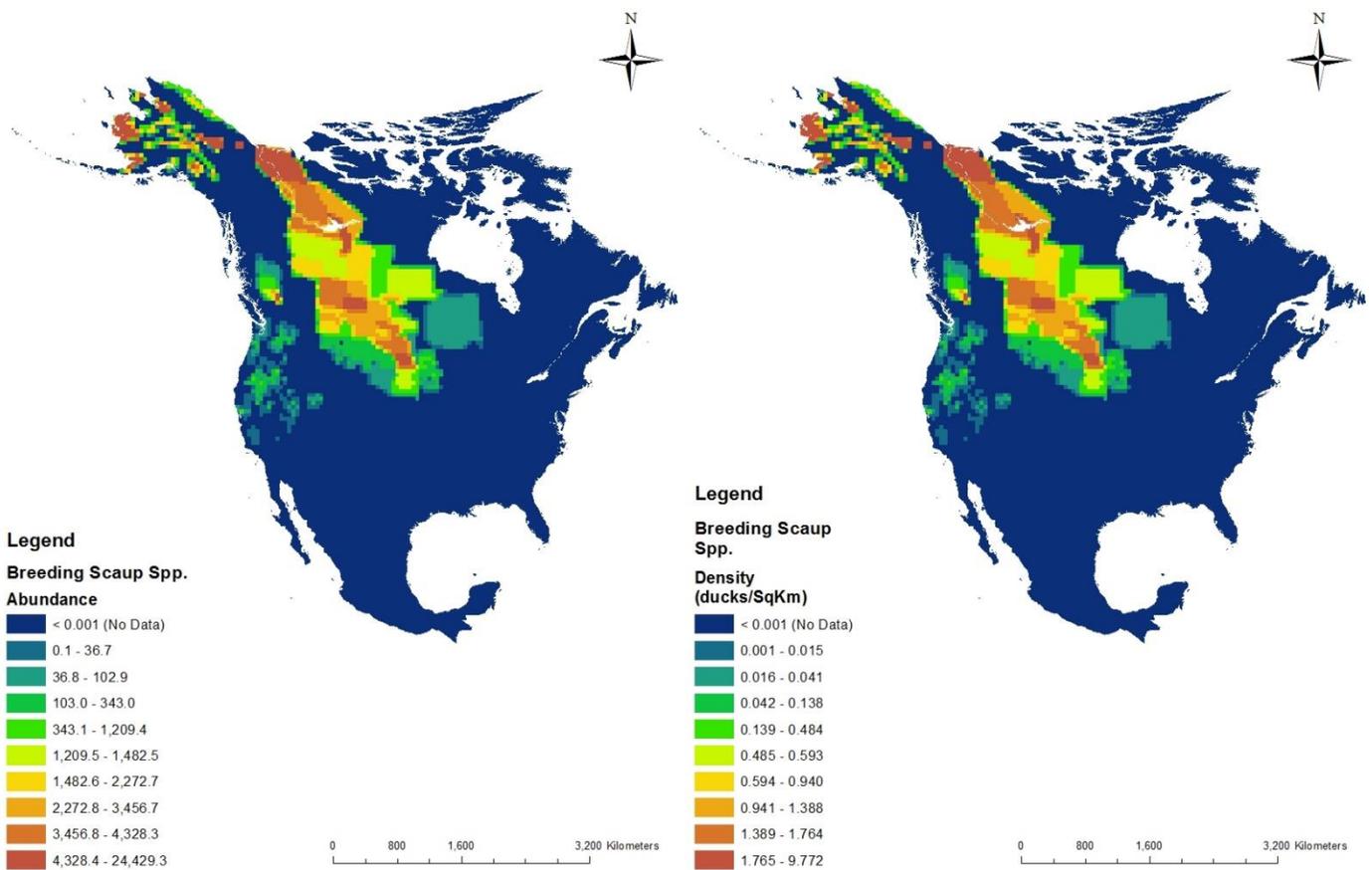
- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [SCAU_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [SCAU_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/stratum specific) associated with each point estimate, however, we feel that given the scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Scaup.
- 3) Each spatial shapefile of strata where Scaup population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Scaup were counted, [TSA_Strata.shp](#), [BC_Strata.shp](#), [WA_Strata.shp](#), [OR_Strata.shp](#), [CA_Strata.shp](#), [NV_Strata.shp](#), [UT_Strata.shp](#), [MN_Strata.shp](#), and [ACP_Strata.shp](#) were merged into file [SCAU_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [SCAU_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'SCAU' (with 'Float' as field type), and 'SCAU_Dens' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Scaup breeding population for the temporal range analyzed within that stratum, and Scaup density, respectively).
 - a. Total area of each 'STRATA' was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'SCAU' field from [Strata_Averages](#) tab in the [SCAU_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'SCAU' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'SCAU' = 0 and 'SCAU_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [SCAU_Breeding_Dens_n_Abun.shp](#), can be used to display density of Scaup per square km in each stratum (using the 'SCAU_Dens' field of the attribute table) or abundance of Scaup per stratum (using the 'SCAU' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, and 10×10 km grid scales were explored. Scaup density and abundance estimates at these scales are available as supplemental information upon request).

- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Scaups need to be added as a 'NoData' value in the 'STRATA' field.
- 9) We used the **Erase** function to erase the areas covered in the survey (**SCAU_Breeding_Dens_n_Abun.shp**) from the shapefile outline of North America (inclusive of Canada and Mexico; **North_America_Boundary.shp**) to create a new shapefile, **North_America2.shp**.
- 10) We then merged **North_America2.shp** with **SCAU_Breeding_Dens_n_Abun.shp** to create a new file, **SCAU_Breeding_Dens_n_Abun2.shp**, encompassing continental North America.
- 11) We used the **Edit** tool to input 'NoData' in the 'STRATA' field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the **Calculate Geometry** function.
- 12) A 50×50 km grid fishnet (**Fishnet_50.shp**) was created using the **Create Fishnet** tool and then clipped to the boundaries of **North_America_Boundary.shp** using the **Clip** tool.
- 13) We then used the **Intersect** tool to intersect **Fishnet_50.shp** and **SCAU_Breeding_Dens_n_Abun2.shp** files to create **50_SCAU_Breeding.shp**. Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the **Calculate Geometry** function in the 'Area_new' field.
- 14) Abundance was calculated by multiplying the 'Area_new' field by the 'SCAU_Dens' field using the **Field Calculator** tool.
- 15) Next, **50_SCAU_Breeding.shp** was dissolved by 'FID_Fishne' field using the **Dissolve** tool to create a new file **50_SCAU_Breeding2.shp**.
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using **Field Calculator** and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
- 16) The final product, **50_SCAU_Breeding2.shp** can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Scaup distribution and density during the breeding season for the Traditional Survey Area, Minnesota, and Utah Breeding Waterfowl Surveys.
2. 2006-2017 time period reflects current Scaup distribution and density during the breeding season for the British Columbia Breeding Waterfowl Survey.
3. 2010-2017 time period reflects current Scaup distribution and density during the breeding season for the Washington Breeding Waterfowl Survey.
4. 2002-2016 time period reflects current Scaup distribution and density during the breeding season for the Oregon Breeding Waterfowl Survey.
5. 2001-2017 time period reflects current Scaup distribution and density during the breeding season for the California Breeding Waterfowl Survey.
6. 2010-2016 time period reflects current Scaup distribution and density during the breeding season for the Nevada Breeding Waterfowl Survey.

7. 2008-2017 time period reflects current Scaup distribution and density during the breeding season for the Arctic Coastal Plain Survey.
8. All surveys and population estimates are consistent across years and strata within a survey.
9. Missing data will not significantly skew results.
10. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
11. High density and high abundance regions represent geographies of continental significance to breeding Scaup.



Dabbling Ground Nesters

American Wigeon (*Anas americana*)

Northern Shoveler (*Spatula clypeata*)

Gadwall (*Anas strepera*)

Green-winged Teal (*Anas carolinensis*)

Blue-winged Teal (Cinnamon Teal) (*Spatula discors* (*Spatula cyanoptera*))

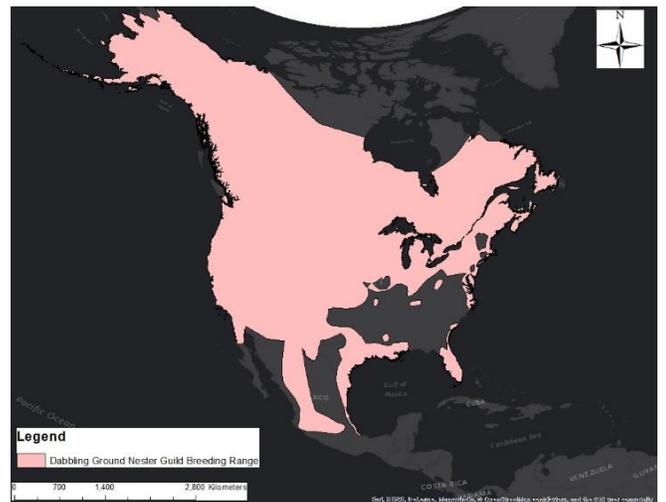
Mottled Duck (*Anas fulvigula*)

Dabbling Ground Nester Guild Account for Habitat Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution for all six species in the group). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to the Dabbling Ground Nester Guild during the breeding season. Data from several surveys were used to determine geographies of greatest continental significance to breeding Dabbling Ground Nesters, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study are described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Traditional Survey Area

Date Range: 2001-2015

Provinces: Manitoba, Saskatchewan, Alberta, and Northwest Territories

States: Alaska, North Dakota, and South Dakota

TSA Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Species Included: American Wigeon, Northern Shoveler, Gadwall, Green-winged Teal, Blue-winged Teal (Cinnamon Teal) *Cinnamon Teal is assumed undifferentiated from Blue-winged Teal during surveys

Missing Data: *Mottled Duck is not surveyed in the TSA because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

Methods: For each stratum the average population estimate was calculated for 2001-2015, by first calculating the average for each species at the strata level and then summing all species within a given stratum. The sum of the values, which is the total estimated population of Dabbling Ground Nesters in the stratum, was assigned to its respective stratum.

Waterfowl Breeding Population and Habitat Survey Eastern Survey Area

Date Range: 2001-2015

Provinces: Ontario, Quebec, Newfoundland and Labrador, New Brunswick, Prince Edward Island, and Nova Scotia

States: Maine

ESA Strata: 51, 52, 53, 54, 55, 56, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Species Included: Green-winged Teal

Missing Data:

Green-winged Teal 2001-2015 for strata 57, 58, 59

*Mottled Duck is not surveyed in the ESA because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida. Northern Shoveler and American Wigeon are not surveyed in the ESA because their breeding range is distributed to the North West (Breeding ranges do not fall within the ESA spatial extent)

**Gadwall and Blue-winged Teal (Cinnamon Teal) are not surveyed in the ESA.

Methods: For each stratum the average population estimate was calculated for 2001-2015. Only Green-winged Teal of the species above are surveyed, and therefore we assume that Green-winged Teal represent the Dabbling Ground Nesting Guild in the Eastern Survey Area. The average Green-winged Teal population estimate was assigned to its respective stratum.

Minnesota Waterfowl Breeding Population Survey

Date Range: 2001-2015

States: Minnesota

Strata: 1-high density of wetlands, 2- medium density of wetlands, and 3- low density of wetlands

Species Included: American Wigeon, Northern Shoveler, Gadwall, Green-winged Teal, Blue-winged Teal (Cinnamon Teal) *Cinnamon Teal is assumed undifferentiated from Blue-winged Teal during surveys

Missing Data:

*Mottled Duck is not surveyed in the Minnesota because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

Methods: For each stratum the average population estimate was calculated for 2001-2015, by first calculating the average for each species at the strata level and then summing all species

within a given stratum. The sum of the values, which is the total estimated population of Dabbling Ground Nesters in the stratum, was assigned to its respective stratum.

Atlantic Flyway Plot Survey

Date Range: 2002-2015

States: Maine, Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Virginia

BBS Strata: 3, 4, 9, 10, 11, 12, 13, 16, 18, 22, 23, 24, 26, 27, 28, 99, 24.1, 24.2, 24.3

Species Included: Gadwall, Green-winged Teal, Blue-winged Teal (Cinnamon Teal)

*Cinnamon Teal is assumed undifferentiated from Blue-winged Teal during surveys

Missing Data:

Green-winged Teal 2006 DE 4,10,99 strata
 2013-2014 MD 24 stratum
 2014 NH 99 stratum

Blue-winged Teal 2006 DE 4,10,99 strata
(Cinnamon Teal) 2009 MA 27 stratum
 2013-2014 MD 24 stratum
 2014 NH 99 stratum

Gadwall 2001 all strata
 2006 DE 4,10,99 strata
 2013-2014 MD 24 stratum
 2014 NH 99 stratum

*Mottled Duck is not surveyed in the AFSA because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida. Northern Shoveler and American Wigeon are not surveyed in the AFSA because their breeding range is distributed to the North West (Breeding ranges do not fall within the AFSA spatial extent)

Methods: The population estimates for species within each stratum from 2001-2015 were summed (each stratum = sum of population estimates for three species). Then the sums were averaged for 2001-2015 for each stratum, where the average represents the Dabbling Ground Nester population estimate for that stratum. We assumed that this value represents the Dabbling Ground Nester guild in the Atlantic Flyway Survey. These values were assigned to their respective state/stratum.

Western Gulf Coast Mottled Duck Survey

Date Range: 2008-2016

States: Texas and Louisiana

WGC Strata: Marsh, Other, Core Marsh, Core Other, Peripheral, LM-Peripheral

Species Included: Mottled Duck (Mexican Duck) *Mexican Duck is assumed undifferentiated from Mottled Duck during surveys.

Missing Data:

2008-2010 LM-Peripheral stratum not surveyed

*Florida Mottled duck currently does not have sufficient mottled duck breeding data to make population estimates for this portion of the specie's range. Additionally, western portions of

Texas are not surveyed for breeding Mexican Duck (possible Mexican Duck range according to NatureServe)

**American Wigeon, Northern Shoveler, Gadwall, Green-winged Teal and Blue-winged Teal (Cinnamon Teal) are not surveyed in the Western Gulf Coast because they are northern breeders and their breeding ranges do not overlap the spatial extent of the survey.

Methods: Average of strata level estimates for all years (for only one species, Mottled Duck (Mexican Duck), where data were available). We acknowledge that there is a standard error (year and strata specific) associated with each point estimate, however, we feel that given the scope of the scale (continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Dabbling Ground Nesters.

Upper Mississippi River and Great Lakes Region Joint Venture Surveys

Date Range: 2006-2015

States: Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Iowa, Arkansas, Kansas, Nebraska

BCR Strata: 12, 13, 22, 23, 24

Species Included: Blue-winged Teal (Cinnamon Teal is not included in this survey, therefore it is not lumped with estimates for BWTE.)

Missing Data: *Mottled Duck is not surveyed in the UMRGLRJV because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

**Northern Shoveler, American Wigeon, Gadwall, and Green-winged Teal breed in very small numbers in this region (about 5% of total breeding ducks), therefore they are not surveyed in the UMRGLRJV (G. Soulliere, personal communication)

Methods: For each BCR stratum, the average population estimate was calculated for 2006-2015. Blue-winged Teal is assumed to be representative of the Dabbling Ground Nester guild in the UMRGLRJV. The average Blue-winged Teal population estimate was assigned to its respective BCR stratum.

Washington State Breeding Waterfowl Population Survey

Data Range: 2010-2017

States: Washington

Strata: Chehalis Valley, Hood Canal, South Puget Lowlands, North Puget Lowlands, Dungeness, Irrigated, Potholes, and Highlands

Species Included: Gadwall, American Wigeon, Northern Shoveler, Green-winged Teal, Blue-winged Teal (Cinnamon Teal) *Cinnamon Teal is assumed undifferentiated from Blue-winged Teal during surveys

Missing Data:

2010-2011 for Highlands stratum

*Mottled Duck is not surveyed in Washington because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

Methods: For each stratum and year the average population estimate was calculated for 2010-2017, by summing the population estimates for all six species. The average (2010-2017) Dabbling Ground Nester population estimate (excluding missing data) was assigned to its respective stratum.

Oregon State Breeding Waterfowl Population Survey

Data Range: 2002-2016

States: Oregon

Strata: Forested Wetlands, Lower Columbia River, Northeast Seasonal Marsh, Southeast Seasonal Marsh, and Willamette Valley

Species Included: Gadwall, American Wigeon, Northern Shoveler, Green-winged Teal, Blue-winged Teal (Cinnamon Teal) *Cinnamon Teal is assumed undifferentiated from Blue-winged Teal during surveys

Missing Data: *Mottled Duck is not surveyed in Oregon because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

Methods: For each stratum the average population estimate was calculated for 2002-2016, by summing the population estimates for all six species. The average (2002-2016) Dabbling Ground Nester population estimate (excluding missing data) was assigned to its respective stratum.

California Waterfowl Breeding Population Survey

Date Range: 2001-2017

States: California

Strata: 1-Sacramento Valley, 2-Delta, 3-San Joaquin Desert, 4-San Joaquin Grasslands, 5-Suisun Marsh, 6-Napa (w/ Santa Rosa), 9-Northeastern, 10-East Valley, and 11-West Valley

Species Included: Gadwall, American Wigeon, Northern Shoveler, Green-winged Teal, Blue-winged Teal (Cinnamon Teal) *Cinnamon Teal is assumed undifferentiated from Blue-winged Teal during surveys

Missing Data: *Mottled Duck is not surveyed in California because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

Methods: For each stratum the average population estimate was calculated for 2001-2017, by summing the population estimates for all six species. The average (2001-2017) Dabbling Ground Nester population estimate (excluding missing data) was assigned to its respective stratum.

Nevada Waterfowl Breeding Survey

Date Range: 2010-2016

States: Nevada

Strata: Agriculture and Marsh

Species Included: Gadwall, American Wigeon, Northern Shoveler, Green-winged Teal, Cinnamon Teal

Missing Data: *Mottled Duck is not surveyed in Nevada because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

**Blue-winged Teal is not surveyed in this survey, possibly because there are few Blue-winged Teal breeding in Nevada.

Green-winged Teal population estimates for all strata in the year 2010.

Methods: The survey includes 4 strata: Agriculture, Marsh, Lake/Reservoir, and River. Only two of the strata and their population estimates were used in this analysis due to technical difficulties with strata shapefiles in ArcGIS. For each stratum, the average population estimate was calculated for 2010-2016, by summing the population estimates for all species per year/stratum and then calculating the average for a stratum (2010-2016).

Utah Breeding Duck Aerial Survey

Date Range: 2001-2015

States: Utah

Strata: Box Elder, Cache, Davis, Rich, Weber, and GLS total (Counties)

Species Included: Gadwall, American Wigeon, Northern Shoveler, Green-winged Teal, Cinnamon Teal

Missing Data: *Mottled Duck is not surveyed in Utah because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

**Blue-winged Teal is not surveyed in this survey, possibly because there are few Blue-winged Teal breeding in Utah.

Methods: For each stratum and year the average population estimate was calculated for 2001-2015, by summing the population estimates for all five species. The average (2001-2015) Dabbling Ground Nester population estimate (excluding missing data) was assigned to its respective stratum.

Arctic Coastal Plain Waterfowl Population Survey

Date Range: 2008-2017

States: Alaska

Strata: Stratum 1, Stratum 2, Stratum 3, and Stratum 4

Species Included: American Wigeon, Northern Shoveler, Green-winged Teal

Missing Data: *Mottled Duck is not surveyed in California because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

**Blue-winged Teal (Cinnamon Teal), and Gadwall are not surveyed in this survey.

Green-winged Teal population estimates for all strata in the year 2010.

Methods: Survey results are reported at Indicated Total Birds per strata annually. Population estimates at the strata level were calculated by applying the Hodges and others (1996) species specific VCFs for Tundra (American Wigeon VCF = 3.04, Northern Shoveler VCF = 3.79, and Green-winged Teal VCF = 8.36). For each stratum, the average population estimate was then calculated for 2008-2017. The average Dabbling Ground Nester population estimate was assigned to its respective stratum.

British Columbia Waterfowl Surveys

Date Range: 2006-2017

Provinces: British Columbia

Eco-sections Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, and 10-Cariboo Basin

Species Included: American Wigeon, Northern Shoveler, Gadwall, Green-winged Teal, Blue-winged Teal (Cinnamon Teal) *Cinnamon Teal is differentiated in these state surveys, however for consistency, population estimates for Blue-winged Teal and Cinnamon Teal were summed.

Missing Data:

American Wigeon	2010-2012 for stratum 6
Blue-Winged Teal	2013-2014, 2016-2017 for stratum 6
Cinnamon Teal	2006, 2009-2013, 2015, 2017 for stratum 1
	2008 for stratum 2
	2009-2010, 2017 for stratum 3
	2017 for stratum 5
	2007-2009, 2011, 2014, 2016 for stratum 6
	2012, 2015, 2017 for stratum 7

Gadwall	2006-2007, 2009-2012, 2014-2017 for stratum 1 2008-2010, 2015-2017 for stratum 2 2008-2009, 2011, 2015, 2017 for stratum 3 2008, 2012-2014, 2016-2017 for stratum 5 2007-2008, 2010-2014, 2016 for stratum 6 2006, 2008, 2010, 2012-2017 for stratum 7
Northern Shoveler	2006-2007, 2009, 2011 for stratum 1 2010 for stratum 2 2006, 2010, 2017 for stratum 6

*Mottled Duck is not surveyed in the British Columbia because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

Methods: For each stratum and year the average population estimate was calculated for 2006-2017, by summing the population estimates for all six species. The average (2006-2017) Dabbling Ground Nester population estimate (excluding missing data) was assigned to its respective stratum.

Nebraska Sandhills Survey

Date Range: 2003-2005

States: Nebraska

Strata: Sandhills

Species Included: Northern Shoveler, Gadwall, Blue-winged Teal (Cinnamon Teal is undifferentiated in this survey)

Missing Data:

*Mottled Duck is not surveyed in this region because it is a non-migratory duck that breeds and winters in the Western Gulf Coast and peninsular Florida.

**American Wigeon and Green-winged Teal are not surveyed in this survey because they are northern breeders and their breeding ranges do not overlap the spatial extent of the survey.

Methods: For each stratum the average population estimate was calculated for 2003-2005, by summing the population estimates for all three species. The average (2003-2005) Dabbling Ground Nester population estimate (excluding missing data) was assigned to the only stratum in the survey.

*Original data and calculations can be found in the

[DabblingGroundNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Dabbling Ground Nester Density and Abundance Spatial Layers

- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [DabblingGroundNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [DabblingGroundNester_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and

state/strata specific) associated with each point estimate, however, we feel that given the scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Dabbling Ground Nester.

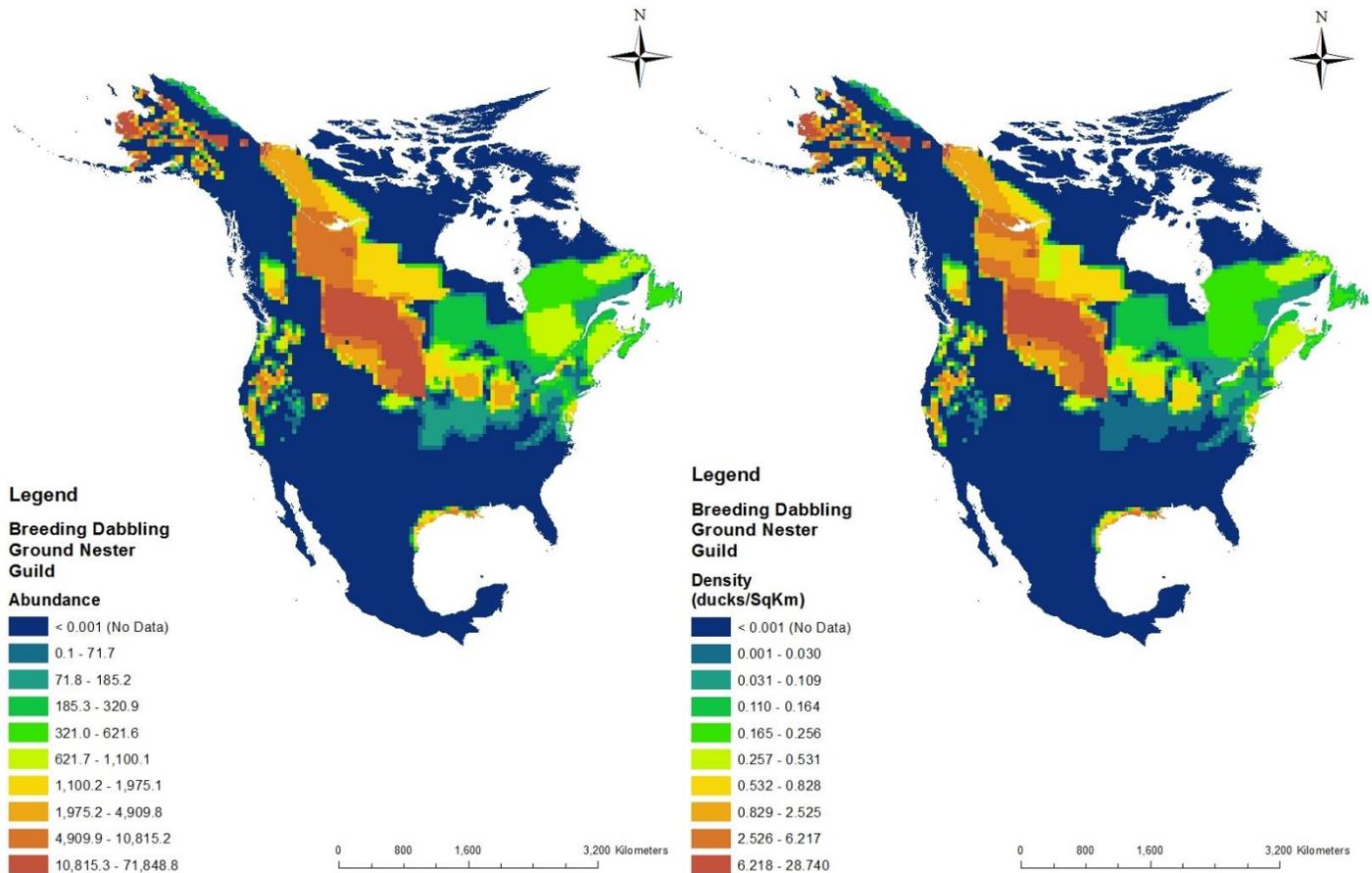
- 3) Each spatial shapefile of strata where Dabbling Ground Nester population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Dabbling Ground Nesters were counted, [TSA_Strata.shp](#), [ESA_Strata.shp](#), [BC_Strata.shp](#), [WA_Strata.shp](#), [OR_Strata.shp](#), [CA_Strata.shp](#), [NV_Strata.shp](#), [UT_Strata.shp](#), [MN_Strata.shp](#), [AFS_Strata.shp](#), [WGC_Strata.shp](#), [BCR_Strata.shp](#), [Sandhills_Strata.shp](#), and [ACP_Strata.shp](#) were merged into file [DabbGrN_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [DabbGrN_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'DabbG' (with 'Float' as field type), and 'DabbG_Dens' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Dabbling Ground Nester breeding population for the temporal range analyzed within that stratum, and Dabbling Ground Nester density, respectively).
 - a. Total area of each 'STRATA' was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'DabbG' field from [Strata_Averages](#) tab in the [DabblingGroundNester_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'DabbG' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'DabbG' = 0 and 'DabbG_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [DabbGrN_Breeding_Dens_n_Abun.shp](#), can be used to display density of Dabbling Ground Nester per square km in each stratum (using the 'DabbG_Dens' field of the attribute table) or abundance of Dabbling Ground Nesters per stratum (using the 'DabbG' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, and 10×10 km grid scales were explored. Dabbling Ground Nester density and abundance estimates at these scales are available as supplemental information upon request).
- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Dabbling Ground Nesters need to be added as a 'NoData' value in the 'STRATA' field.
- 9) We used the [Erase](#) function to erase the areas covered in the survey ([DabbGrN_Breeding_Dens_n_Abun.shp](#)) from the shapefile outline of North America

- (inclusive of Canada and Mexico; [North_America_Boundary.shp](#)) to create a new shapefile, [North_America2.shp](#).
- 10) We then merged [North_America2.shp](#) with [DabbGrN_Breeding_Dens_n_Abun.shp](#) to create a new file, [DabbGrN_Breeding_Dens_n_Abun2.shp](#), encompassing continental North America.
 - 11) We used the [Edit](#) tool to input 'NoData' in the 'STRATA' field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
 - 12) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
 - 13) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [DabbGrN_Breeding_Dens_n_Abun2.shp](#) files to create [50_DabbGrN_Breeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - 14) Abundance was calculated by multiplying the 'Area_new' field by the 'DabbG_Dens' field using the [Field Calculator](#) tool.
 - 15) Next, [50_DabbGrN_Breeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_DabbGrN_Breeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
 - 16) The final product, [50_DabbGrN_Breeding2.shp](#) can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Dabbling Ground Nester distribution and density during the breeding season in the Traditional Survey Area, Eastern Survey Area (represented by Green-winged Teal only), Utah, and Minnesota state Breeding Waterfowl Surveys.
2. 2008-2016 time period reflects current Mottled Duck distribution and density during the breeding season in the Western Gulf Coast.
3. 2006-2015 time period reflects current Blue-winged Teal distribution and density during the breeding season in the UMGLRJV. Blue-winged Teal represents the Dabbling Ground Nester guild in this region.
4. 2006-2017 time period reflects current Dabbling Ground Nester distribution and density during the breeding season in British Columbia.
5. 2003-2005 time period reflects current Dabbling Ground Nester distribution and density during the breeding season in the Sandhills of Nebraska.
6. 2008-2017 time period reflect current Dabbling Ground Nester distribution and density during the breeding season in the Arctic Coastal Plain.
7. 2010-2017 time period reflect current Dabbling Ground Nester distribution and density during the breeding season in Washington state.

8. 2002- 2016 time period reflect current Dabbling Ground Nester distribution and density during the breeding season in Oregon state.
9. 2001-2017 time period reflect current Dabbling Ground Nester distribution and density during the breeding season in California state.
10. 2010-2016 time period reflect current Dabbling Ground Nester distribution and density during the breeding season in Nevada state.
11. 2002-2015 time period reflect current Dabbling Ground Nester distribution and density during the breeding season in the Atlantic Flyway Breeding Survey.
1. All surveys and population estimates are consistent across years and strata within a survey.
2. Missing data will not significantly skew results.
3. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
4. High-density regions represent geographies of continental significance to breeding Dabbling Ground Nesters



Diving Cavity Nesters

Bufflehead (*Bucephala albeola*)

Goldeneye Spp. (*Bucephala islandica*, *Bucephala clangula*)

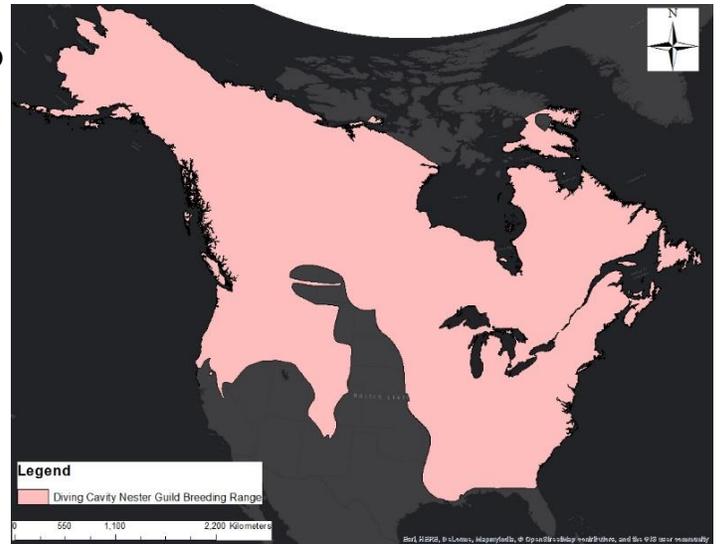
Merganser Spp. (*Mergus serrator*, *Mergus merganser*, *Lophodytes cucullatus*)

Diving Cavity Nester Guild Account for Habitat Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution for all three species/Spp. in the group). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to the Diving Cavity Nester Guild during the breeding season. Data from several surveys were used to determine geographies of greatest continental significance to breeding Diving Cavity Nesters, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Traditional Survey Area

Date Range: 2001-2015

Provinces: Manitoba, Saskatchewan, Alberta, and Northwest Territories

States: Alaska, North Dakota, and South Dakota

TSA Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Species Included: Bufflehead and Goldeneye (undifferentiated)

Missing Data: Merganser Species.

Methods: For each stratum the average population estimate was calculated for 2001-2015, by first calculating the average for each species at the strata level and then summing all species within a given stratum. The sum of the values, which is the total estimated population of Diving Cavity Nesters in the stratum, was assigned to its respective stratum.

Waterfowl Breeding Population and Habitat Survey Eastern Survey Area

Date Range: 2001-2015

Provinces: Ontario, Quebec, Newfoundland and Labrador, New Brunswick, Prince Edward Island, and Nova Scotia

States: Maine

ESA Strata: 51, 52, 53, 54, 55, 56, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Species Included: Merganser (undifferentiated) and Goldeneye (undifferentiated)

Missing Data: Bufflehead

Merganser 2001-2015 for strata 57, 58, 59

Goldeneye 2001-2015 for strata 57, 58, 59

Methods: For each stratum the average population estimate was calculated for 2001-2015, by summing the Merganser and Goldeneye population estimates. The average Diving Cavity Nester population estimate was assigned to its respective stratum.

British Columbia Waterfowl Surveys

Date Range: 2006-2017

Provinces: British Columbia

Eco-sections Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, and 10-Cariboo Basin

Species Included: Bufflehead, Goldeneye (undifferentiated), and Merganser (undifferentiated)

Missing Data:

Merganser 2006, 2009 for stratum 7

Methods: For each stratum the average population estimate was calculated for 2006-2017, by summing the population estimates for all three species. The average (2006-2017) Diving Cavity Nester population estimate (excluding missing data) was assigned to its respective stratum.

Washington State Breeding Waterfowl Population Survey

Data Range: 2010-2017

States: Washington

Strata: Chehalis Valley, Hood Canal, South Puget Lowlands, North Puget Lowlands, Dungeness, Irrigated, Potholes, and Highlands

Species Included: Bufflehead, Goldeneye (undifferentiated), Common Merganser, Hooded Merganser

Missing Data: Red-breasted Merganser

2010-2011 for Highlands stratum (all species)

Methods: For each stratum the average population estimate was calculated for 2010-2017, by summing the population estimates for all four species. The average (2010-2017) Diving Cavity Nester population estimate (excluding missing data) was assigned to its respective stratum.

Oregon State Breeding Waterfowl Population Survey

Data Range: 2002-2016

States: Oregon

Strata: Forested Wetlands, Lower Columbia River, Northeast Seasonal Marsh, Southeast Seasonal Marsh, and Willamette Valley

Species Included: Bufflehead, Goldeneye (undifferentiated), Common Merganser, Hooded Merganser

Missing Data: Red-breasted Merganser

Methods: For each stratum the average population estimate was calculated for 2002-2016, by summing the population estimates for all four species. The average (2002-2016) Diving Cavity Nester population estimate (excluding missing data) was assigned to its respective stratum.

California Waterfowl Breeding Population Survey

Date Range: 2001-2017

States: California

Strata: 1-Sacramento Valley, 2-Delta, 3-San Joaquin Desert, 4-San Joaquin Grasslands, 5-Suisun Marsh, 6-Napa (w/ Santa Rosa), 9-Northeastern, 10-East Valley, 11-West Valley

Species Included: Bufflehead, Common Goldeneye, Common Merganser

Missing Data: Burrow's Goldeneye, Hooded Merganser, Red-breasted Merganser

Methods: For each stratum the average population estimate was calculated for 2001-2017, by summing the population estimates for all three species. The average (2001-2017) Diving Cavity Nester population estimate (excluding missing data) was assigned to its respective stratum.

Nevada Waterfowl Breeding Survey

Date Range: 2010-2016

States: Nevada

Strata: Agriculture and Marsh

Species Included: Bufflehead, Hooded Merganser, Common Merganser, Common Goldeneye

Missing Data: Burrow's Goldeneye, Red-breasted Merganser

Hooded Merganser 2010, 2011, 2012, 2016 for all strata

Common Goldeneye 2012, 2016 for all strata

Bufflehead 2012 for all strata

Methods: The survey includes 4 strata: Agriculture, Marsh, Lake/Reservoir, and River. Only two of the strata and their population estimates were used in this analysis due to technical difficulties with strata shapefiles in ArcGIS. For each stratum, the average population estimate was calculated for 2010-2016, by summing the population estimates for all species per year/strata and then calculating the average for a stratum (2010-2016). The average Diving Cavity Nester population estimate was assigned to its respective stratum.

Minnesota Waterfowl Breeding Population Survey

Date Range: 2001-2015

States: Minnesota

Strata: 1-high density of wetlands, 2- medium density of wetlands, and 3- low density of wetlands

Species Included: Bufflehead, Goldeneye (undifferentiated), Hooded Merganser, Large Merganser (assumed Red-breasted and Common Merganser undifferentiated)

Missing Data: NONE

Methods: For each stratum the average population estimate was calculated for 2001-2015, by first calculating the average for each species at the strata level and then summing all species within a given stratum. The sum of the values, which is the total estimated population of Diving Cavity Nesters in the stratum, was assigned to its respective stratum.

Atlantic Flyway Plot Survey

Date Range: 2002-2015

States: Maine, Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia

BBS Strata: 3, 4, 9, 10, 11, 12, 13, 16, 18, 22, 23, 24, 26, 27, 28, 99, 24.1, 24.2, 24.3

Species Included: Hooded Merganser, Common Merganser

Missing Data: Goldeneye (undifferentiated), Bufflehead, and Red-breasted merganser

Common Merganser 2006 DE 4,10,99 strata
2013-2014 MD 24 stratum
2014 NH 99 stratum

Hooded Merganser 2006 DE 4,10,99 strata
2013-2014 MD 24 stratum
2014 NH 99 stratum
2013 VA 99 stratum
2013 VT 13, 18, 27 strata
2001-2004, 2006-2007, 2009-2013, 2015 VT 28 stratum

Methods: The population estimates for species within each stratum from 2001-2015 were summed (each stratum = sum of population estimates for two species). Then the sums were averaged for the 2001-2015 time frame for each stratum, where the average represents the Diving Cavity Nester population estimate for that stratum. We assumed that this value represents the Diving Cavity Nester guild in the Atlantic Flyway Survey. These values were assigned to their respective state/stratum.

Arctic Coastal Plain Waterfowl Population Survey

Date Range: 2008-2017

States: Alaska

Strata: Stratum 1, Stratum 2, Stratum 3, and Stratum 4

Species Included: Red-breasted Merganser

Missing Data: Goldeneye species, Bufflehead, Hooded and Common Merganser

Methods: Survey results are reported at Indicated Total Birds per strata annually. Population estimates at the strata level were calculated by applying the Hodges and others (1996) species specific VCFs for Tundra (Red-breasted Merganser VCF = 1.27). For each stratum, the average population estimate was then calculated for 2008-2017. The average Diving Cavity Nester (represented by Red-breasted Merganser) population estimate was assigned to its respective stratum.

*Original data and calculations can be found in the [DivingCavityNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Diving Cavity Nester Density and Abundance Spatial Layers

- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [DivingCavityNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [DivingCavityNester_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/strata specific) associated with each point estimate, however, we feel that given the scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Diving Cavity Nesters.
- 3) Each spatial shapefile of strata where Diving Cavity Nester population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Diving Cavity Nesters were counted, [TSA_Strata.shp](#), [ESA_Strata.shp](#), [BC_Strata.shp](#), [WA_Strata.shp](#), [OR_Strata.shp](#), [CA_Strata.shp](#), [NV_Strata.shp](#), [MN_Strata.shp](#), [AFS_Strata.shp](#) and [ACP_Strata.shp](#) were merged into file [DivinCaN_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [DivinCaN_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'DivinC' (with 'Float' as field type), and 'DivinC_Dens' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Diving Cavity Nester breeding population for the temporal range analyzed within that stratum, and Diving Cavity Nester density, respectively).
 - a. Total area of each 'STRATA' was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'DivinC' field from [Strata_Averages](#) tab in the [DivingCavityNester_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'DivinC' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'DivinC' = 0 and 'DivinC_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [DivinCaN_Breeding_Dens_n_Abun.shp](#), can be used to display density of Diving Cavity Nesters per square km in each stratum (using the 'DivinC_Dens' field of the attribute table) or abundance of Diving Cavity Nesters per stratum (using the 'DivinC' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, and 10×10 km grid scales were explored. Diving Cavity Nester

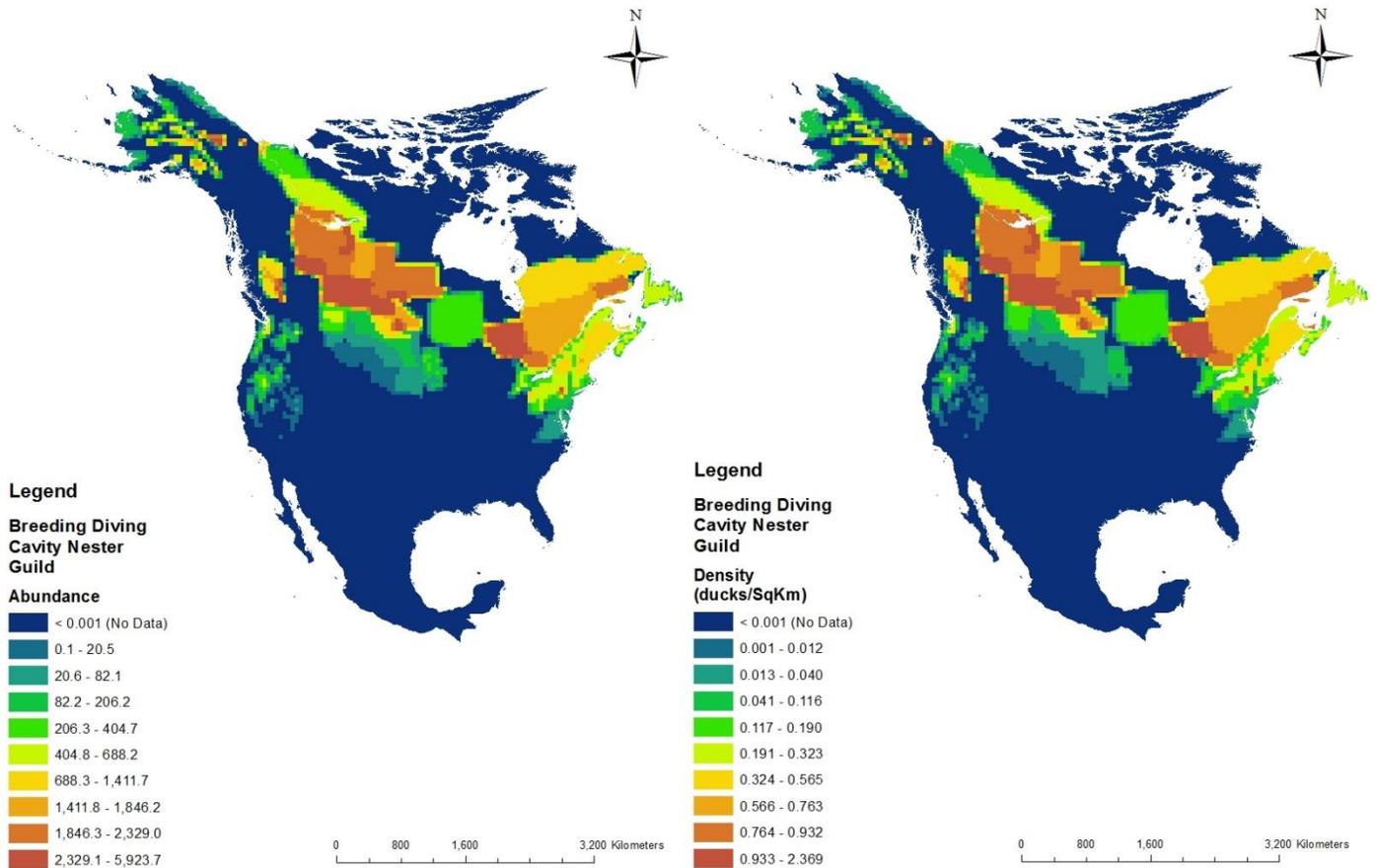
density and abundance estimates at these scales are available as supplemental information upon request).

- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Diving Cavity Nesters need to be added as a 'NoData' value in the 'STRATA' field.
- 9) We used the [Erase](#) function to erase the areas covered in the survey ([DivinCaN_Breeding_Dens_n_Abun.shp](#)) from the shapefile outline of North America (inclusive of Canada and Mexico; [North_America_Boundary.shp](#)) to create a new shapefile, [North_America2.shp](#).
- 10) We then merged [North_America2.shp](#) with [DivinCaN_Breeding_Dens_n_Abun.shp](#) to create a new file, [DivinCaN_Breeding_Dens_n_Abun2.shp](#), encompassing continental North America.
- 11) We used the [Edit](#) tool to input 'NoData' in the 'STRATA' field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 12) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 13) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [DivinCaN_Breeding_Dens_n_Abun2.shp](#) files to create [50_DivinCaN_Breeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
- 14) Abundance was calculated by multiplying the 'Area_new' field by the 'DivinC_Den' field using the [Field Calculator](#) tool.
- 15) Next, [50_DivinCaN_Breeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_DivinCaN_Breeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
- 16) The final product, [50_DivinCaN_Breeding2.shp](#) can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Diving Cavity Nester distribution and density during the breeding season in the Traditional Survey Area, the Eastern Survey Area and in Minnesota.
2. 2006-2017 time period reflect current Diving Cavity Nester distribution and density during the breeding seasons in British Columbia.
3. 2010-2017 time period reflect current Diving Cavity Nester distribution and density during the breeding season in Washington state.
4. 2002-2016 time period reflect current Diving Cavity Nester distribution and density during the breeding season in Oregon state.
5. 2001-2017 time period reflect current Diving Cavity Nester distribution and density during the breeding season in California state.

6. 2010-2016 time period reflect current Diving Cavity Nester distribution and density during the breeding season in Nevada state.
7. 2002-2015 time period reflect current Diving Cavity Nester distribution and density during the breeding season in the Atlantic Flyway Survey.
8. 2008-2017 time period reflect current Diving Cavity Nester distribution and density during the breeding season in the Arctic Coastal Plain.
9. All surveys and population estimates are consistent across years and states within a survey.
10. Missing data or not surveyed states will not significantly skew results.
11. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
12. High-density regions represent geographies of continental significance to breeding Diving Cavity Nesters.



Diving Overwater Nesters

Redhead (*Aythya americana*)

Ring-necked duck (*Aythya collaris*)

Canvasback (*Aythya valisineria*)

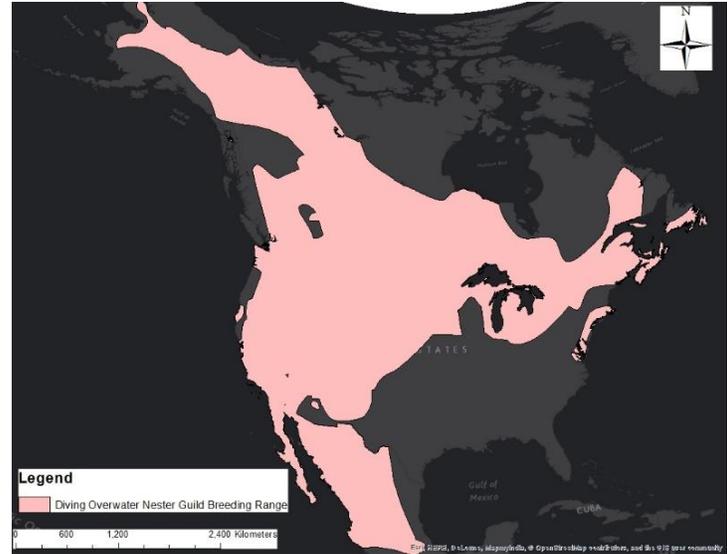
Ruddy Duck (*Oxyura jamaicensis*)

Diving Overwater Nester Guild Account for Habitat Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution for all four species in the group). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to the Diving Overwater Nester Guild during the breeding season. Data from several surveys were used to determine geographies of greatest continental significance to breeding Diving Overwater Nesters, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Traditional Survey Area

Date Range: 2001-2015

Provinces: Manitoba, Saskatchewan, Alberta, and Northwest Territories

States: Alaska, North Dakota, and South Dakota

TSA Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Species Included: Canvasback, Ring-necked Duck, Ruddy Duck, Redhead

Missing Data: NONE

Methods: For each stratum the average population estimate was calculated for 2001-2015, by first calculating the average (2001-2015) for each species at the stratum level and then summing all species within a given stratum. The sum of the values, which is the total estimated population of Diving Overwater Nesters in the stratum, was assigned to its respective stratum.

Waterfowl Breeding Population and Habitat Survey Eastern Survey Area

Date Range: 2001-2015

Provinces: Ontario, Quebec, Newfoundland and Labrador, New Brunswick, Prince Edward Island, and Nova Scotia

States: Maine

ESA Strata: 51, 52, 53, 54, 55, 56, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Species Included: Ring-necked Duck

Missing Data: Canvasback, Redhead, Ruddy Duck

Ring-necked Duck 2001-2015 for strata 57, 58, 59

Methods: For each stratum the average population estimate was calculated for 2001-2015, for the Ring-necked Duck. The average Diving Overwater Nester population (represented by the Ring-necked Duck) estimate was assigned to its respective stratum.

British Columbia Waterfowl Surveys

Date Range: 2006-2017

Provinces: British Columbia

Ecoregions Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, and 10-Cariboo Basin

Species Included: Canvasback, Ring-necked Duck, Ruddy Duck, Redhead

Missing Data:

Canvasback 2006-2009, 2011-2017 for stratum 1

2007-2017 for stratum 2

2006-2017 for strata 3, 5, 6, 7

2008, 2010-2017 for stratum 9

Redhead 2006-2017 for strata 1, 5, 6, 7

2007-2017 for stratum 2

2006-2015, 2017 for stratum 3

2006, 2008-2009, 2011-2015, 2017 for stratum 9

Ruddy Duck 2006-2013, 2016-2017 for stratum 1

2007-2017 for stratum 2

2006-2012, 2014-2017 for stratum 3

2007-2017 for stratum 5

2006, 2008, 2010-2014 for stratum 6

2006-2010, 2012-2016 for stratum 7

2012-2013 for stratum 9

Methods: For each stratum the average population estimate was calculated for 2006-2017, by summing the population estimates for all four species. The average (2006-2017) Diving Overwater Nester population estimate (excluding missing data) was assigned to its respective stratum.

Washington State Breeding Waterfowl Population Survey

Data Range: 2010-2017

States: Washington

Strata: Chehalis Valley, Hood Canal, South Puget Lowlands, North Puget Lowlands, Dungeness, Irrigated, Potholes, and Highlands

Species Included: Canvasback, Ring-necked Duck, Ruddy Duck, Redhead

Missing Data:

2010-2011 for Highlands stratum (all species)

Methods: For each stratum the average population estimate was calculated for 2010-2017, by summing the population estimates for all four species. The average (2010-2017) Diving Overwater Nester population estimate (excluding missing data) was assigned to its respective stratum.

Oregon State Breeding Waterfowl Population Survey

Data Range: 2002-2016

States: Oregon

Strata: Forested Wetlands, Lower Columbia River, Northeast Seasonal Marsh, Southeast Seasonal Marsh, and Willamette Valley

Species Included: Canvasback, Ring-necked Duck, Ruddy Duck, Redhead

Missing Data: NONE

Methods: For each stratum the average population estimate was calculated for 2002-2016, by summing the population estimates for all four species. The average (2002-2016) Dabbling Overwater Nester population estimate (excluding missing data) was assigned to its respective stratum.

California Waterfowl Breeding Population Survey

Date Range: 2001-2017

States: California

Strata: 1-Sacramento Valley, 2-Delta, 3-San Joaquin Desert, 4-San Joaquin Grasslands, 5-Suisun Marsh, 6-Napa (w/ Santa Rosa), 9-Northeastern, 10-East Valley, and 11-West Valley

Species Included: Canvasback, Ring-necked Duck, Ruddy Duck, Redhead

Missing Data: NONE

Methods: For each stratum the average population estimate was calculated for 2001-2017, by summing the population estimates for all four species. The average (2001-2017) Diving Overwater Nester population estimate (excluding missing data) was assigned to its respective stratum.

Nevada Waterfowl Breeding Survey

Date Range: 2010-2016

States: Nevada

Strata: Agriculture and Marsh

Species Included: Canvasback, Ring-necked Duck, Ruddy Duck, Redhead

Missing Data:

Ruddy Duck 2013 for Agriculture stratum

Canvasback 2013 for Agriculture stratum

Methods: The survey includes 4 strata: Agriculture, Marsh, Lake/Reservoir, and River. Only two of the strata and their population estimates were used in this analysis due to technical difficulties with strata shapefiles in ArcGIS. For each stratum, the average population estimate was calculated for 2010-2016, by summing the population estimates for all species per year/stratum and then calculating the average for a stratum (2010-2016). The average Diving Overwater Nester population estimate (excluding missing data) was assigned to its respective stratum.

Utah Breeding Duck Aerial Survey

Date Range: 2001-2015

States: Utah

Strata: Box Elder, Cache, Davis, Rich, Weber, and GLS total (Counties)

Species Included: Canvasback, Ruddy Duck, Redhead

Missing Data: Ring-necked Duck

Methods: For each stratum the average population estimate was calculated for 2001-2015, by summing the population estimates for all three species. The average (2001-2015) Dabbling Overwater Nester population estimate (excluding missing data) was assigned to its respective stratum.

Minnesota Waterfowl Breeding Population Survey

Date Range: 2001-2015

States: Minnesota

Strata: 1-high density of wetlands, 2- medium density of wetlands, and 3- low density of wetlands

Species Included: Canvasback, Ring-necked Duck, Ruddy Duck, Redhead

Missing Data: NONE

Methods: For each stratum the average population estimate was calculated for 2001-2015, by first calculating the average for each species at the strata level and then summing all species within a given stratum. The sum of the values, which is the total estimated population of Diving Overwater Nesters in the stratum, was assigned to its respective stratum.

Upper Mississippi River and Great Lakes Region Joint Venture Surveys

Date Range: 2006-2015

States: Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Iowa, Arkansas, Kansas, and Nebraska

BCR Strata: 12, 13, 22, 23, 24

Species Included: Ring-necked Duck

Missing Data: Ruddy Duck, Redhead, Canvasback

Methods: For each BCR stratum, the average population estimate was calculated for 2006-2015. Ring-necked Duck is assumed to be representative of the Dabbling Overwater Nester guild in the UMRGLRJV. The average Ring-necked Duck population estimate was assigned to its respective BCR strata.

*Original data and calculations can be found in the [DivingOverwaterNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Diving Overwater Nester Density and Abundance Spatial Layers

- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [DivingOverwaterNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [DivingOverwaterNester_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/strata specific) associated with each point estimate, however, we feel that given the scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Diving Overwater Nesters.
- 3) Each spatial shapefile of strata where Diving Overwater Nester population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Diving Overwater Nesters were counted, [TSA_Strata.shp](#), [ESA_Strata.shp](#), [BC_Strata.shp](#), [WA_Strata.shp](#), [OR_Strata.shp](#), [CA_Strata.shp](#), [NV_Strata.shp](#), [UT_Strata.shp](#), [MN_Strata.shp](#), and [BCR_Strata.shp](#) were merged into file [DivinOvN_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [DivinOvN_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'DivinO' (with 'Float' as field type), and 'DivinO_Den' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Diving Overwater Nester breeding population for the temporal range analyzed within that stratum, and Diving Overwater Nester density, respectively).
 - a. Total area of each 'STRATA' was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'DivinO' field from [Strata_Averages](#) tab in the [DivingOverwaterNester_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'DivinO' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'DivinO' = 0 and 'DivinO_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [DivinOvN_Breeding_Dens_n_Abun.shp](#), can be used to display density of Diving Overwater Nesters per square km in each stratum (using the 'DivinO_Dens' field of the attribute table) or abundance of Diving Overwater Nesters per stratum (using the 'DivinO' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and

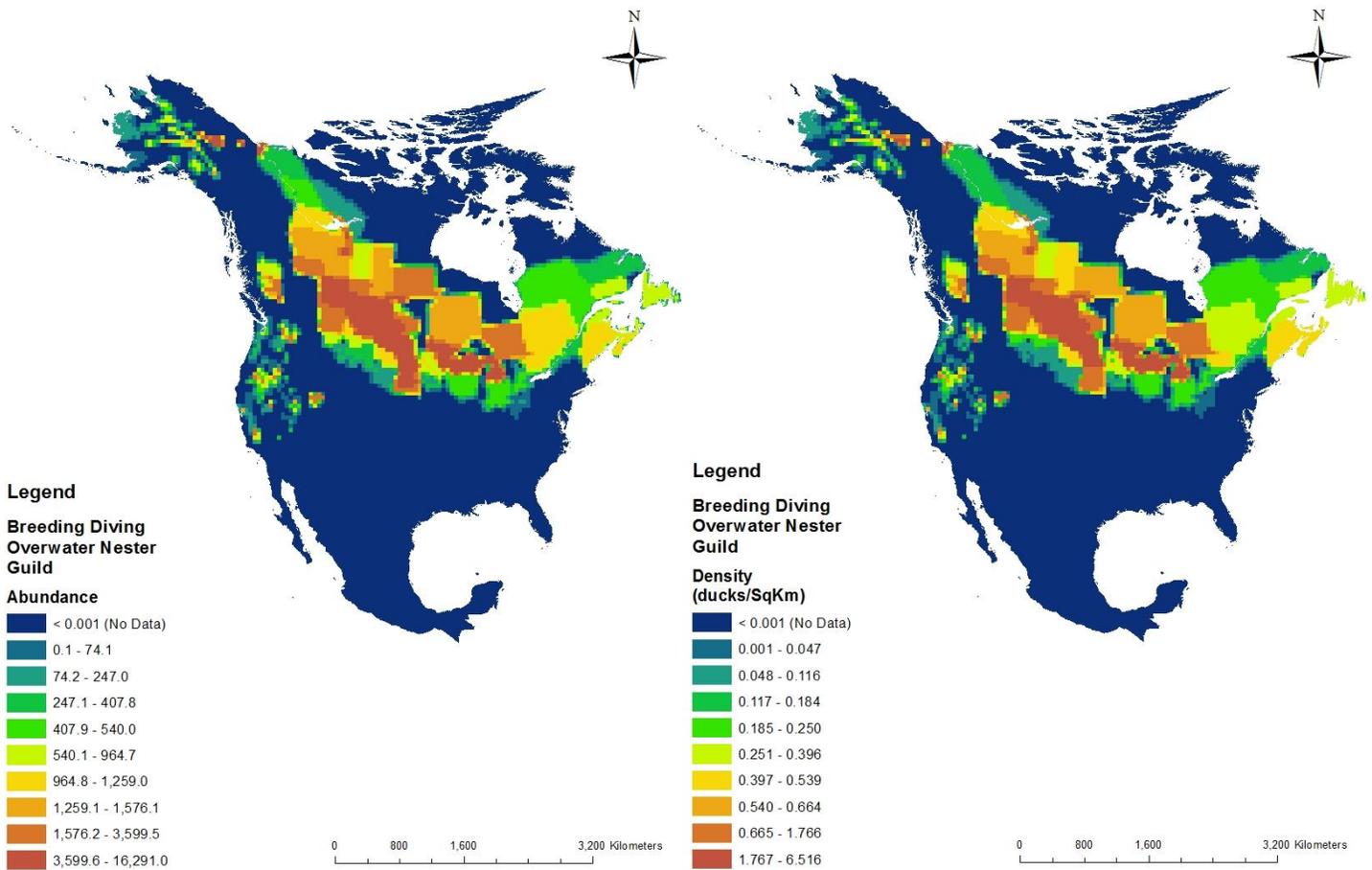
abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, and 10×10 km grid scales were explored. Diving Overwater Nester density and abundance estimates at these scales are available as supplemental information upon request).

- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Diving Overwater Nesters need to be added as a 'NoData' value in the 'STRATA' field.
- 9) We used the **Erase** function to erase the areas covered in the survey (**DivinOvN_Breeding_Dens_n_Abun.shp**) from the shapefile outline of North America (inclusive of Canada and Mexico; **North_America_Boundary.shp**) to create a new shapefile, **North_America2.shp**.
- 10) We then merged **North_America2.shp** with **DivinOvN_Breeding_Dens_n_Abun.shp** to create a new file, **DivinOvN_Breeding_Dens_n_Abun2.shp**, encompassing continental North America.
- 11) We used the **Edit** tool to input 'NoData' in the 'STRATA' field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the **Calculate Geometry** function.
- 12) A 50×50 km grid fishnet (**Fishnet_50.shp**) was created using the **Create Fishnet** tool and then clipped to the boundaries of **North_America_Boundary.shp** using the **Clip** tool.
- 13) We then used the **Intersect** tool to intersect **Fishnet_50.shp** and **DivinOvN_Breeding_Dens_n_Abun2.shp** files to create **50_DivinOvN_Breeding.shp**. Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the **Calculate Geometry** function in the 'Area_new' field.
- 14) Abundance was calculated by multiplying the 'Area_new' field by the 'DivinO_Den' field using the **Field Calculator** tool.
- 15) Next, **50_DivinOvN_Breeding.shp** was dissolved by 'FID_Fishne' field using the **Dissolve** tool to create a new file **50_DivinOvN_Breeding2.shp**.
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using **Field Calculator** and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
- 16) The final product, **50_DivinOvN_Breeding2.shp** can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Diving Overwater Nester distribution and density during the breeding season in the Traditional Survey Area, the Eastern Survey Area, Utah and in Minnesota.
2. 2006-2017 time period reflect current Diving Overwater Nester distribution and density during the breeding seasons in British Columbia.
3. 2010-2017 time period reflect current Diving Overwater Nester distribution and density during the breeding season in Washington state.
4. 2002-2016 time period reflect current Diving Overwater Nester distribution and density during the breeding season in Oregon state.

5. 2001-2017 time period reflect current Diving Overwater Nester distribution and density during the breeding season in California state.
6. 2010-2016 time period reflects current Diving Overwater Nester distribution and density during the breeding season in Nevada state.
7. 2006-2015 time period reflects current Diving Overwater Nester distribution and density during the breeding season in the UMGLRJV.
8. All surveys and population estimates are consistent across years and states within a survey.
9. Missing data or not surveyed states will not significantly skew results.
10. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
11. High-density regions represent geographies of continental significance to breeding Diving Overwater Nesters



Diving Ground Nesters

Eider Spp. (*Somateria mollissima*, *S. fischeri*, *S. spectabilis*, *Polysticta stelleri*)

Scoter Spp. (*Melanitta americana*, *M. perspicillata*, *M. fusca*)

Long-tailed Duck (*Clangula hyemalis*)

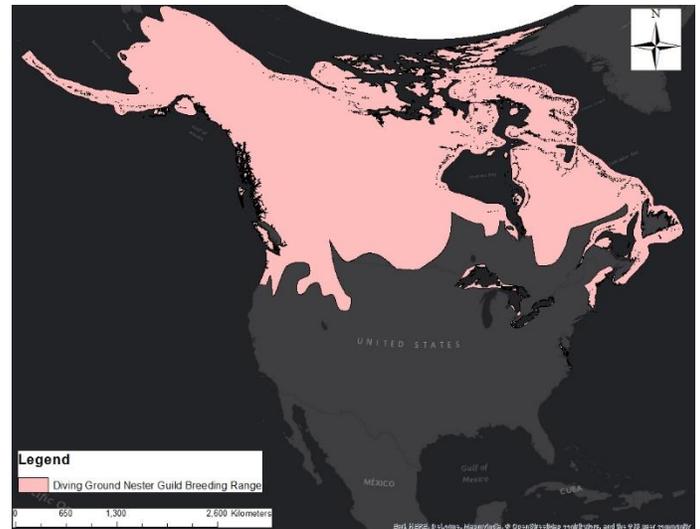
Harlequin Duck (*Histrionicus histrionicus*)

Diving Ground Nester Guild Account for Habitat Planning in the Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Breeding Distribution:

Breeding (Inclusive of Breeding Distribution AND Permanent Resident Distribution for all three species in the group). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to the Diving Ground Nester Guild during the breeding season. Data from several surveys were used to determine geographies of greatest continental significance to breeding Diving Ground Nesters, they are listed below. Because survey methods and analytical methods for population estimation differ for some surveys, the process for determining population estimates at the strata level for this study is described in the methods section of each survey. Note that some surveys are not available for all years, while others exclude certain strata during some survey years. These missing data are acknowledged, but disregarded in the analysis because they were not considered to have a critical impact on the final products of this study. Sources of the survey data and contact persons are listed in the Metadata Report (Supplement 7).

Breeding Range Surveys Used in Analysis

Waterfowl Breeding Population and Habitat Survey Traditional Survey Area

Date Range: 2001-2015

Provinces: Manitoba, Saskatchewan, Alberta, and Northwest Territories

States: Alaska, North Dakota, and South Dakota

TSA Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Species Included: Long-tailed Duck, Generic Scoter (undifferentiated)

Missing Data: Harlequin Duck, Eider Spp. for all strata

Scoter Spp. 2002 for stratum 36
 2005 for stratum 7
 2013 for strata 1, 6, 20

Long-tailed Duck 2002 for stratum 36
 2005 for stratum 7
 2013 for strata 1, 6, 20

Methods: For each stratum the average population estimate was calculated for 2001-2015, by first multiplying the total indicated birds by the strata-specific expansion factor and then multiplying by the species-specific (Tundra or Boreal) visibility correction factor (Hodges and others, 1996). Then the average across 2001-2015 was calculated by species at the strata level. Finally, the average per stratum for each species was summed within a given stratum and that sum, which is the total estimated population of Diving Ground Nesters in the stratum, was assigned to its respective stratum.

Waterfowl Breeding Population and Habitat Survey Eastern Survey Area

Date Range: 2001-2007

Provinces: Ontario, Quebec, Newfoundland and Labrador, New Brunswick, Prince Edward Island, and Nova Scotia

States: Maine

ESA Strata: 51, 52, 53, 54, 55, 56, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Species Included: Long-tailed Duck, Generic Scoter (undifferentiated)

Missing Data: Harlequin Duck, Eider Spp. for all strata

Scoter Spp. 2001-2002 for strata 58, 59, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72
 2003 for strata 57, 58, 59, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72
 2004-2006 for strata 58, 59, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72
 2007 for strata 55, 58, 59, 70, 71, 72

Long-tailed Duck 2001-2002 for strata 58, 59, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72
 2003 for strata 57, 58, 59, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72
 2004-2006 for strata 58, 59, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72
 2007 for strata 55, 58, 59, 70, 71, 72

Methods: For each stratum the average population estimate was calculated for 2001-2007, by first multiplying the total indicated birds by the strata-specific expansion factor and then multiplying by the species-specific (Tundra or Boreal) visibility correction factor (Hodges and others, 1996). Then the average across 2001-2007 was calculated by species at the strata level. Finally, the average per stratum for each species was summed within a given stratum and that sum, which is the total estimated population of Diving Ground Nesters in the stratum, was assigned to its respective stratum.

Arctic Coastal Plain Waterfowl Population Survey

Date Range: 2008-2017

States: Alaska

Strata: Stratum 1, Stratum 2, Stratum 3, and Stratum 4

Species Included: Long-tailed Duck, King Eider, Common Eider, Spectacled Eider, Steller Eider, Surf Scoter, Black Scoter, White-winged Scoter

Missing Data: Harlequin Duck

Methods: Survey results are reported at Indicated Total Birds per stratum annually. Population estimates at the stratum level were calculated by applying the Hodges and others (1996) species specific VCFs for Tundra (Eider VCF = 3.58, Scoter VCF = 1.17, Long-tailed Duck VCF = 1.87). For each stratum, the average population estimate was then calculated for 2008-2017. The averages were summed across species and the average Diving Ground Nester (excluding missing data) population estimate was assigned to its respective stratum.

Aerial Scoter and Scaup Monitoring Survey of the Yukon Flats, Alaska

Date Range: 2008-2017

States: Alaska

Strata: West, East, South Central, and North Central

Species Included: White-winged Scoter, Surf Scoter

Missing Data: Eider Spp., Long-tailed Duck, Harlequin Duck, Black Scoter

Methods: Population estimates for each species surveyed (2) were derived from annual reports for each stratum for the years 2008-2017. The average for each species for each stratum was calculated for the time frame 2008-2017. The averages of the two species were summed and the total average population estimate (represented by White-winged and Surf Scoter) for Diving Ground Nesters was assigned to each stratum, respectively.

Pacific Black Scoter Breeding Survey

Date Range: 2004-2012

States: Alaska

Strata: Bristol Bay High, Bristol Bay Low, YKD High, YKD Low, Seward Peninsula, Selawik

Species Included: Black Scoter

Missing Data: Surf Scoter, White-winged Scoter, Eider Spp. Long-tailed Duck, Harlequin Duck

Methods: The population estimates for Black Scoter from 2004 to 2012 were reported as the average per stratum across this time frame in the report. Estimates were copied and assigned to their respective stratum. These population averages represent the Diving Ground Nesting Guild in coastal Alaska.

Alaska's Yukon-Kuskokwim Delta Coast Aerial Waterfowl Survey

Data Range: 2001-2016

States: Alaska

Strata: *All strata were combined into one area, the YKD strata

Species Included: Spectacled Eider, Common Eider, Black Scoter, Long-Tailed Duck

Missing Data: 2011 for all species

Methods: Survey results are reported as a Population Index per stratum annually. Population estimates at the stratum level were calculated by applying the Hodges and others (1996) species specific VCFs for Tundra (Eider VCF = 3.58, Scoter VCF = 1.17, Long-tailed Duck VCF = 1.87). For each stratum, the average population estimate was then calculated for 2001-2016. The averages were summed across species and the average Diving Ground Nester (excluding missing data) population estimate was assigned to the stratum.

British Columbia Waterfowl Surveys

Date Range: 2006-2017

Provinces: British Columbia

Eco-sections Strata: 1-Babine Upland, 2-Bulkley Basin, 3-Nechako Lowland, 5-Nazco Upland, 6-Quesnel Lowland, 7-Western Chilcotin Upland, 9-Chilcotin Plateau, and 10-Cariboo Basin

Species Included: Scoter Spp. (undifferentiated)

Missing Data: Eider Spp., Long-tailed Duck, Harlequin Duck

Scoter Spp. 2016 for stratum 1
2013, 2016 for stratum 2
2010 for stratum 5
2006-2010, 2015 for stratum 6
2006-2013, 2015-2017 for stratum 7
2007, 2009-2010 for stratum 9

Methods: For each stratum the average population estimate was calculated for 2006-2017. The average (2006-2017) Diving Ground Nester population estimate (excluding missing data) was assigned to its respective stratum.

Canadian Central and Eastern Arctic Survey

Date Range: 2005-2011

Provinces:

Strata: A, AP, B, Banks1, Banks2, Banks3, Banks4, BB, C, CP, D, K, KP, KW, P, QL, QM, RL, T, TA, TP, V, W, BIC, BIN, BIS, CIN, CIS, CIW, SHIB, SHIBE, SHIBEAR, SHIC, SHIEB, SHIELL, SHIH, SHII, and SHIK

Species Included: King Eider, Common Eider, Long-Tailed Duck, Scoter Spp. (undifferentiated)

Missing Data: Harlequin Duck, Spectacled Eider, Steller Eider (*some strata were surveyed inconsistently)

Methods: Values for species are reported as Population Index rather than a population estimate. For each species population index was converted to population estimate using species specific VCFs for Tundra (Eider VCF = 3.58, Scoter VCF = 1.17, and Long-tailed Duck VCF = 1.87; Hodges and others, 1996; Conant and others, 1991). Population estimates across all species were then summed at the stratum level and total population estimate for Diving Ground Nesters was assigned to its respective stratum.

*Original data and calculations can be found in the [DivingGroundNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet, available as supplemental data within the geodatabase.

Developing Diving Ground Nester Density and Abundance Spatial Layers

- 1) Original survey data (listed above, various sources cited in Supplement 7) and the data formatting methods that are used to calculate strata specific estimates are stored in [DivingGroundNester_Breeding_Pop_Estimates](#) Microsoft Excel Worksheet. ArcGIS was used as the platform for all data analysis and calculations described below.
- 2) An average population estimate for state/strata level for all years (where data were available) was calculated according to methods described above and stored in [Strata_Averages](#) tab in the [DivingGroundNester_Breeding_Pop_Estimates](#) Excel file. Standard error was disregarded. We acknowledge that there is a standard error (year and state/strata specific) associated with each point estimate, however, we feel that given the

scale (i.e., continental) this error becomes irrelevant at altering the spatial extent of geographically significant regions for breeding Diving Ground Nesters.

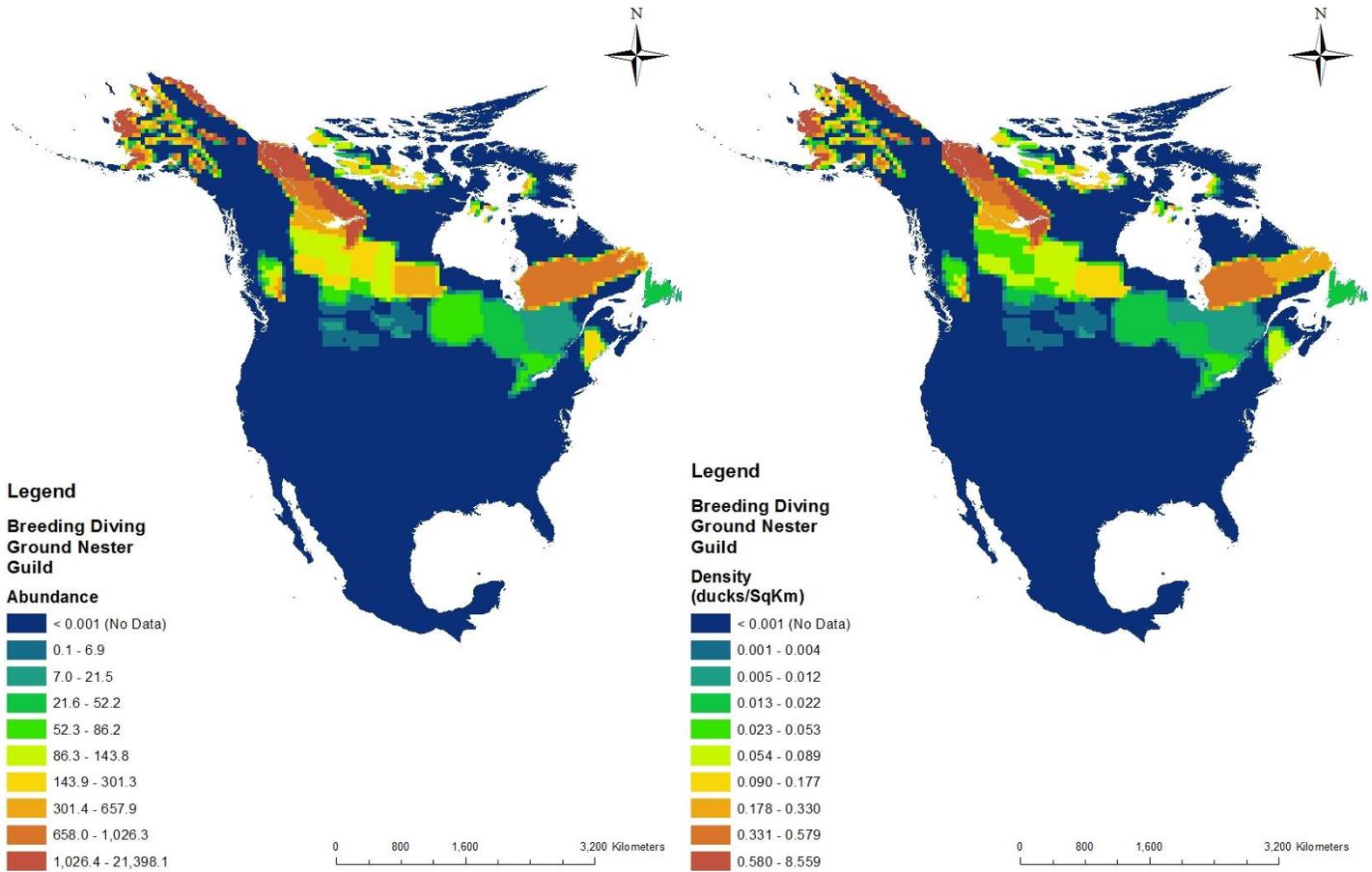
- 3) Each spatial shapefile of strata where Diving Ground Nester population estimates are available must have a 'STRATA' field and be in the same coordinate system (Projected: North_American_Albers_Equal_Area_Conic and Geographic: GCS_North_American_1983). Shapefiles of strata associated with surveys where Diving Ground Nesters were counted, [ACP_Strata.shp](#), [BC_Strata.shp](#), [BLSC_Survey_Strata.shp](#), [YF_Strata.shp](#), [YKD_Strata.shp](#), [CenCAArctic_Strata.shp](#), [ESA_Strata.shp](#), [TSA_Strata.shp](#), and [EasCAArctic_Strata.shp](#) were merged into file [DivinGrN_Breeding_Dens_n_Abun.shp](#). (Shapefiles of strata associated with each survey were provided by the same source as the survey data, see Supplement 7)
- 4) In the attribute table of [DivinGrN_Breeding_Dens_n_Abun.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'DivinG' (with 'Float' as field type), and 'DivinG_Dens' (with 'Float' as field type) were added. (These represent, area of strata in square kilometers, average Diving Ground Nester breeding population for the temporal range analyzed within that stratum, and Diving Ground Nester density, respectively).
 - a. Total area of each 'STRATA' was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Population estimates for each stratum were copied and pasted in the 'DivinG' field from [Strata_Averages](#) tab in the [DivingGroundNester_Breeding_Pop_Estimates](#) Excel file using the editor toolbar in ArcGIS.
 - c. Density was calculated using the [Field Calculator](#) tool by dividing 'DivinG' field by 'Area_sqkm' field.
- 5) All rows in the attribute table where 'DivinG' = 0 and 'DivinG_Dens' = 0 were excluded (i.e., deleted) from further analysis (*these strata were either not surveyed or do not have population estimates from the original data source).
- 6) The resulting spatial layer, [DivinGrN_Breeding_Dens_n_Abun.shp](#), can be used to display density of Diving Ground Nesters per square km in each stratum (using the 'DivinG_Dens' field of the attribute table) or abundance of Diving Ground Nesters per stratum (using the 'DivinG' field of the attribute table).
- 7) However, the PLC felt that it was important to standardize all spatial layers for comparable visual products and a consensus was reached that 50×50 km grid (of conterminous North America) would be an appropriate scale to report density and abundance of waterfowl. (*other resolution levels, including Joint Venture scale, BCR scale, 500×500, 250×250, and 10×10 km grid scales were explored. Diving Ground Nester density and abundance estimates at these scales are available as supplemental information upon request).
- 8) To calculate density and abundance at the 50×50 km grid scale, areas that were not surveyed or have no observed breeding Diving Ground Nesters need to be added as a 'NoData' value in the 'STRATA' field.
- 9) We used the [Erase](#) function to erase the areas covered in the survey ([DivinGrN_Breeding_Dens_n_Abun.shp](#)) from the shapefile outline of North America (inclusive of Canada and Mexico; [North_America_Boundary.shp](#)) to create a new shapefile, [North_America2.shp](#).

- 10) We then merged [North_America2.shp](#) with [DivinGrN_Breeding_Dens_n_Abun.shp](#) to create a new file, [DivinGrN_Breeding_Dens_n_Abun2.shp](#), encompassing continental North America.
- 11) We used the [Edit](#) tool to input 'NoData' in the 'STRATA' field in the attribute table of the new file where appropriate and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 12) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 13) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [DivinGrN_Breeding_Dens_n_Abun2.shp](#) files to create [50_DivinGrN_Breeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Abundance' (with a 'Float' type). Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
- 14) Abundance was calculated by multiplying the 'Area_new' field by the 'DivinG_Den' field using the [Field Calculator](#) tool.
- 15) Next, [50_DivinGrN_Breeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_DivinGrN_Breeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Abundance' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Abunda' by field 'SUM_Area_n'
- 16) The final product, [50_DivinGrN_Breeding2.shp](#) can be used to display breeding density (ducks/km²) and abundance (number of ducks) at the 50×50 km for North America (visuals of both products are below).

Assumptions:

1. 2001-2015 time period reflects current Diving Ground Nester distribution and density during the breeding season in the Traditional Survey Area.
2. 2001-2007 timer period reflects current Diving Ground Nester distribution and density during the breeding season in the Eastern Survey Area
3. 2008-2017 time period reflects current Diving Ground Nester distribution and density during the breeding season in the Arctic Coastal Plain and In the Yukon Flats of Alaska.
4. 2004-2012 time period reflects current Diving Ground Nester distribution and density during the breeding season in Coastal Alaska (YKD).
5. 2001-2016 time period reflects current Diving Ground Nester distribution and density during the breeding season in the Yukon-Kuskokwim Delta.
6. 2006-2017 time period reflects current Diving Ground Nester distribution and density during the breeding season in British Columbia.
7. 2005-2011 time period reflects current Diving Ground Nester distribution and density during the breeding season in the Canadian Central and Eastern Arctic.
8. Harlequin Duck was only counted in two surveys, and these represented too little data to include in identifying geographies of significance for breeding Diving Ground Nester distribution and density.
9. All surveys and population estimates are consistent across years and states within a survey.
10. Missing data or not surveyed states will not significantly skew results.

11. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
12. High-density regions represent geographies of continental significance to breeding Dabbling Ground Nester.



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Supplement 2.

Developing Spatial Layers of Duck Use Days for Non-Breeding Ducks

Non-Breeding Range

Mallard (*Anas platyrhynchos*)

Species Account for Habitat Planning in Non-Breeding Range

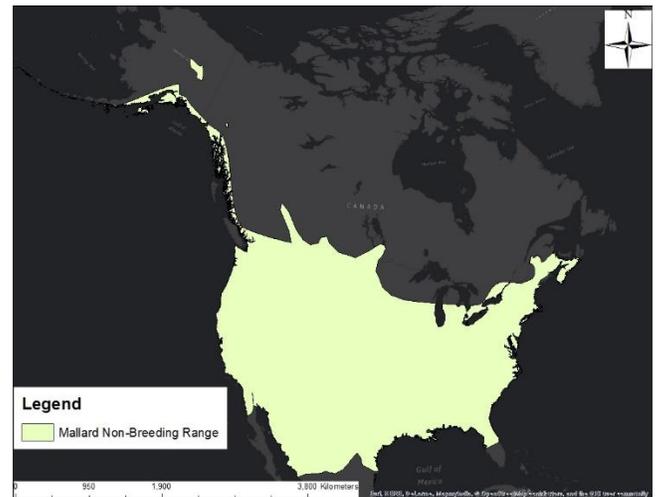
Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Mallards during the non-breeding season. Ducks Unlimited provided Duck Use Days (DUD) data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others, 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

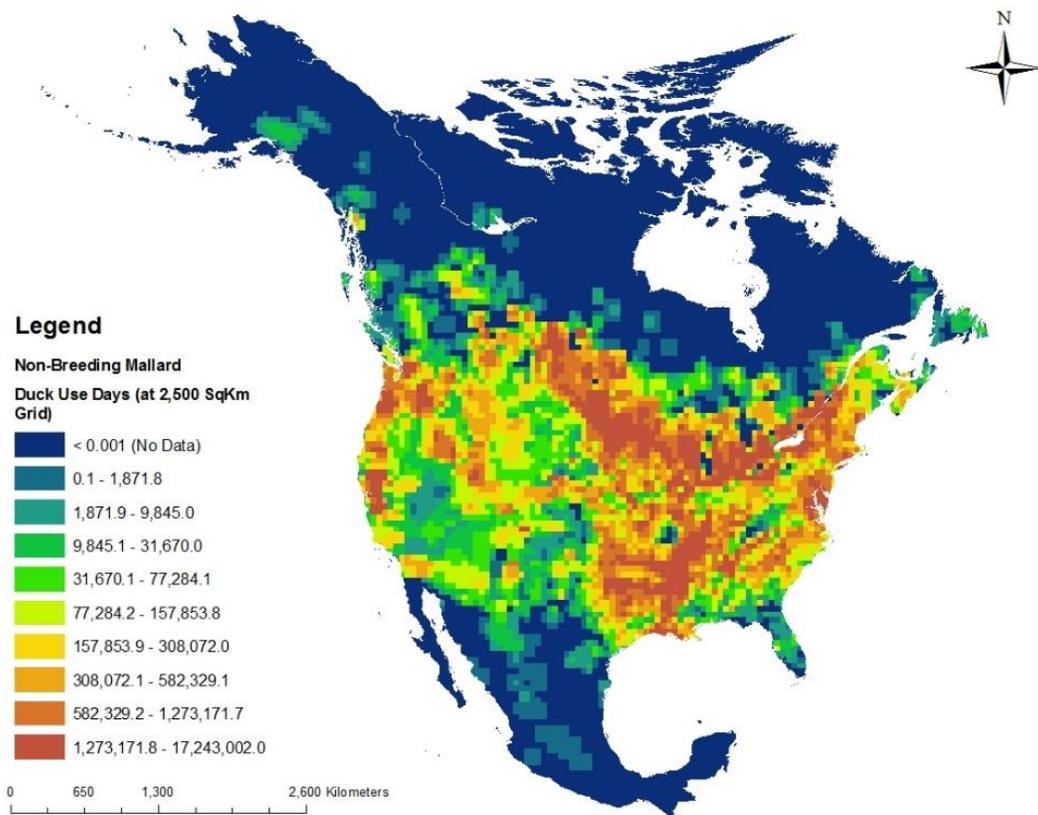
Developing Mallard Duck Use Days Spatial Layers

- 1) Original data were provided by DU as two ArcGIS Shapefiles, [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Mexico and Canada. Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as MALL within [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#) were exported to two new files [MALL_Non_Breeding_DUD.shp](#) and [MALL_non_Breeding_DUD_mex.shp](#), respectively.

- 3) Next, the [MALL_Non_Breeding_DUD.shp](#) and [MALL_Non_Breeding_DUD_mex.shp](#), were merged using the [Merge](#) function to create one spatial layer, [MALL_Non_Breeding_DUD2.shp](#).
- 4) In the attribute table of [MALL_Non_Breeding_DUD2.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and Mallard DUD density, respectively).
 - a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing 'LTAPop' (DUD calculation based on the Long-Term Average Population) field by 'Area_sqkm' field.
- 5) To calculate Mallard DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a 'NoData' value in the 'fips' field (fips = county ID or grid block ID).
- 6) We used the [Erase](#) function to erase the areas of [MALL_Non_Breeding_DUD2.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
- 7) We then merged [North_America2.shp](#) with [MALL_Non_Breeding_DUD2.shp](#) to create a new file, [MALL_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
- 8) We used the [Edit](#) tool to input 'NoData' in the 'fips' field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 9) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 10) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [MALL_Non_Breeding_DUD_Final.shp](#) files to create [50_MALL_NonBreeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Total_DUD' (with a 'Float' type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - b. Total of DUD was calculated by multiplying the 'Area_new' field by the 'DUD_Dens' field using the [Field Calculator](#) tool.
- 11) Next, [50_MALL_NonBreeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_MALL_NonBreeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Total_DUD' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Total_' by field 'SUM_Area_n'
- 12) The final product, [50_MALL_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period) at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

1. 2002-2011 time period reflects current Mallard non-breeding distribution and DUD.
2. All surveys and population estimates are consistent across years.
3. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
4. Harvest data reflects true abundance and distribution of Mallard in the non-breeding range.
5. Regions of high DUD for Mallard represent geographies of continental significance to non-breeding Mallard.



American Black Duck (*Anas rubripes*)

Species Account for Habitat Planning in the Non-Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution). *Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to American Black Duck during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing American Black Duck Use Days Spatial Layers

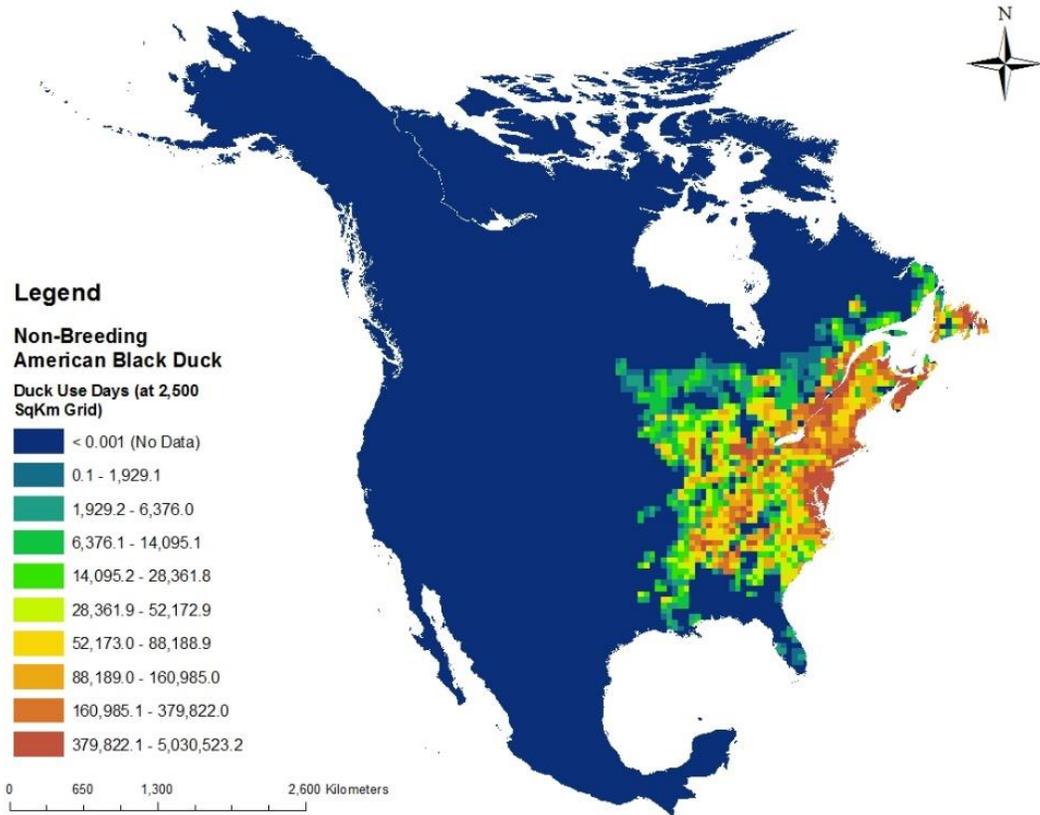
- 1) Original data were provided by DU as an ArcGIS Shapefile, [DUD_AllSpecies_US_n_CA.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Canada (American Black Duck Use Days were not available for Mexico). Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as ABDU within [DUD_AllSpecies_US_n_CA.shp](#) were exported to a new file [ABDU_Non_Breeding_DUD.shp](#).
- 3) In the attribute table of [ABDU_Non_Breeding_DUD.shp](#), fields 'Area_sqkm' (with 'Float' as field type), 'DUD_' (with 'Float' as field type), and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and American Black Duck DUD density, respectively).

- a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing ‘LTAPop’ (DUD calculation based on the Long-Term Average Population) field by ‘Area_sqkm’ field.
- 4) To calculate American Black Duck DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a ‘NoData’ value in the ‘fips’ field (fips = county ID or grid block ID).
 - 5) We used the [Erase](#) function to erase the areas of [ABDU_Non_Breeding_DUD.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
 - 6) We then merged [North_America2.shp](#) with [ABDU_Non_Breeding_DUD.shp](#) to create a new file, [ABDU_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
 - 7) We used the [Edit](#) tool to input ‘NoData’ in the ‘fips’ field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
 - 8) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
 - 9) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [ABDU_Non_Breeding_DUD_Final.shp](#) files to create [50_ABDU_NonBreeding.shp](#). Two new fields were added to the attribute table, ‘Area_new’ (with a ‘Float’ type) and ‘Total_DUD’ (with a ‘Float’ type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the ‘Area_new’ field.
 - b. Total of DUD was calculated by multiplying the ‘Area_new’ field by the ‘DUD_Dens’ field using the [Field Calculator](#) tool.
 - 10) Next, [50_ABDU_NonBreeding.shp](#) was dissolved by ‘FID_Fishne’ field using the [Dissolve](#) tool to create a new file [50_ABDU_NonBreeding2.shp](#).
 - a. Statistics for ‘Area_new’ and ‘Total_DUD’ fields were summed.
 - b. New field for ‘Density’ was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field ‘SUM_Total_’ by field ‘SUM_Area_n’
 - 11) The final product, [50_ABDU_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period) at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

6. 2002-2011 time period reflects current American Black Duck non-breeding distribution and DUD.
7. All surveys and population estimates are consistent across years.
8. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.

9. Harvest data reflects true abundance and distribution of American Black Duck in the non-breeding range.
10. Regions of high DUD for American Black Duck represent geographies of continental significance to non-breeding American Black Duck.



Northern Pintail (*Anas acuta*)

Species Account for Habitat Planning in the Non-Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Northern Pintail during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing Northern Pintail Duck Use Days Spatial Layers

- 1) Original data were provided by DU as two ArcGIS Shapefiles, [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Mexico and Canada. Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as NOPI within [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#) were exported to two new files [NOPI_Non_Breeding_DUD.shp](#) and [NOPI_non_Breeding_DUD_mex.shp](#), respectively.
- 3) Next, the [NOPI_Non_Breeding_DUD.shp](#) and [NOPI_Non_Breeding_DUD_mex.shp](#), were merged using the [Merge](#) function to create one spatial layer, [NOPI_Non_Breeding_DUD2.shp](#).
- 4) In the attribute table of [NOPI_Non_Breeding_DUD2.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These

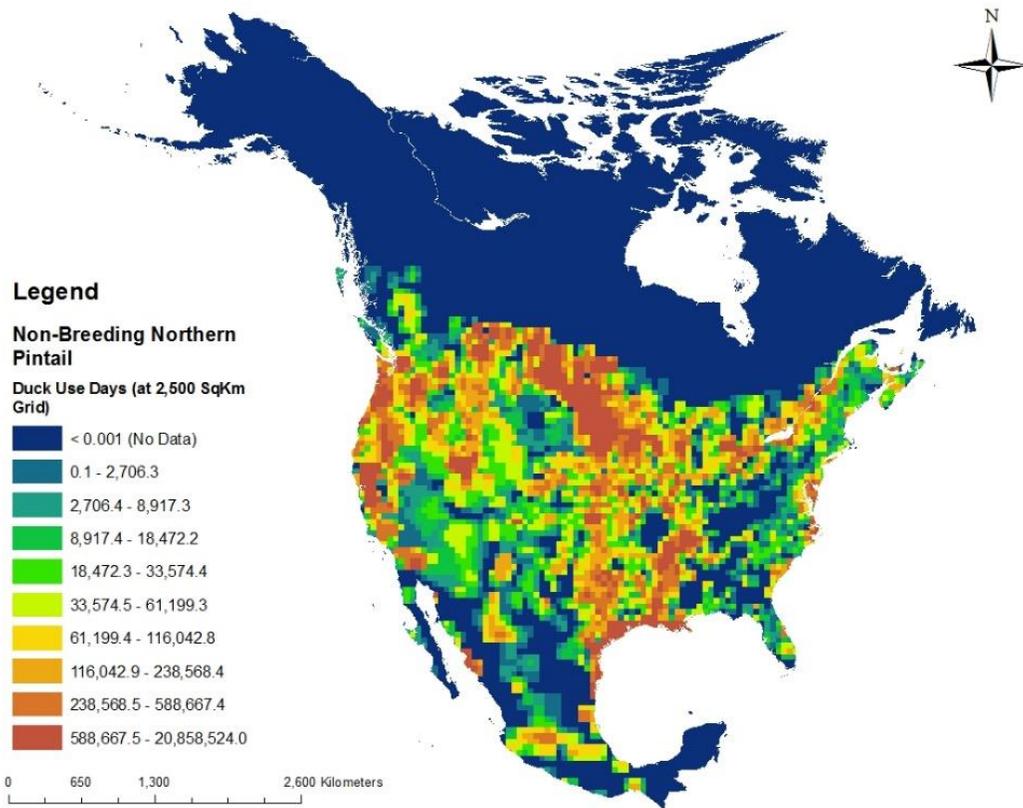
represent, area of the county/degree block in square kilometers and Northern Pintail DUD density, respectively).

- a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing 'LTAPop' (DUD calculation based on the Long-Term Average Population) field by 'Area_sqkm' field.
- 5) To calculate Northern Pintail DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a 'NoData' value in the 'fips' field (fips = county ID or grid block ID).
 - 6) We used the [Erase](#) function to erase the areas of [NOPI_Non_Breeding_DUD2.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
 - 7) We then merged [North_America2.shp](#) with [NOPI_Non_Breeding_DUD2.shp](#) to create a new file, [NOPI_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
 - 8) We used the [Edit](#) tool to input 'NoData' in the 'fips' field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
 - 9) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
 - 10) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [NOPI_Non_Breeding_DUD_Final.shp](#) files to create [50_NOPI_NonBreeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Total_DUD' (with a 'Float' type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - b. Total of DUD was calculated by multiplying the 'Area_new' field by the 'DUD_Dens' field using the [Field Calculator](#) tool.
 - 11) Next, [50_NOPI_NonBreeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_NOPI_NonBreeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Total_DUD' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Total_' by field 'SUM_Area_n'
 - 12) The final product, [50_NOPI_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km² and total DUD (Duck Use days for a 242-day planning period) at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

11. 2002-2011 time period reflects current Northern Pintail non-breeding distribution and DUD.
12. All surveys and population estimates are consistent across years.

13. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
14. Harvest data reflects true abundance and distribution of Northern Pintail in the non-breeding range.
15. Regions of high DUD for Northern Pintail represent geographies of continental significance to non-breeding Northern Pintail.



Wood Duck (*Aix sponsa*)

Species Account for Habitat Planning in the Non-Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Wood Duck during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing Wood Duck Use Days Spatial Layers

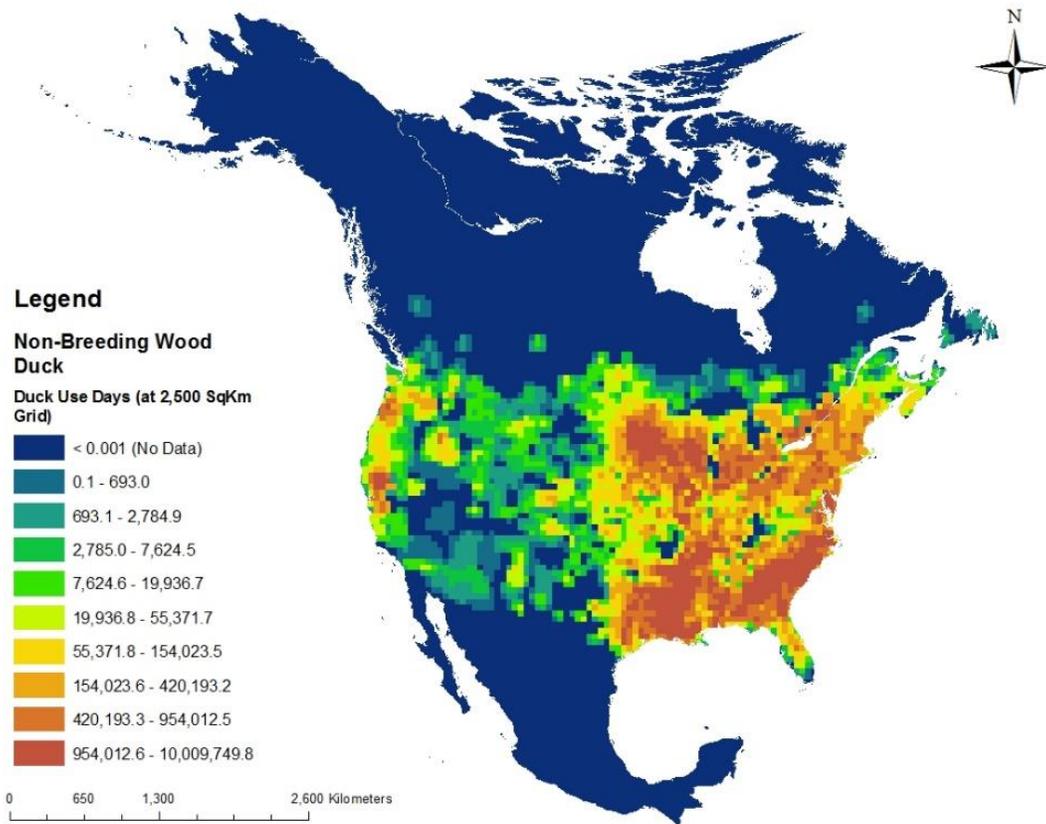
- 1) Original data were provided by DU as an ArcGIS Shapefile, [DUD_AllSpecies_US_n_CA.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Canada (Wood Duck Use Days were not available for Mexico). Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as WODU within [DUD_AllSpecies_US_n_CA.shp](#) were exported to a new file [WODU_Non_Breeding_DUD.shp](#).
- 3) In the attribute table of [WODU_Non_Breeding_DUD.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and Wood Duck DUD density, respectively).

- a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing ‘LTAPop’ (DUD calculation based on the Long-Term Average Population) field by ‘Area_sqkm’ field.
- 4) To calculate Wood Duck DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a ‘NoData’ value in the ‘fips’ field (fips = county ID or grid block ID).
 - 5) We used the [Erase](#) function to erase the areas of [WODU_Non_Breeding_DUD.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
 - 6) We then merged [North_America2.shp](#) with [WODU_Non_Breeding_DUD.shp](#) to create a new file, [WODU_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
 - 7) We used the [Edit](#) tool to input ‘NoData’ in the ‘fips’ field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
 - 8) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
 - 9) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [WODU_Non_Breeding_DUD_Final.shp](#) files to create [50_WODU_NonBreeding.shp](#). Two new fields were added to the attribute table, ‘Area_new’ (with a ‘Float’ type) and ‘Total_DUD’ (with a ‘Float’ type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the ‘Area_new’ field.
 - b. Total of DUD was calculated by multiplying the ‘Area_new’ field by the ‘DUD_Dens’ field using the [Field Calculator](#) tool.
 - 10) Next, [50_WODU_NonBreeding.shp](#) was dissolved by ‘FID_Fishne’ field using the [Dissolve](#) tool to create a new file [50_WODU_NonBreeding2.shp](#).
 - a. Statistics for ‘Area_new’ and ‘Total_DUD’ fields were summed.
 - b. New field for ‘Density’ was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field ‘SUM_Total_’ by field ‘SUM_Area_n’
 - 11) The final product, [50_WODU_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period) at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

16. 2002-2011 time period reflects current Wood Duck non-breeding distribution and DUD.
17. All surveys and population estimates are consistent across years.
18. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.

19. Harvest data reflects true abundance and distribution of Wood Duck in the non-breeding range.
20. Regions of high DUD for Wood Duck represent geographies of continental significance to non-breeding Wood Duck.



Scaup Spp. (*Aythya affinis*, *Aythya marila*)

Species Account for Habitat Planning in the Non-Breeding Range

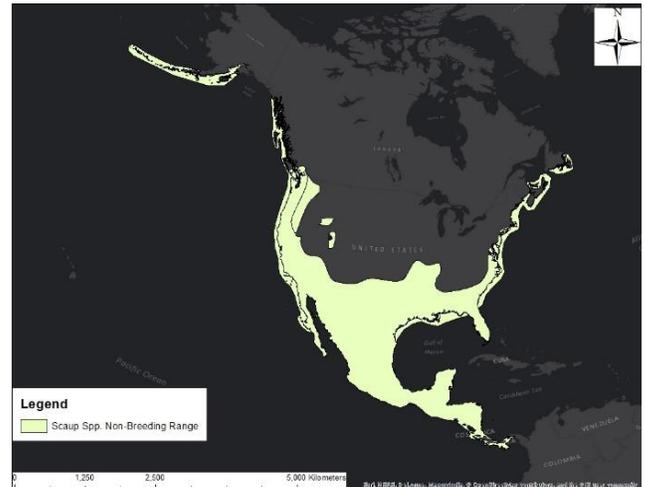
Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Scaup during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing Scaup Duck Use Days Spatial Layers

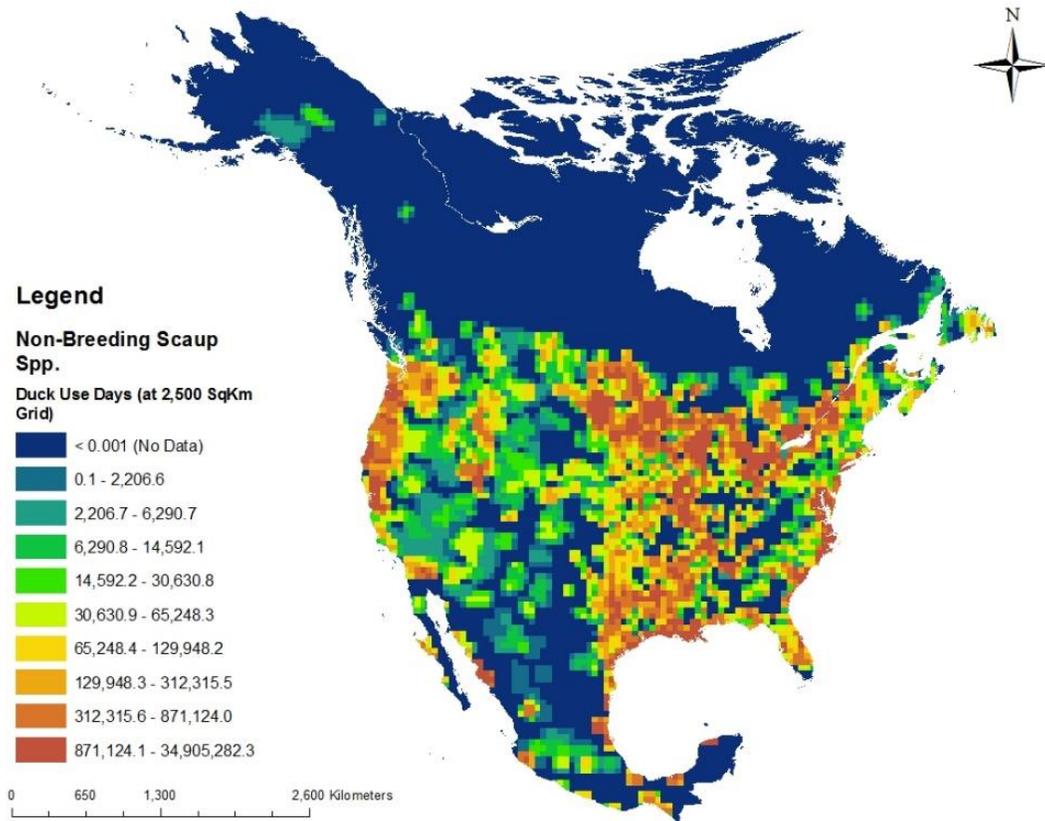
- 1) Original data were provided by DU as two ArcGIS Shapefiles, [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Mexico and Canada. Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as SCAU within [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#) were exported to two new files [SCAU_Non_Breeding_DUD.shp](#) and [NOPI_non_Breeding_DUD_mex.shp](#), respectively.
- 3) Next, the [SCAU_Non_Breeding_DUD.shp](#) and [SCAU_Non_Breeding_DUD_mex.shp](#), were merged using the [Merge](#) function to create one spatial layer, [SCAU_Non_Breeding_DUD2.shp](#).
- 4) In the attribute table of [SCAU_Non_Breeding_DUD2.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and Scaup DUD density, respectively).

- a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing 'LTAPop' (DUD calculation based on the Long-Term Average Population) field by 'Area_sqkm' field.
- 5) To calculate Scaup DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a 'NoData' value in the 'fips' field (fips = county ID or grid block ID).
 - 6) We used the [Erase](#) function to erase the areas of [SCAU_Non_Breeding_DUD2.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
 - 7) We then merged [North_America2.shp](#) with [SCAU_Non_Breeding_DUD2.shp](#) to create a new file, [SCAU_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
 - 8) We used the [Edit](#) tool to input 'NoData' in the 'fips' field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
 - 9) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
 - 10) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [SCAU_Non_Breeding_DUD_Final.shp](#) files to create [50_SCAU_NonBreeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Total_DUD' (with a 'Float' type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - b. Total of DUD was calculated by multiplying the 'Area_new' field by the 'DUD_Dens' field using the [Field Calculator](#) tool.
 - 11) Next, [50_SCAU_NonBreeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_SCAU_NonBreeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Total_DUD' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Total_' by field 'SUM_Area_n'
 - 12) The final product, [50_SCAU_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period) at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

21. 2002-2011 time period reflects current Scaup non-breeding distribution and DUD.
22. All surveys and population estimates are consistent across years.
23. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
24. Harvest data reflects true abundance and distribution of Scaup in the non-breeding range.

25. Regions of high DUD for Scaup represent geographies of continental significance to non-breeding Scaup.



Dabbling Ground Nesters

American Wigeon (*Anas americana*)

Northern Shoveler (*Spatula clypeata*)

Gadwall (*Anas strepera*)

Green-winged Teal (*Anas carolinensis*)

Blue-winged Teal (Cinnamon Teal) (*Spatula discors* (*Spatula cyanoptera*))

Mottled Duck (*Anas fulvigula*)

Species Account for Habitat Planning in the Non-Breeding Range

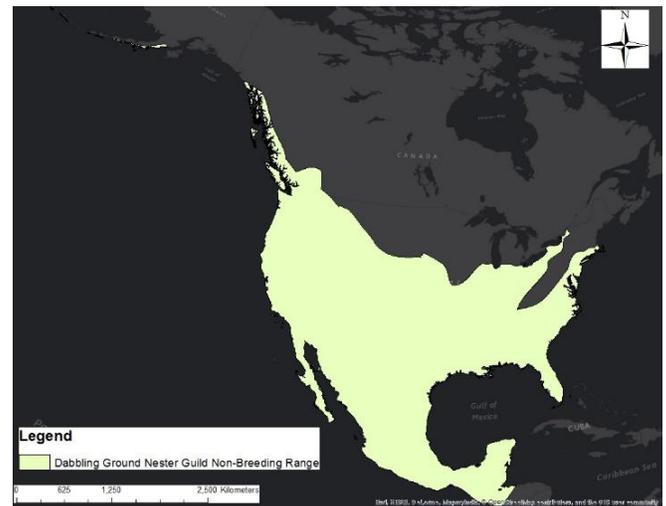
Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Dabbling Ground Nesters during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing Dabbling Ground Nester Duck Use Days Spatial Layers

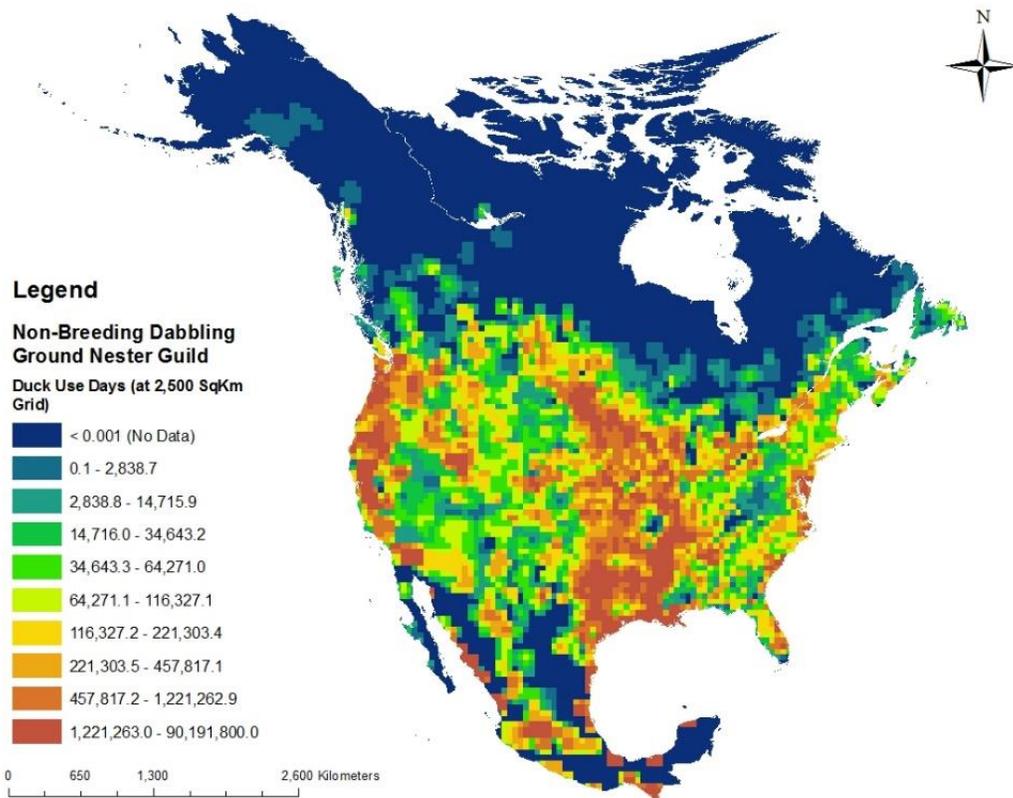
- 1) Original data were provided by DU as two ArcGIS Shapefiles, [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Mexico and Canada. Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as AMWI, NSHO, GADW, AGWT, and BCTE (Blue-winged and Cinnamon Teal, undifferentiated) within [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#) were exported to two new files

- [DabbGrN_Non_Breeding_DUD.shp](#) and [DabbGrN_non_Breeding_DUD_mex.shp](#), respectively. (*DUD calculations were not available for Mottled Duck and therefore are not included in this analysis)
- 3) Next, the [DabbGrN_Non_Breeding_DUD.shp](#) and [DabbGrN_Non_Breeding_DUD_mex.shp](#), were merged using the [Merge](#) function to create one spatial layer, [DabbGrN_Non_Breeding_DUD2.shp](#).
 - 4) In this case there are multiple species accounts per county/degree block (i.e., AMWI, NSHO, AGWT, etc. or any combination of the five species for which DUD estimate was available). Therefore, we used the [Dissolve](#) function (dissolve by 'fips' field) to SUM the statistics for 'LTAPop' and 'Pct80' and retain FIRST the 'BCR' field and 'CODE' field. This process produced a new layer, [DabbGrN_Non_Breeding_DUD2_Diss.shp](#).
 - 5) In the attribute table of [DabbGrN_Non_Breeding_DUD2_Diss.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and Dabbling Ground Nester DUD density, respectively).
 - a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing 'SUM_LTAPop' (DUD calculation based on the Long-Term Average Population) field by 'Area_sqkm' field.
 - 6) To calculate Dabbling Ground Nester DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a 'NoData' value in the 'fips' field (fips = county ID or grid block ID).
 - 7) We used the [Erase](#) function to erase the areas of [DabbGrN_Non_Breeding_DUD2_Diss.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
 - 8) We then merged [North_America2.shp](#) with [DabbGrN_Non_Breeding_DUD2_Diss.shp](#) to create a new file, [DabbGrN_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
 - 9) We used the [Edit](#) tool to input 'NoData' in the 'fips' field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
 - 10) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
 - 11) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [DabbGrN_Non_Breeding_DUD_Final.shp](#) files to create [50_DabbGrN_NonBreeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Total_DUD' (with a 'Float' type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - b. Total of DUD was calculated by multiplying the 'Area_new' field by the 'DUD_Dens' field using the [Field Calculator](#) tool.
 - 12) Next, [50_DabbGrN_NonBreeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_DabbGrN_NonBreeding2.shp](#).

- a. Statistics for 'Area_new' and 'Total_DUD' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Total_' by field 'SUM_Area_n'
- 13) The final product, [50_DabbGrN_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period) at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

26. 2002-2011 time period reflects current Dabbling Ground Nester non-breeding distribution and DUD.
27. All surveys and population estimates are consistent across years.
28. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
29. Harvest data reflects true abundance and distribution of Dabbling Ground Nester in the non-breeding range.
30. Regions of high DUD for Dabbling Ground Nester represent geographies of continental significance to non-breeding Dabbling Ground Nester.



Diving Cavity Nesters

Bufflehead (*Bucephala albeola*)

Goldeneye Spp. (*Bucephala islandica*, *Bucephala clangula*)

Merganser Spp. (*Mergus serrator*, *Mergus merganser*, *Lophodytes cucullatus*)

Species Account for Habitat Planning in the Non-Breeding Range

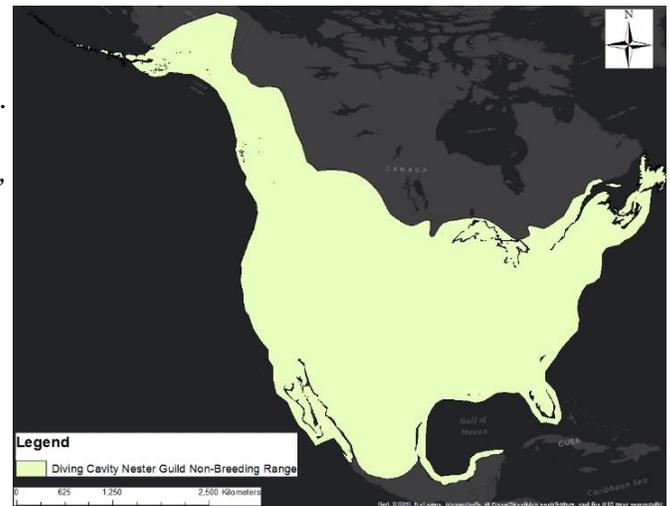
Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Diving Cavity Nesters during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing Diving Cavity Nester Duck Use Days Spatial Layers

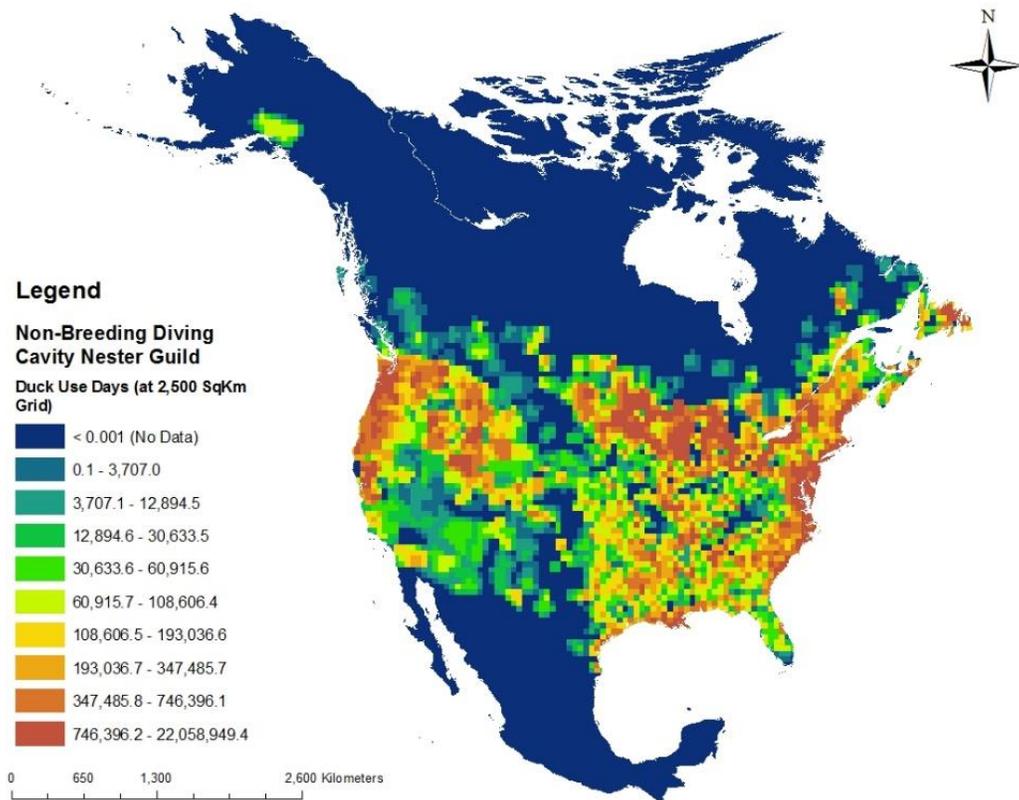
- 1) Original data were provided by DU as an ArcGIS Shapefile, [DUD_AllSpecies_US_n_CA.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Canada (No Duck Use Days data for MERG, GOLD, or BUFF were available for Mexico). Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as BUFF, COGO, BAGO, and MERG within [DUD_AllSpecies_US_n_CA.shp](#) were exported to anew file [DivinCaN_Non_Breeding_DUD.shp](#).

- 3) In this case there are multiple species accounts per county/degree block (i.e., BUFF, MERG, etc. or any combination of the four species for which DUD estimate was available). Therefore, we used the [Dissolve](#) function (dissolve by 'fips' field) to SUM the statistics for 'LTAPop' and 'Pct80' and retain FIRST the 'BCR' field and 'CODE' field. This process produced a new layer, [DivinCaN_Non_Breeding_DUD_Diss.shp](#).
- 4) In the attribute table of [DivinCaN_Non_Breeding_DUD_Diss.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and Diving Cavity Nester DUD density, respectively).
 - a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing 'SUM_LTAPop' (DUD calculation based on the Long-Term Average Population) field by 'Area_sqkm' field.
- 5) To calculate Diving Cavity Nester DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a 'NoData' value in the 'fips' field (fips = county ID or grid block ID).
- 6) We used the [Erase](#) function to erase the areas of [DivinCaN_Non_Breeding_DUD_Diss.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
- 7) We then merged [North_America2.shp](#) with [DivinCaN_Non_Breeding_DUD_Diss.shp](#) to create a new file, [DivinCaN_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
- 8) We used the [Edit](#) tool to input 'NoData' in the 'fips' field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 9) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 10) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [DivinCaN_Non_Breeding_DUD_Final.shp](#) files to create [50_DivinCaN_NonBreeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Total_DUD' (with a 'Float' type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - b. Total of DUD was calculated by multiplying the 'Area_new' field by the 'DUD_Dens' field using the [Field Calculator](#) tool.
- 11) Next, [50_DivinCaN_NonBreeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_DivinCaN_NonBreeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Total_DUD' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Total_' by field 'SUM_Area_n'
- 12) The final product, [50_DivinCaN_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period)

at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

- 31. 2002-2011 time period reflects current Diving Cavity Nester non-breeding distribution and DUD.
- 32. All surveys and population estimates are consistent across years.
- 33. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
- 34. Harvest data reflects true abundance and distribution of Diving Cavity Nester in the non-breeding range.
- 35. Regions of high DUD for Diving Cavity Nester represent geographies of continental significance to non-breeding Diving Cavity Nester.



Diving Overwater Nesters

Redhead (*Aythya americana*)

Ring-necked duck (*Aythya collaris*)

Canvasback (*Aythya valisineria*)

Ruddy Duck (*Oxyura jamaicensis*)

Species Account for Habitat Planning in the Non-Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Diving Overwater Nesters during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing Diving Overwater Nester Duck Use Days Spatial Layers

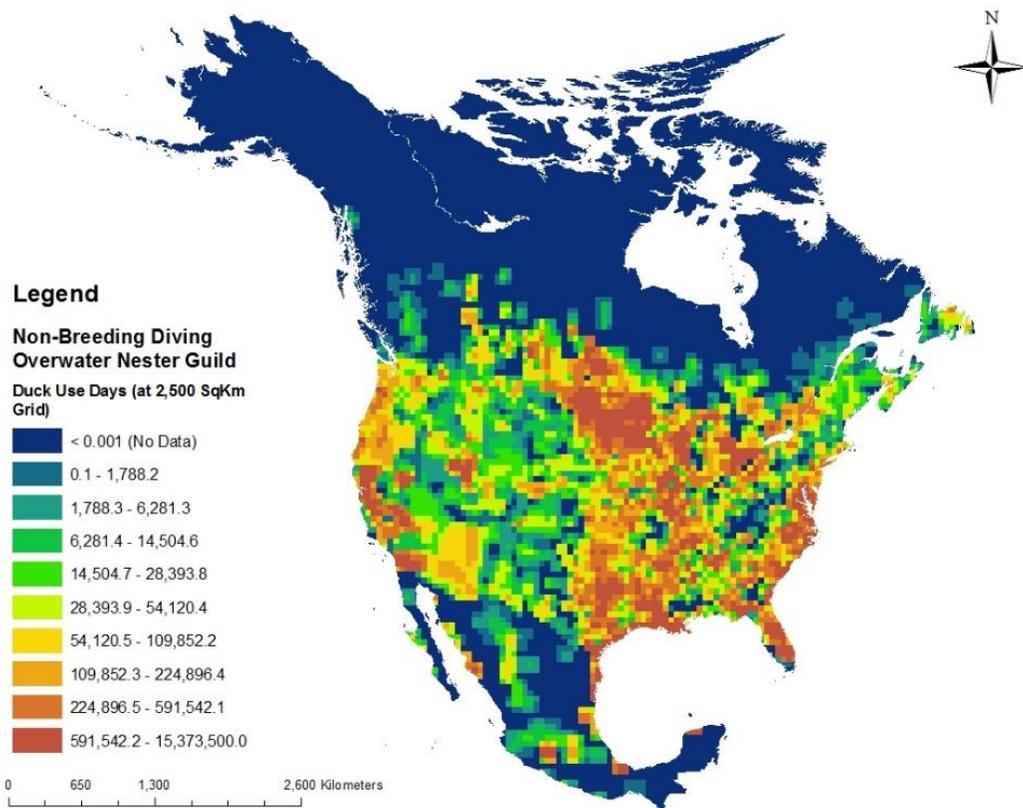
- 1) Original data were provided by DU as two ArcGIS Shapefiles, [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Mexico and Canada. Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as CANV, REDH, RUDU, and RNDU within [DUD_AllSpecies_US_n_CA.shp](#) and [DUD_AllSpecies_MX.shp](#) were exported to two new files [DivinOvN_Non_Breeding_DUD.shp](#) and [DivinOvN_non_Breeding_DUD_mex.shp](#), respectively.

- 3) Next, the [DivinOvN_Non_Breeding_DUD.shp](#) and [DivinOvN_Non_Breeding_DUD_mex.shp](#), were merged using the [Merge](#) function to create one spatial layer, [DivinOvN_Non_Breeding_DUD2.shp](#).
- 4) In this case there are multiple species accounts per county/degree block (i.e., REDH, RUDU, RNDU, etc. or any combination of the four species for which DUD estimate was available). Therefore, we used the [Dissolve](#) function (dissolve by 'fips' field) to SUM the statistics for 'LTAPop' and 'Pct80' and retain FIRST the 'BCR' field and 'CODE' field. This process produced a new layer, [DivinOvN_Non_Breeding_DUD2_Diss.shp](#).
- 5) In the attribute table of [DivinOvN_Non_Breeding_DUD2_Diss.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and Diving Overwater Nester DUD density, respectively).
 - a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing 'SUM_LTAPop' (DUD calculation based on the Long-Term Average Population) field by 'Area_sqkm' field.
- 6) To calculate Diving Overwater Nester DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a 'NoData' value in the 'fips' field (fips = county ID or grid block ID).
- 7) We used the [Erase](#) function to erase the areas of [DivinOvN_Non_Breeding_DUD2_Diss.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
- 8) We then merged [North_America2.shp](#) with [DivinOvN_Non_Breeding_DUD2_Diss.shp](#) to create a new file, [DivinOvN_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
- 9) We used the [Edit](#) tool to input 'NoData' in the 'fips' field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 10) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 11) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [DivinOvN_Non_Breeding_DUD_Final.shp](#) files to create [50_DivinOvN_NonBreeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Total_DUD' (with a 'Float' type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - b. Total of DUD was calculated by multiplying the 'Area_new' field by the 'DUD_Dens' field using the [Field Calculator](#) tool.
- 12) Next, [50_DivinOvN_NonBreeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_DivinOvN_NonBreeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Total_DUD' fields were summed.

- b. New field for ‘Density’ was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field ‘SUM_Total_’ by field ‘SUM_Area_n’
- 13) The final product, [50_DivinOvN_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period) at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

1. 2002-2011 time period reflects current Diving Overwater Nester non-breeding distribution and DUD.
2. All surveys and population estimates are consistent across years.
3. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
4. Harvest data reflects true abundance and distribution of Diving Overwater Nester in the non-breeding range.
5. Regions of high DUD for Diving Overwater Nester represent geographies of continental significance to non-breeding Diving Overwater Nester.



Diving Ground Nesters

Eider Spp. (*Somateria mollissima*, *S. fischeri*, *S. spectabilis*, *Polysticta stelleri*)

Scoter Spp. (*Melanitta americana*, *M. perspicillata*, *M. fusca*)

Long-tailed Duck (*Clangula hyemalis*)

Harlequin Duck (*Histrionicus histrionicus*)

Species Account for Habitat Planning in the Non-Breeding Range

Species Range Map Data Source: BirdLife International: Bird species distribution maps of the world, version 6.0 (BirdLife International and Handbook of the Birds of the World, 2016)

Projection: North American Albers Equal Area Conic

Non-Breeding Distribution:

Non-Breeding (Inclusive of Non-Breeding Distribution AND Permanent Resident Distribution).

*Modified boundaries to match distribution account of Birds of North America Online and *Ducks, Geese, and Swans of North America* (Baldassarre, 2014)



Our goal was to identify geographies of greatest significance to Diving Ground Nesters during the non-breeding season. Ducks Unlimited provided DUD data based on ongoing research into the development of DUD from harvest information and eBird migration data (Brasher et al., in prep). Step down population objectives (LTA and 80th percentile) were calculated by Fleming and others (2017) for each Joint Venture using harvest data (per county) and two methods (4b and 4d → see Fleming and others 2017 for details). Additionally, a similar analysis was conducted to determine DUD in Canada and Mexico (where harvest rates were available) at the degree block resolution. All development of DUD was based on the Mid-winter Surveys from 2002-2011.

Developing Diving Ground Nester Duck Use Days Spatial Layers

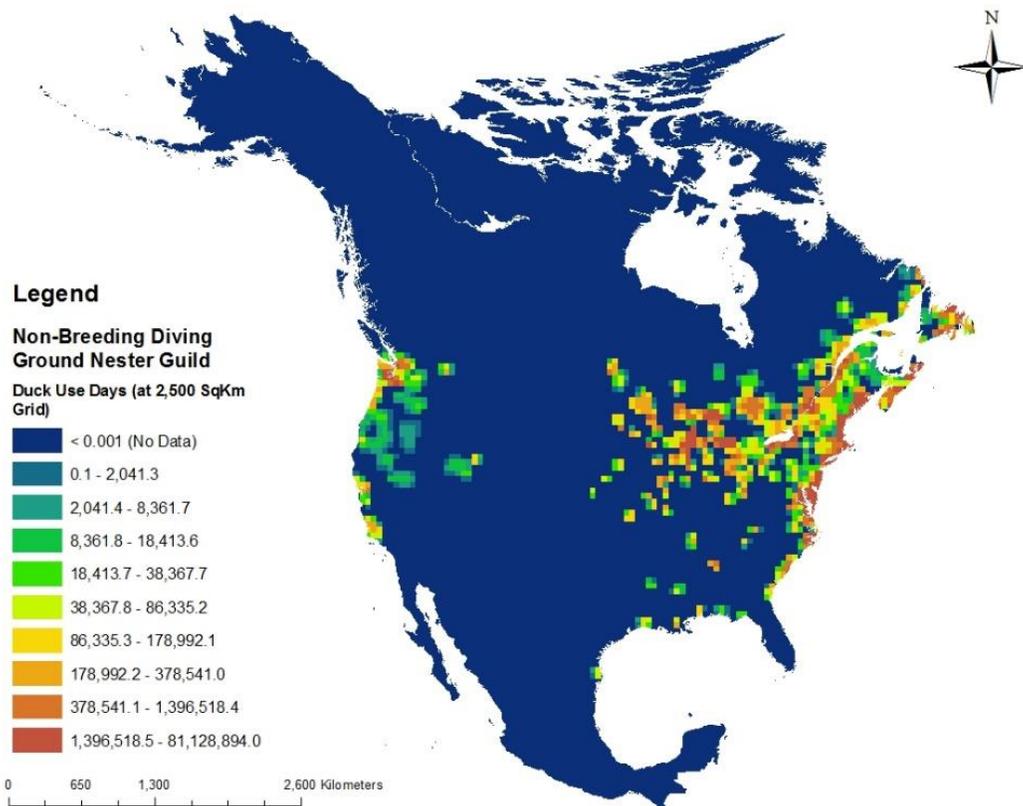
- 1) Original data were provided by DU as an ArcGIS Shapefile, [DUD_AllSpecies_US_n_CA.shp](#), which represent target DUD for each species at the county scale (where available) for the United States and at the degree block scale for Canada (No Duck Use Days data for SCOT, EIDR, LTDU were available for Mexico. Also, no Duck Use Days data for HADU were available in either US or CA). Values for DUD are based on averages (2002-2011) of harvest information and eBird migration curves (species-specific).
- 2) All entries coded as SCOT, EIDR, and LTDU within [DUD_AllSpecies_US_n_CA.shp](#) were exported to a new file [DivinGrN_Non_Breeding_DUD.shp](#).

- 3) In this case there are multiple species accounts per county/degree block (i.e., SCOT, EIDR, etc. or any combination of the three species for which DUD estimate was available). Therefore, we used the [Dissolve](#) function (dissolve by 'fips' field) to SUM the statistics for 'LTAPop' and 'Pct80' and retain FIRST the 'BCR' field and 'CODE' field. This process produced a new layer, [DivinGrN_Non_Breeding_DUD_Diss.shp](#).
- 4) In the attribute table of [DivinGrN_Non_Breeding_DUD_Diss.shp](#), fields 'Area_sqkm' (with 'Float' as field type) and 'DUD_Dens' (with 'Float' as field type) were added. (These represent, area of the county/degree block in square kilometers and Diving Ground Nester DUD density, respectively).
 - a. Total area of each county/degree block was calculated using the [Calculate Geometry](#) tool (using NA Albers Equal Area Conic projection to minimize distortion in area).
 - b. Density was calculated using the [Field Calculator](#) tool by dividing 'SUM_LTAPop' (DUD calculation based on the Long-Term Average Population) field by 'Area_sqkm' field.
- 5) To calculate Diving Ground Nester DUD density at the 50×50 km grid scale, areas (counties/degree blocks) where no harvest data were reported need to be added as a 'NoData' value in the 'fips' field (fips = county ID or grid block ID).
- 6) We used the [Erase](#) function to erase the areas of [DivinGrN_Non_Breeding_DUD_Diss.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a new shapefile, [North_America2.shp](#).
- 7) We then merged [North_America2.shp](#) with [DivinGrN_Non_Breeding_DUD_Diss.shp](#) to create a new file, [DivinGrN_Non_Breeding_DUD_Final.shp](#) encompassing continental North America.
- 8) We used the [Edit](#) tool to input 'NoData' in the 'fips' field in the attribute table of the new file and calculated area in square kilometers (NA Albers Equal Area Conic) using the [Calculate Geometry](#) function.
- 9) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 10) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [DivinGrN_Non_Breeding_DUD_Final.shp](#) files to create [50_DivinGrN_NonBreeding.shp](#). Two new fields were added to the attribute table, 'Area_new' (with a 'Float' type) and 'Total_DUD' (with a 'Float' type).
 - a. Area was recalculated using the [Calculate Geometry](#) function in the 'Area_new' field.
 - b. Total of DUD was calculated by multiplying the 'Area_new' field by the 'DUD_Dens' field using the [Field Calculator](#) tool.
- 11) Next, [50_DivinGrN_NonBreeding.shp](#) was dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create a new file [50_DivinGrN_NonBreeding2.shp](#).
 - a. Statistics for 'Area_new' and 'Total_DUD' fields were summed.
 - b. New field for 'Density' was created and density was recalculated at the 50×50 km grid using [Field Calculator](#) and dividing field 'SUM_Total_' by field 'SUM_Area_n'
- 12) The final product, [50_DivinGrN_NonBreeding2.shp](#) can be used to display breeding DUD density (DUD/km²) and total DUD (Duck Use days for a 242-day planning period)

at the 50×50 km for North America. However, for the purposes of this project only total amount of DUD for a 242-day planning period is used. Therefore, DUD density is not further discussed, but can be provided upon request.

Assumptions:

1. 2002-2011 time period reflects current Diving Ground Nester non-breeding distribution and DUD.
2. All surveys and population estimates are consistent across years.
3. Regional (small scale) differentiation that occurs without the incorporation of standard error is irrelevant at the larger continental scale.
4. Harvest data reflects true abundance and distribution of Diving Ground Nester in the non-breeding range.
5. Regions of high DUD for Diving Ground Nester represent geographies of continental significance to non-breeding Diving Ground Nester.



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Fleming, K.K., Brasher, M.G., Humburg, D.D., Petrie, M.J., and Soulliere, G.J., 2017, Derivation of regional non-breeding duck population abundance objectives to inform regional conservation planning: North American Waterfowl Management Plan Science Support Team Technical Report No. 2017-01 32 pp.

Supplement 3.

Developing Spatial Layers for Breeding and Non-Breeding Geese and Swan

In the process of identifying biological objectives at the continental scale, the PLC debated the inclusion of geese and swans in determining geographies of continental significance for waterfowl. There are several concerns that the PLC debated. Firstly, some goose species (i.e., Canada Goose and Snow Goose) are above their NAWMP target population levels and their populations continue to increase. The ability of geese to exploit food resources on agricultural lands is thought to be one of the primary causes for these population increases (Batt, 1997). Additionally, overabundant goose populations may now be directly competing with duck species (Vrtiska and Sullivan, 2009; Webb and others, 2010) that are still below their NAWMP target levels. Finally, breeding, non-breeding and migratory data on goose and swan species are not as readily available, organized, and consistent as that available for most of the duck species. Therefore, it would be difficult, if not impossible, to determine breeding goose and swan densities in the breeding range. Additionally, there are no available data for Goose Use Days, as it pertains to food resources in the non-breeding range. However, the exclusion of goose and swan species from the efforts of identifying geographies of continental significance to waterfowl would be flawed; and would bring about well-deserved criticism from the waterfowl community. These reasons were some of the justifications for using a different set of performance measures to represent geographies of significance for breeding and non-breeding goose and swan species. We reasoned that to include geese and swan as one of the biological objectives, the PLC would use species-specific range and distribution spatial data provided by NatureServe (BirdLife International: Bird species distribution maps of the world, version 6.0; BirdLife International and Handbook of the Birds of the World, 2016).

Developing Goose and Swan Breeding and Non-Breeding Spatial Layers

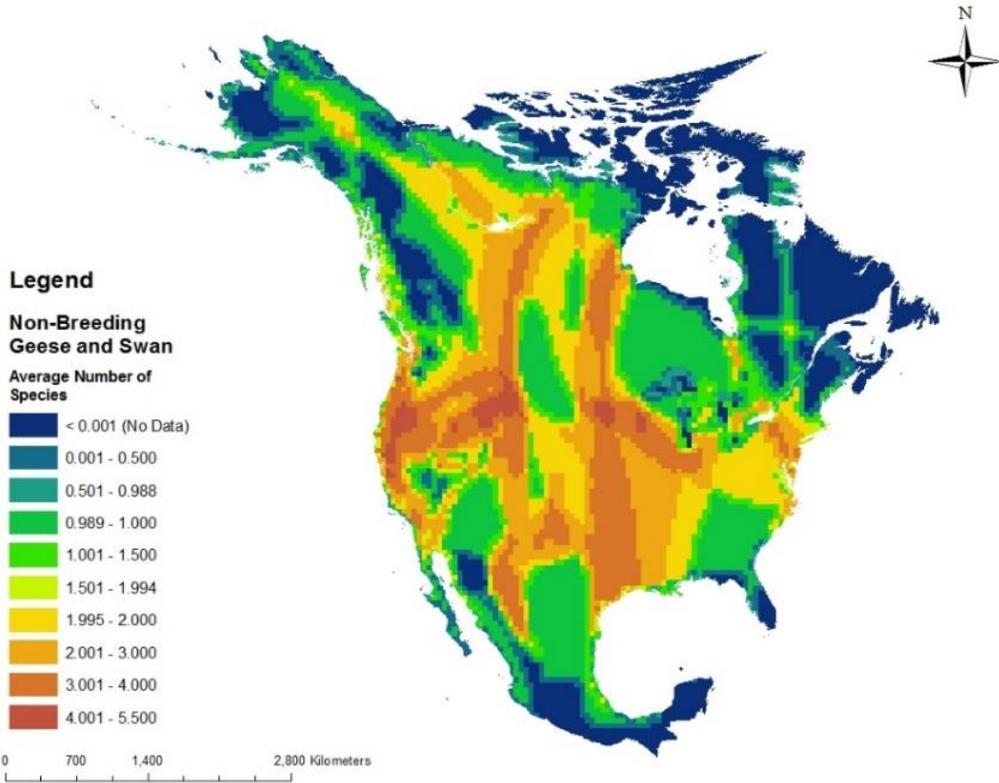
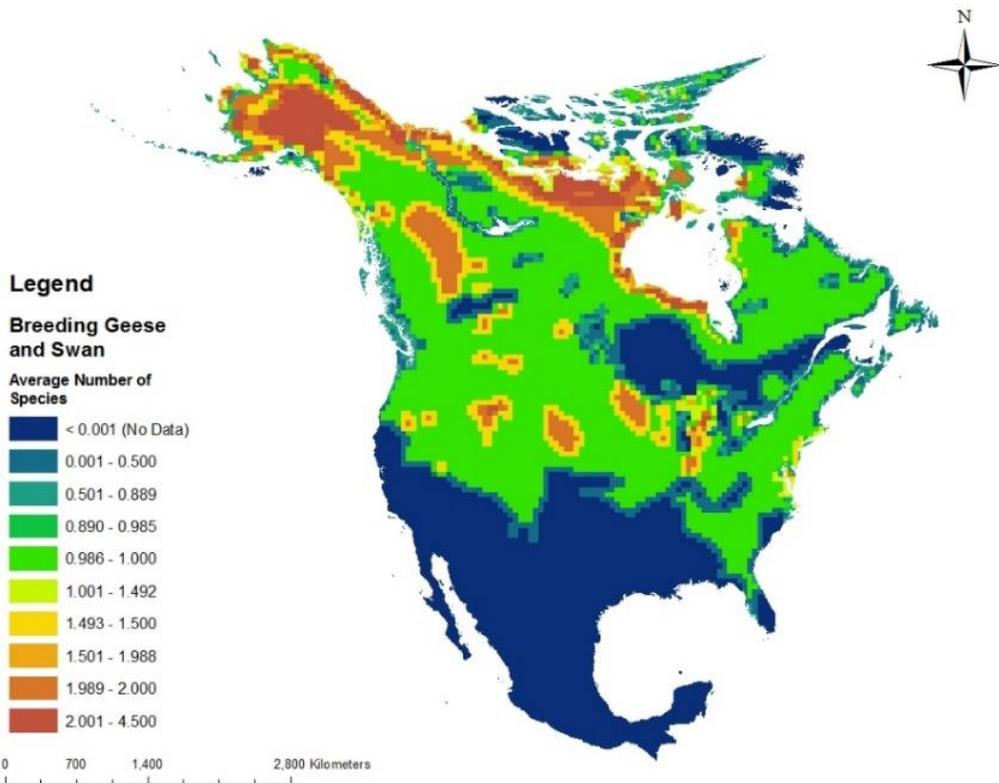
- 1) Original data were provided NatureServe (BirdLife International: Bird species distribution maps of the world, version 6.0; BirdLife International and Handbook of the Birds of the World, 2016) in geodatabase format. From the geodatabase all records of breeding, migrating and wintering goose and swan species were exported into a new ArcGIS shapefile [All_Species.shp](#).
- 2) Next, the boundary for North America, [North_America_Boundary.shp](#), was used to clip the [All_Species.shp](#) spatial layer to reflect the PLC's area of analysis. Using the [Clip](#) tool, a new file [All_Species_NA.shp](#), was created.
- 3) From this file, individual spatial layers were created for each species (9 species), [Brant_Goose.shp](#), [Canada_Goose.shp](#), [Emperor_Goose.shp](#), [Greater_White_Fronted_Goose.shp](#), [Mute_Swan.shp](#), [Ross_Goose.shp](#), [Snow_Goose.shp](#), [Trumpeter_Swan.shp](#), and [Tundra_Swan.shp](#), using the [Export Data](#) function in the attribute table and stored in the [Individual_Spp](#) folder.
- 4) These species-specific spatial layers were further divided into two folders, [Breeding](#) and [Non_Breeding](#), into each of which the breeding or non-breeding (includes migration pathways) ranges, respectively, for each species were exported using the [Export Data](#) function in the attribute table. The file names were retained as above but were segregated by folder ([Breeding](#) vs. [Non_Breeding](#)).
- 5) Each file (n =18) was then converted to raster using the [Polygon to Raster](#) tool, where raster value was equal to PRESENCE field of the attribute table. This step resulted in 18

new raster files ([brnt_g](#), [cand_g](#), [empr_g](#), [grwf_g](#), [mute_s](#), [ross_g](#), [snow_g](#), [trmp_s](#), and [tund_s](#) × 2 for [Breeding](#) and [Non_Breeding](#)), where raster value 1 is equal to presence of the specific species and raster value of 'NoData' is equal to absence of the species (based on the distribution range).

- 6) Finally, the [Cell Statistics](#) tool was used to calculate the number of goose and swan species present at a raster cell size of 1×1 km. This step resulted in two new raster files, [gs_breed](#) and [gs_nobreed](#), for breeding and non-breeding spatial layers, respectively.
- 7) Finally, the two raster files were converted back to polygon files using [Raster to Polygon](#) tool, where 'Field' was equal to VALUE column in the attribute table. This resulted in two shapefiles, [geese_swan_breeding.shp](#) and [geese_swan_nonbreeding.shp](#).
- 8) To convert the Geese and Swans distribution data to the same scale as the other biological objectives, a 50×50 km grid scale, we first used the [Erase](#) function to erase the areas of [geese_swan_breeding.shp](#) and [geese_swan_nonbreeding.shp](#) from the shapefile outline of North America (inclusive of Canada and Mexico), [North_America_Boundary.shp](#) to create a two new shapefiles, [North_America2.shp](#), which were stored in [Breeding](#) and [Non_Breeding](#) folders, respectively.
- 9) We then merged each of the [North_America2.shp](#) with the [geese_swan_breeding.shp](#) and [geese_swan_nonbreeding.shp](#) to create a two new file, [geese_swan_breeding2.shp](#) and [geese_swan_nonbreeding2.shp](#), respectively, encompassing continental North America.
- 10) A 50×50 km grid fishnet ([Fishnet_50.shp](#)) was created using the [Create Fishnet](#) tool and then clipped to the boundaries of [North_America_Boundary.shp](#) using the [Clip](#) tool.
- 11) We then used the [Intersect](#) tool to intersect [Fishnet_50.shp](#) and [geese_swan_breeding2.shp](#) and [geese_swan_nonbreeding2.shp](#) files to create two files named [Breeding_Geese_n_Swans_50km.shp](#) and [NonBreeding_Geese_n_Swans_50km.shp](#) and stored in their respective folders, [Breeding](#) and [Non_Breeding](#).
- 12) Next, both [Breeding_Geese_n_Swans_50km.shp](#) and [NonBreeding_Geese_n_Swans_50km.shp](#) ([Breeding](#) and [Non_Breeding](#)) files were dissolved by 'FID_Fishne' field using the [Dissolve](#) tool to create two new files [Breeding_Geese_n_Swans_50km2.shp](#) and [NonBreeding_Geese_n_Swans_50km2.shp](#).
 - a. Statistics for 'GRIDCODE' were designated to find the mean.
- 13) The final two spatial layers [Geese_n_Swans_50km2.shp](#) (one for breeding and one for non-breeding in their respective folders) represent the average number of goose and swan species breeding (or wintering) per 50×50 km grid block. These two spatial layers are visually represented below.

Assumptions:

1. The NatureServe species distribution polygon reflect current distribution of geese and swan in North America. (We acknowledge, that not all areas where goose and swan species are found are represented, this is likely the case for Canada and Snow geese, which are becoming more abundant throughout North America)
2. Goose and swan breeding and non-breeding spatial layers will be updated to goose and swan abundance and density performance measures as survey data becomes available in the future.



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Supplement 4.

Developing Spatial Layers for Social Objectives

Data sources for the development of social objectives' performance measures spatial layers were gathered from various sources (see reference section below). Although the biological objectives were scaled to a 50×50 km grid for representation, this scale was deemed too coarse to represent performance measures of social objectives. The PLC reasoned that since much of the data used to represent social values are available at a finer scale (i.e., 30×30 m), it is justifiable to use a 10×10 km grid scale. Therefore, for all social objectives, final spatial layers were summarized at the 10×10 km grid scale to account for finer resolution data availability, while adding only a negligible amount of processing time.

Distance to Urban Centers

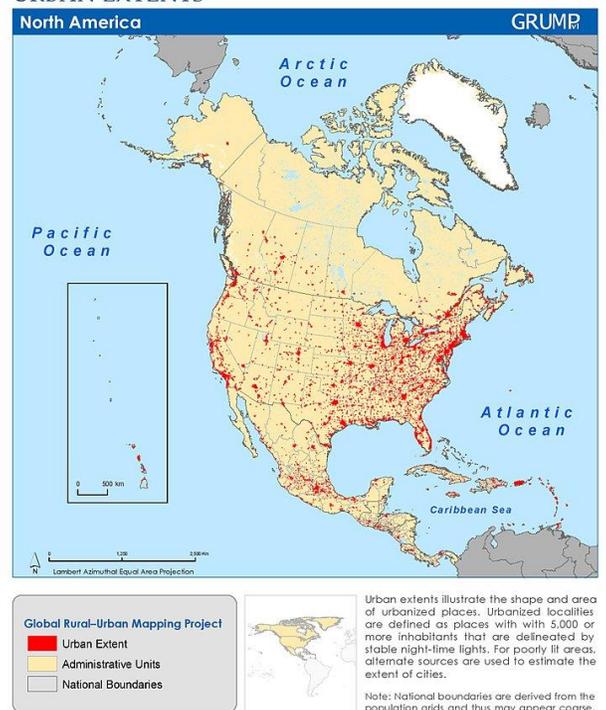
Spatial data for urban centers were downloaded from Socioeconomic Data and Application Center (<http://sedac.ciesin.columbia.edu/data/set/grump-v1-urban-extents/maps>). The Global Rural-Urban Mapping Project, Version 1 (GRUMPv1) consists of estimates of human population for the years 1990, 1995, and 2000 by 30 arc-second (1km) grid. The urban extent grids distinguish urban and rural areas based on a combination of population counts (persons), settlement points, and the presence of Nighttime Lights. Areas are defined as urban where contiguous lighted cells from the Nighttime Lights or approximated urban extents based on buffered settlement points for which the total population is greater than 5,000 persons. This data set is produced by the Columbia University Center for International Earth Science Information Network (CIESIN) in collaboration with the International Food Policy Research Institute (IFPRI), The World Bank, and Centro Internacional de Agricultura Tropical (CIAT).

Literature Cited

Center for International Earth Science Information Network - CIESIN - Columbia University, International Food Policy Research Institute - IFPRI, The World Bank, and Centro Internacional de Agricultura Tropical - CIAT. 2011. Global Rural-Urban Mapping Project, Version 1 (GRUMPv1): Urban Extents Grid. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <http://dx.doi.org/10.7927/H4GH9FVG>. Accessed 25, September, 2017.

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URBAN EXTENTS



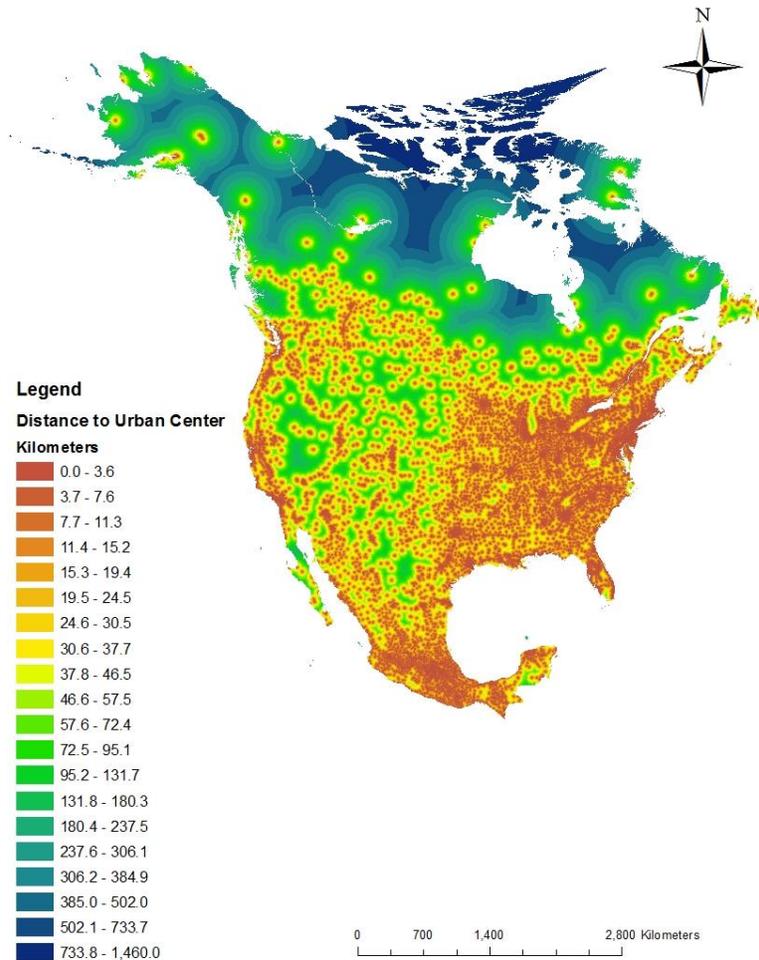
Copyright 2009. The Trustees of Columbia University in the City of New York, Center for International Earth Science Information Network, CIESIN, Columbia University, International Food Policy Research Institute (IFPRI), the World Bank, and Centro Internacional de Agricultura Tropical (CIAT), Global Rural-Urban Mapping Project (GRUMP), Population Density, Palisades, NY: CIESIN, Columbia University. Available at <http://sedac.ciesin.columbia.edu/gpw>

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Developing Distance to Urban Centers Spatial Layer

- 1) Three datasets were downloaded from open source website, Socioeconomic Data and Applications Center (SEDAC). ArcGIS shapefiles of urban centers in US, Canada, and Mexico were transformed to North America Albers Equal Area Conic projection, named [US_UrbanAreas.shp](#), [CA_UrbanAreas.shp](#), and [MX_UrbanAreas.shp](#), respectively, and stored in the [UrbanAreas_byCountry](#) folder.
- 2) Next, we used the [Merge](#) tool to combine the three shapefiles into one, [NorthAmerica_UrbanAreas.shp](#), for a continuous extent of all urban centers.
- 3) We used the [Dissolve](#) tool to convert the [NorthAmerica_UrbanAreas.shp](#) to a multipart single polygon layer, [NorthAmerica_UrbanAreas_dissolved.shp](#).
- 4) Next, we used the [Euclidean Distance](#) tool to calculate a continuous raster of distances, in meters, expanding from boundaries of urban centers polygons and extending to the boundaries of North America (the [North_America_Boundary.shp](#) was used as the processing extent for the analysis).
- 5) This process produced a continuous raster file, [distance](#), which extended beyond the boundaries of North America (*this is a processing default output).
- 6) Next, we created a 10×10 km grid fishnet, [Fishnet_10km.shp](#), using the [Create Fishnet](#) tool and clipped the file to the [North_America_Boundary.shp](#).
- 7) To calculate a distance value for each 10×10 km grid block, we reasoned that the distance assigned to the block should be value at the center of the block. Since the [distance](#) file was a continuous raster file with 1×1 km resolution, there were multiple distance values for each 10×10 km grid block. We could only have one value for each block and therefore, we reasoned that the center of the block would be representative of the average travel distance from nearest urban center to that specific 10×10 km grid block.
- 8) To determine the distance value at the center of each 10×10 km grid block, we used the [Feature to Point](#) tool and the [Fishnet_10km.shp](#), as an input file, to create [10km_Fishnet_centerPNTS.shp](#) file, which represents the center point of each 10×10 km grid block.
- 9) Next, we used the [Extract Values to Points](#) tool with the [10km_Fishnet_centerPNTS.shp](#) as the input point file and the [distance](#) file as the input raster, to extract a single distance value to each center point. The new point file that was created, [centerPNTS_distance.shp](#).
- 10) We used the [Export Data](#) function in the attribute table of [centerPNTS_distance.shp](#) file to export values to an Excel file ([distance_toUA.csv](#)). Then we used the join option on the [Fishnet_10km.shp](#) file to join the Excel file with the fishnet file using 'Id' attribute header in the [Fishnet_10km.shp](#) file and the 'ORIG_FID' attribute header in the Excel ([distance_toUA.csv](#)) file. This process affectively joined the single value for distance with its respective 10×10 km grid block. To save the joined file, we used [Export Data](#) function of [Fishnet_10km.shp](#) to create a new file, [Distance_to_UrbanCenters_FINAL.shp](#).
- 11) Since the distance measure was calculated in meters, we converted the values to kilometers by creating a new field, 'Dist_KM' with a 'Float' type. Next, we used the field calculator option in the attribute table to divide the 'RASTERVALU' field by 1,000
- 12) The final product for the distance to urban centers objective is the [Distance_to_UrbanCenters_FINAL.shp](#) file. It can be used to display the distance (in km) to the center of any 10×10 km grid block from the nearest urban center using the 'Dist_KM' attribute header. A visualization of the product is provided below.

*There were three 10×10 km grid blocks that received a value of -9999, indicating that there was no distance data available. There were in the Aleutian Islands of Alaska and were manually edited to reflect the longest possible distance (i.e., 1,460,020 m) from an urban center. Additionally, for the purposes of creating Utility Functions (described elsewhere in the report) distances were converted to a measure of miles.



Impaired Watersheds

Impaired watersheds were identified based on two performance measures. The PLC believes that the level of impairment is related to the percent of land cover that is classified as ‘developed’ and to the amount of phosphorus and nitrogen application for agricultural practices. Two assumptions govern these choices of performance measures: 1) developed land constitutes impermeable surfaces, which increase runoff and prevent water infiltration and 2) nitrogen and phosphorus application increases runoff of nutrients causing eutrophication and negatively impacting water quality.

Phosphorus and Nitrogen Application

Data sources used for this performance measure were downloaded from Socioeconomic Data and Applications Center, hosted by Columbia University ([http://sedac.ciesin.columbia.edu/maps/gallery/search?facets=theme:agriculture&facets=region:north America](http://sedac.ciesin.columbia.edu/maps/gallery/search?facets=theme:agriculture&facets=region:north%20America)). The data represent the amount of nitrogen and phosphorus fertilizer applied, average over all crops within a 0.5-degree grid cell. Grid cell values are expressed in kilograms per hectare ranging from 0-370. The data values were computed by fusing global maps of harvested areas for 175 crops with national information on fertilizer use for each crop.

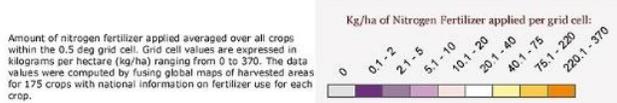
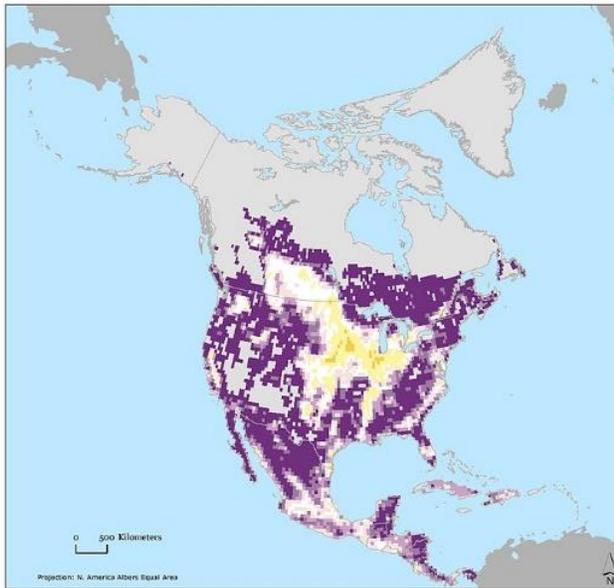
Literature Cited

Potter, P., Ramankutty, N., Bennett, E.M., and Donner, S.D., 2010, Characterizing the spatial patterns of global fertilizer application and manure production: *Earth Interactions*, v. 14, n. 002, p. 1-22. Data distributed by the Socioeconomic Data and Applications Center (SEDAC): <http://sedac.ciesin.columbia.edu/data/collection/fertilizer-and-manure.html>. Accessed 12, November 2017

Potter, P., Ramankutty, N., Bennett, E.M., and Donner, S.D., 2010, Characterizing the spatial patterns of global fertilizer application and manure production: *Earth Interactions*, v. 14, n. 002, p. 1-22. Data distributed by the Socioeconomic Data and Applications Center (SEDAC): <http://sedac.ciesin.columbia.edu/data/collection/fertilizer-and-manure.html>. Accessed 12, November 2017

North America Nitrogen Fertilizer Application

Global Fertilizer and Manure, Version 1

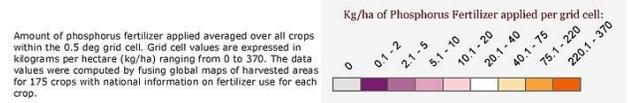
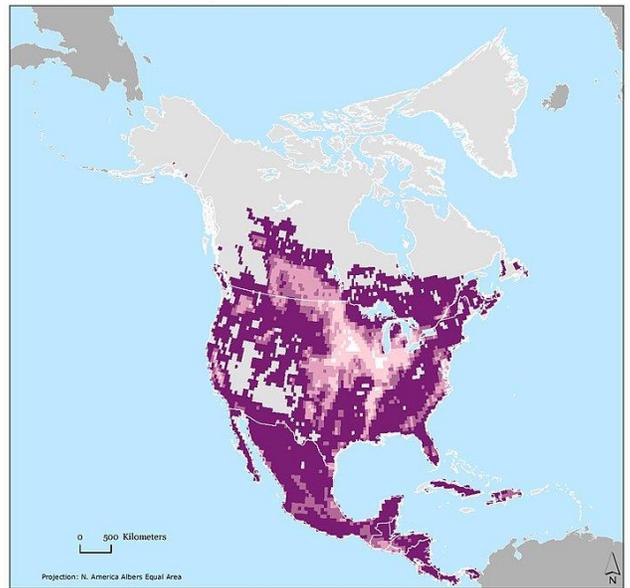


Center for International Earth Science Information Network
 Copyright 2011. The Trustees of Columbia University in the City of New York.
 Source: Potter, P., and N. Ramankutty, et al. (2010). Global Fertilizer Application and Manure Production. Data distributed by the NASA Socioeconomic Data and Applications Center (SEDAC). <http://sedac.ciesin.columbia.edu/data/collection/fertilizer-and-manure>
 Publication Date: 1/24/2011

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North America Phosphorus Fertilizer Application

Global Fertilizer and Manure, Version 1



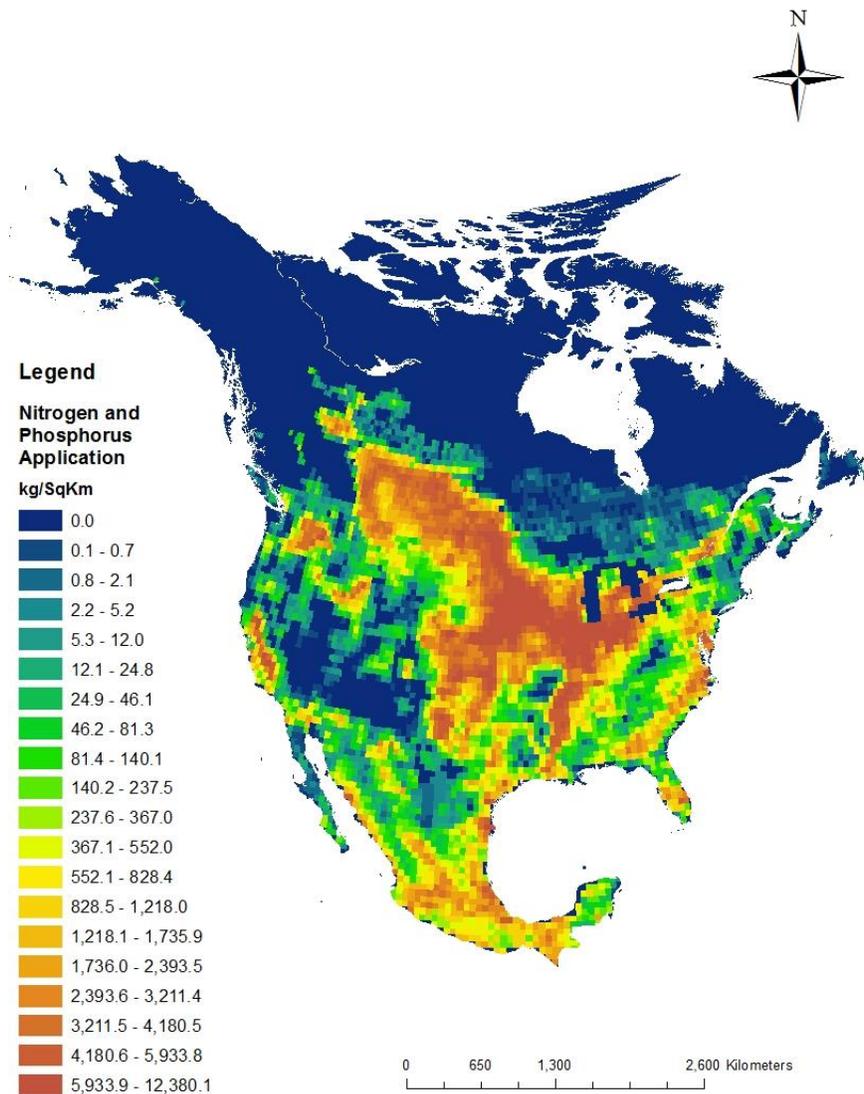
Center for International Earth Science Information Network
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 Source: Potter, P., and N. Ramankutty, et al. (2010). Global Fertilizer Application and Manure Production. Data distributed by the NASA Socioeconomic Data and Applications Center (SEDAC). <http://sedac.ciesin.columbia.edu/data/collection/fertilizer-and-manure>
 Publication Date: 1/24/2011

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Developing Nitrogen and Phosphorus Fertilizer Application Spatial Layer

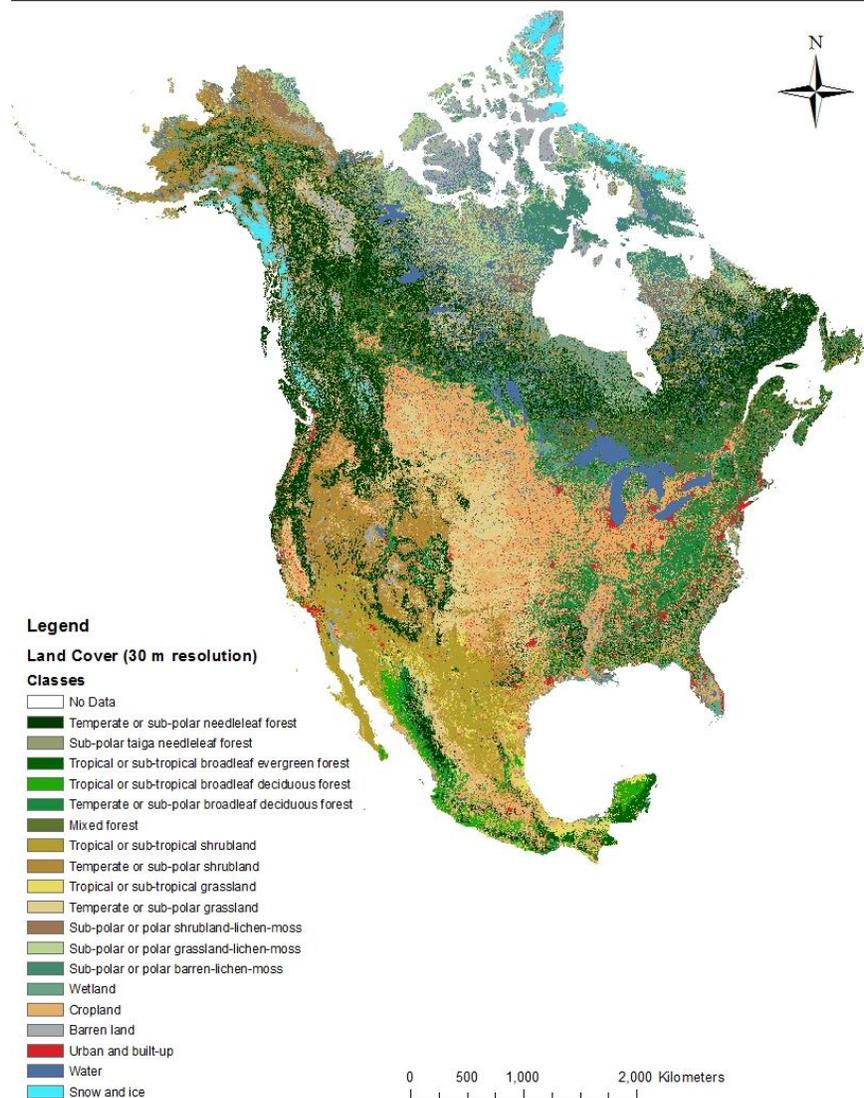
- 1) Two geodatabases were downloaded, one for Nitrogen fertilizer application and the other for Phosphorus fertilizer application (**PFertilizer_namerica_geotif** and **NFertilizer_namerica_geotif**)
- 2) These raster files were added together using the **Cell Statistics** tool and the Nitrogen and Phosphorus application values were summed at a raster cell size of 1×1 km. This was done to get a raster with one value, that is equal to total fertilizer application (kg/ha) per raster cell. The resulting raster file is **fertilizer.tif**.
- 3) Using the **Zonal Statistics** tool, the amount of applied fertilizer (nitrogen and phosphorus) was calculated at the 10×10 km scale.
- 4) To calculate a fertilizer application value for each 10×10 km grid block, we reasoned that the value assigned to the block should be value at the center of the block. 0.5-degree blocks are larger in scale than 10×10 km grid blocks, therefore, only one value should be applicable to the 10×10 km grid.
- 5) To determine the amount of nitrogen and phosphorus applied at each 10×10 km grid block, we used the **Feature to Point** tool and the **Fishnet_10km.shp**, as an input file, to create **10km_Fishnet_centerPNTS.shp** file, which represents the center point of each 10×10 km grid block.
- 6) Next, we used the **Extract Values to Points** tool with the **10km_Fishnet_centerPNTS.shp** as the input point file and the **fertilizer.tif** file as the input raster, to extract a single fertilizer application value to each center point. The new point file that was created, **centerPNTS_fertilizer.shp**.
- 7) We used the **Export Data** function in the attribute table of **centerPNTS_fertilizer.shp** file to export values to an Excel file (**fertilizer_Application.csv**). Then we used the join option on the **Fishnet_10km.shp** file to join the Excel file with the fishnet file using 'Id' attribute header in the **Fishnet_10km.shp** file and the 'ORIG_FID' attribute header in the Excel (**fertilizer_Application.csv**) file. This process affectively joined the single value for amount of fertilizer applied with its respective 10×10 km grid block. To save the joined file, we used the **Export Data** function of **Fishnet_10km.shp** to create a new file, **N_P_FertilizerApplied_FINAL.shp**.
- 8) Since the fertilizer application measure was calculated in kg/ha, we converted the values to kg/km² by creating a new field, 'Fert_SqKm' with a 'Float' type. Next, we used the field calculator option in the attribute table to multiply the 'RASTERVALU' field by 100
- 9) The final product for the Nitrogen and Phosphorus Fertilizer Application objective is the **N_P_FertilizerApplied_FINAL.shp** file. It can be used to display the fertilizer application (kg/km²) per 10×10 km grid block using the 'Fert_SqKm' attribute header. A visualization of the product is provided below.

*There were 14,621 10×10 km grid blocks that received a value of -9999, indicating that there was no fertilizer application data available. These were manually edited to a value of 0, indicating that either no data were available or that no nitrogen or phosphorus fertilizer is applied at the site. Usually these are areas outside of agricultural production zone.



Percent Land in Urban Development

The amount of land classified as ‘developed’ was assumed to be an indication of the impairment status of a watershed. The PLC agreed that using the North American Land Change Monitoring System (2010) was the more appropriate spatial dataset, since it encompassed the entire continent, whereas others (i.e., National Land Cover Dataset, and Cropland Data Layer) only classify land cover in the United States. The spatial dataset was downloaded from Data.gov, a spatial data geodatabase maintained by USGS. (<https://catalog.data.gov/dataset/2010-land-cover-of-north-america-at-250-meters>). There are 20 classes (one of which is classified as No Data) of land cover that are represented. For a full methodology of the development of this data set, please see website cited above.



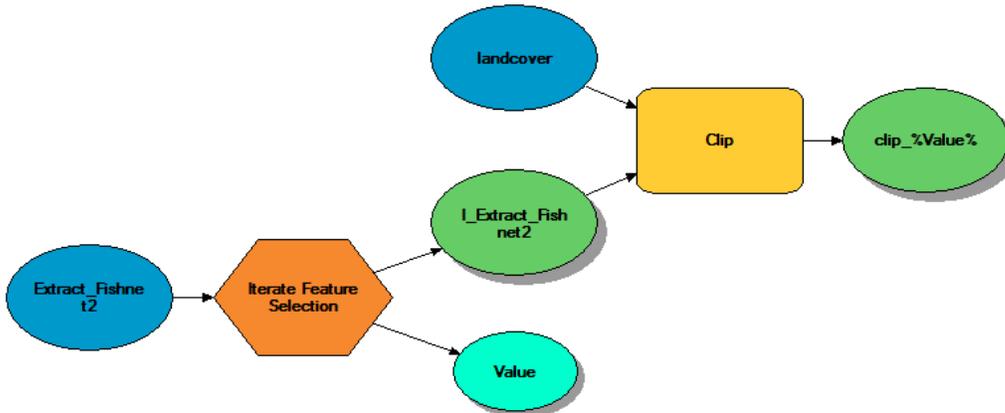
The resolution (30 m resolution) and the storage needs of the original dataset (above) required a great deal of processing power, which made reclassification of the entire dataset impossible. Therefore, we followed the steps below to clip the dataset into manageable pieces and reclassify by sections.

Developing the Percent of Land in Urban Development Spatial Layer

- 1) Original raster file, [NA_NALCMS_LC_30m_LAEA_mmu12_urb05.tif](#) of North American Land Change Monitoring System (2010) was uploaded into ArcGIS Desktop and the, [NALCMS_legend_19class_english.lyr](#), class name layer was used as class name link to display class names.
- 2) We exported the original layer to a grid raster file instead of using the .tif file. This increases processing speed while retaining all relevant data. Additionally, this process allowed us to change the coordinate system to match that of the fishnet used to break up

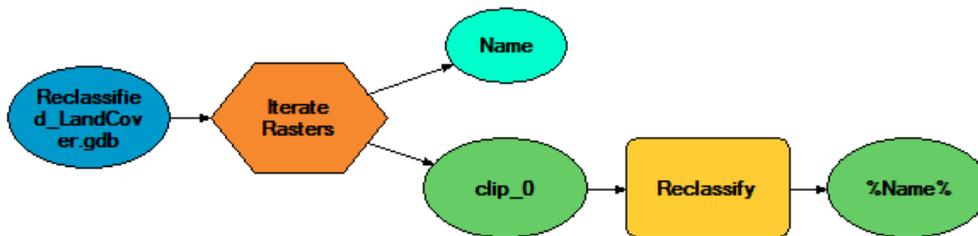
the file (NAD 1983 Albers). The resulting file was named **landcover** and stored in the **LandCover** folder.

- 3) Next, a 500×500 km grid fishnet, **Extract_Fishnet2.shp**, was created for the purposes of breaking up the land cover raster dataset into manageable units (original raster dataset was too large for the computers processing power).
- 4) To automate the process of breaking up the original file, we build a model:



Where, each of 146, 500×500 km grids, was selected one at a time and used as the boundary for clipping, using the **Clip** tool, the land cover dataset. This process resulted in 146 raster files being created, each with a unique name corresponding to the grid cell number and stored in **Extract_LandCover.gdb** geodatabase.

- 5) We also build a model to automate the process of reclassifying 146 rasters. All rasters were reclassified where class 'Urban and built up' was assigned a value of 1 and all other classes were assigned a value of 0.

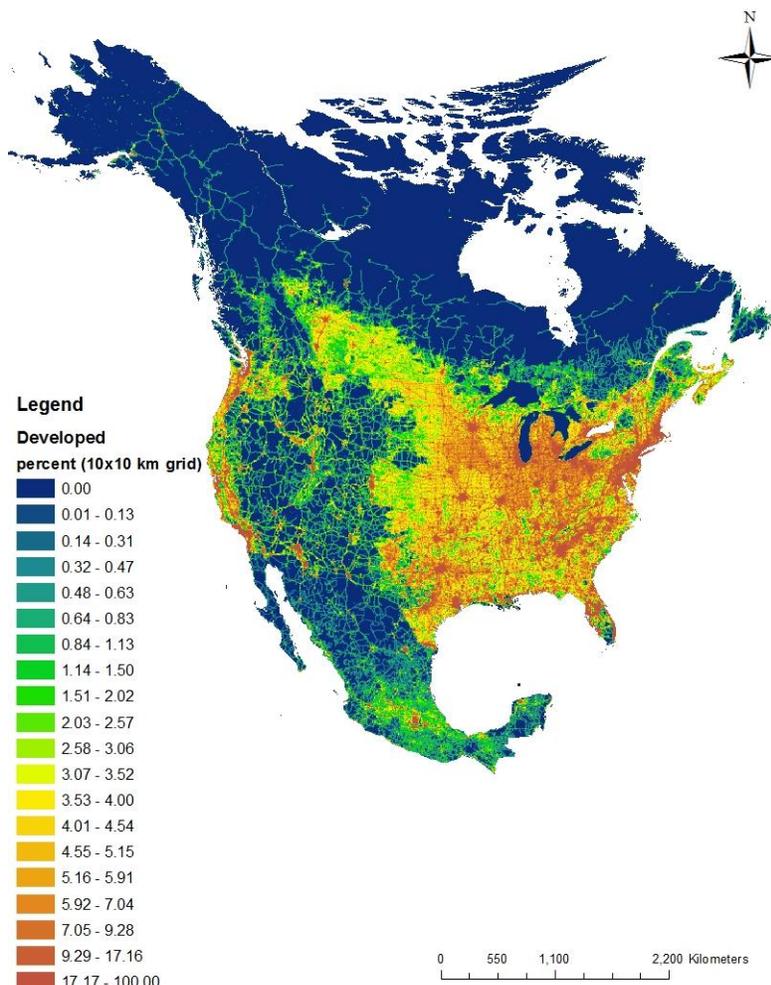


The model above selects one raster at a time from the geodatabase and using the **Reclassify** tool, reclassifies all classes into either, a value of 1 or 0. This process created 146 new raster files each with a unique name and stored in the **Reclassified_LandCover.gdb** geodatabase.

- 6) Next, we used the **Cell Statistics** tool to merge all 146 rasters into one continuous file, **LC_rec.tif**.
- 7) We used the 10x10 km fishnet, **Fishnet_10km.shp**, and **Zonal Statistics as a Table**, with inputs 'Id' as zone field, **LC_rec.tif** as input value raster, and SUM and statistics type to

sum the total number of pixels that had a value of 1 (i.e., classified as ‘Developed and built up’). The resulting table, [zonal_10kmgrid](#) was joined to the [Fishnet_10km.shp](#) file using the ‘Id’ attribute header of the shapefile and the ‘ORIG_FID’ attribute header of the table.

- 8) Next, we used the [Export Data](#) function to create a new file, [PRCNT_Developed_FINAL.shp](#).
- 9) The value under the ‘SUM’ attribute header represents the number of 30×30 m cells that were classified as 1 (i.e., ‘Developed and built up’ class).
 - a. A new attribute field was added, ‘Dev_area’ with float type and was populated using the raster calculator option, where the ‘SUM’ field was multiplied by 900 (30×30 m resolution level of original raster) to get the total amount of land in m² classified as ‘Developed and built up’.
 - b. A new attribute field was added ‘PRCNT_dev’ with float type and populated using the raster calculator option, where then ‘Dev_area’ field was divided by 100,000,000 m (area of 10×10 km grid cells) and multiplied by 100 to get the percent of grid that was in the developed class. The resulting value was the final metric, representing the percent of land in developed and built up category per 10×10 km grid cell.
- 10) The final product for the Percent of Land in Urban Developed Class objective is the [PRCNT_Developed_FINAL.shp](#) file. It can be used to display the percent of developed land per 10×10 km grid block using the ‘RCNT_dev’ attribute header. A visualization of the product is provided below.

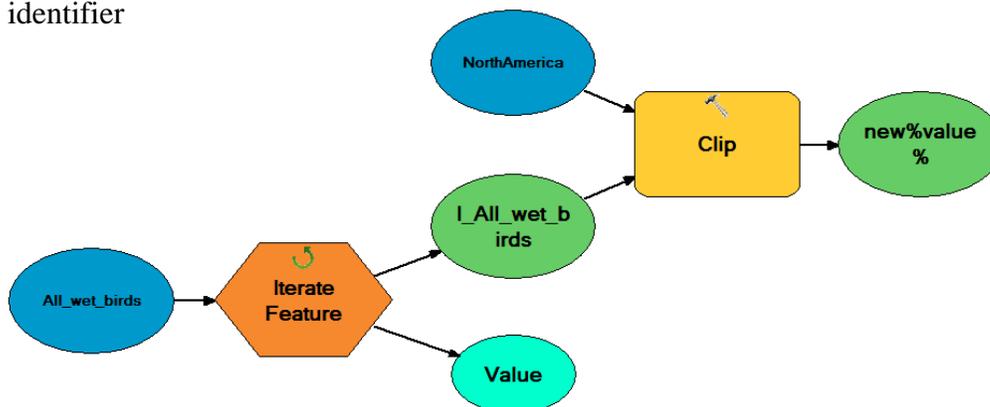


Obligate Wetland Bird Diversity

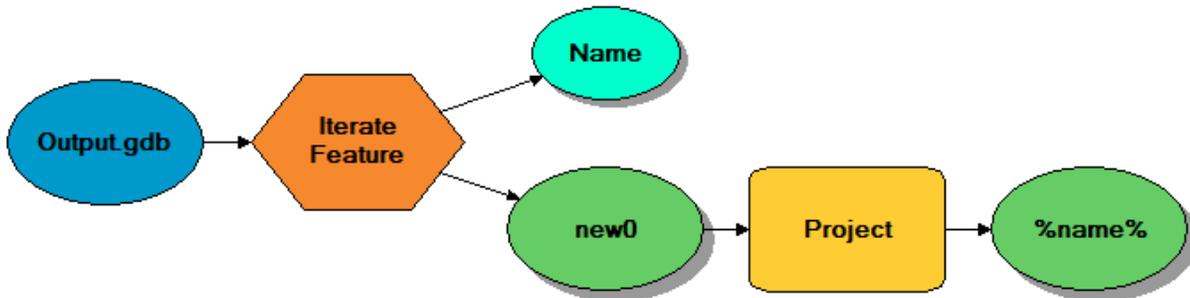
Human Dimensions Working Group preliminary results indicated that bird watcher satisfaction is, to some degree, based on bird diversity. However, since this project deals particularly with waterfowl habitat conservation, the PLC believed that wetland bird diversity is a more accurate representation of the social benefits gained, from the bird watcher stakeholder perspective, when identifying geographies for resource investment in waterfowl habitat conservation. Since accurate density and abundance estimates are not available for many of the wetland bird species, the PLC agreed that spatial layers of wetland bird distributions in North America would sufficiently represent the average wetland bird diversity. The spatial data were obtained from BirdLife International and Handbook of the Birds of the World (2016) Bird species distribution maps of the world. Version 6.0 Geodatabase (Available at <http://datazone.birdlife.org/species/requestdis>). The geodatabase BOTW.gdb was downloaded and used in the following methodology to derive an Obligate Wetland Bird Diversity objective spatially explicit performance measure.

Developing Obligate Wetland Bird Diversity Spatial Layers

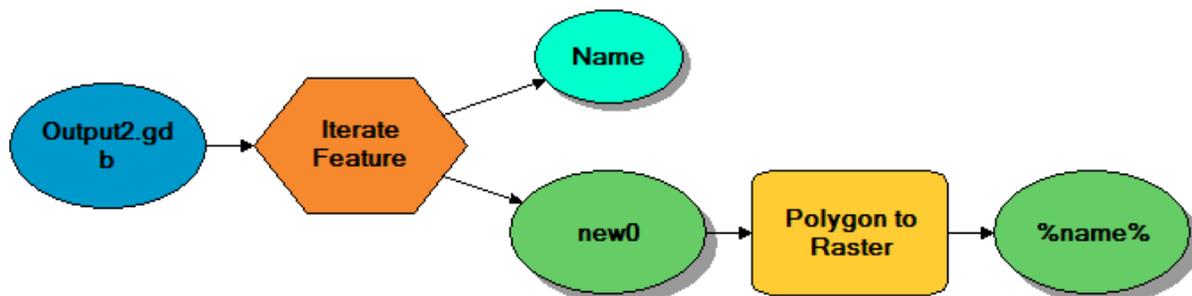
- 1) Geodatabase **BOTW.gdb** (Birds of The World) contains the spatial layers for the distribution for over >10,000 birds around the world. We used the spatial layer in the geodatabase and the **Clip** tool to cut the distribution layers of all bird species to the North American Boundary layer, **NorthAmerica.shp**. This produced a new shapefile, **All_birds.shp**.
- 2) **All_birds.shp** contained multiple entries per species, representing, resident, breeding and non-breeding ranges. We used the **Dissolve** tool to dissolve multiple species entries by scientific name. This process produced a new shapefile, **All_birds2.shp**, which has a single distribution polygon per bird species.
- 3) Next, we used the list of obligate wetland bird species (n=156, see table below) to select all entries that constituted wetland birds and export them to a new file, **All_wet_birds.shp**.
 - a. We added a new attribute field, 'value', with 'Short Integer' as type and populated the column with the value 1. This represented that a species was present, based on the boundary of the distribution polygon.
- 4) We built a model to separate the 156 bird species into individual shapefiles and stored in the geodatabase, **Output.gdb**. We used the **All_wet_birds.shp** as the input file and the **NorthAmerica.shp** as the clip file to create 156 individual polygons, each with a unique identifier



- 5) We re-projected the all shapefiles in **Output.gdb** from WGS 1984 coordinate system to North America Albers Equal Area Conic coordinate system, using a model. (This was done for technical purposes and computational ease.) The results were stored in **Output2.gdb**.



- 6) Then, we created another model to convert all 156 polygon files into raster files with attribute field 'value' as the raster value (i.e., 1 because the raster cell value where bird species was present). The model used the **Output2.gdb** as the input feature and the Polygon to Raster tool as the converting function. The resulting 156 rasters were stored in **Output3.gdb**.

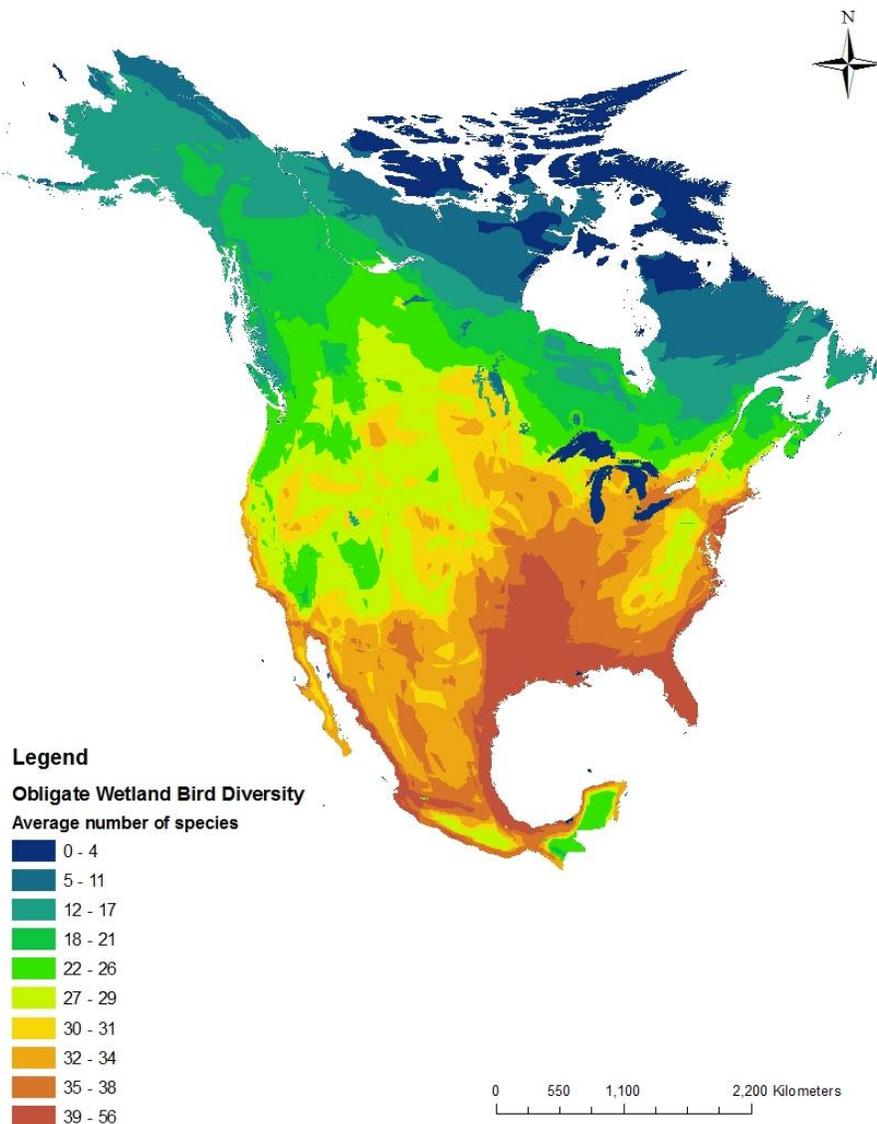


- 7) Finally, we used the **Cell Statistics** tool to aggregate all 156 raster layers, with the raster cell output being the sum of the values (i.e., the number of overlapping 'presence' cells). This process created a new raster file, **wet_bird_div**.
- 8) Next, we used the **Extract Values to Points** tool with the **10km_Fishnet_centerPNTS.shp** as the input point file and the **wet_bird_div** file as the input raster, to extract a single average wetland bird diversity value to each center point. The new point file that was created, **Wet_Bird_Div_toCenterPNTS.shp**.
- 9) We used the **Export Data** function in the attribute table of **centerPNTS_fertilizer.shp** file to export values to an Excel file (**Wetland_Bird_Diversity.csv**). Then we used the join

option on the [Fishnet_10km.shp](#) file to join the Excel file with the fishnet file using 'Id' attribute header in the [Fishnet_10km.shp](#) file and the 'ORIG_FID' attribute header in the Excel ([Wetland_Bird_Diversity.csv](#)) file. This process affectively joined the single value for the average obligate wetland bird diversity with its respective 10×10 km grid block. To save the joined file, we used the [Export Data](#) function of [Fishnet_10km.shp](#) to create a new file, [Wetland_Bird_Diversity_FINAL.shp](#).

10) The final product for the Obligate Wetland Bird Diversity objective is the [Wetland_Bird_Diversity_FINAL.shp](#) file. It can be used to display average obligate wetland bird diversity per 10×10 km grid block using the 'RASTERVALU' attribute header. A visualization of the product is provided below.

*There were 3,853 10×10 km grid blocks that received a value of -9999, indicating that there was wetland bird distribution data available. These were manually edited to a value of 0, indicating that either no data were available or that obligate wetland birds were at this site.



List of Species Considered Obligate Wetland Bird Species (State of the Birds 2011)

Actitis macularius	Calidris himantopus	Hydroprogne caspia	Phalaropus lobatus
Aechmophorus clarkii	Calidris mauri	Ixobrychus exilis	Phoenicopterus ruber
Aechmophorus occidentalis	Calidris melanotos	Larus californicus	Platalea ajaja
Agelaius phoeniceus	Calidris minutilla	Larus canus	Plegadis chihi
Agelaius tricolor	Calidris pusilla	Larus delawarensis	Plegadis falcinellus
Aix sponsa	Charadrius melodus	Larus hyperboreus	Pluvialis squatarola
Anas acuta	Charadrius nivosus	Larus marinus	Podiceps griseigena
Anas crecca	Charadrius semipalmatus	Larus philadelphia	Podiceps nigricollis
Anas fulvigula	Chlidonias niger	Larus pipixcan	Podilymbus podiceps
Anas platyrhynchos	Chloroceryle americana	Laterallus jamaicensis	Polysticta stelleri
Anas rubripes	Cinclus mexicanus	Limnodromus griseus	Porphyrio martinicus
Anhinga anhinga	Cistothorus palustris	Limnodromus scolopaceus	Porzana carolina
Anser albifrons	Cistothorus platensis	Limnolyphus swainsonii	Protonotaria citrea
Anser caerulescens	Clangula hyemalis	Limosa fedoa	Pyrocephalus rubinus
Anser canagicus	Coturnicops noveboracensis	Limosa haemastica	Quiscalus major
Anser rossii	Cygnus buccinator	Lophodytes cucullatus	Rallus crepitans
Aramus guarana	Cygnus columbianus	Mareca americana	Rallus elegans
Ardea alba	Cygnus olor	Mareca strepera	Rallus limicola
Ardea herodias	Cypseloides niger	Megaceryle alcyon	Recurvirostra americana
Arenaria melanocephala	Dendrocygna autumnalis	Megaceryle torquata	Rostrhamus sociabilis
Aythya affinis	Dendrocygna bicolor	Melanitta americana	Sayornis nigricans
Aythya americana	Egretta caerulea	Melanitta deglandi	Setophaga palmarum
Aythya collaris	Egretta thula	Melanitta perspicillata	Somateria fischeri
Aythya marila	Egretta tricolor	Melospiza georgiana	Somateria spectabilis
Aythya valisineria	Empidonax traillii	Melospiza lincolni	Spatula clypeata
Botaurus lentiginosus	Eudocimus albus	Mergus merganser	Spatula cyanoptera
Branta bernicla	Euphagus carolinus	Mergus serrator	Spatula discors
Branta canadensis	Fulica americana	Mycteria americana	Stercorarius pomarinus
Branta hutchinsii	Gallinago delicata	Nomonyx dominicus	Sterna forsteri
Bubulcus ibis	Gavia adamsii	Nyctanassa violacea	Sterna hirundo
Bucephala albeola	Gavia arctica	Nycticorax nycticorax	Sterna paradisaea
Bucephala clangula	Gavia immer	Oxyura jamaicensis	Sternula antillarum
Bucephala islandica	Gavia pacifica	Pandion haliaetus	Tachybaptus dominicus
Buteogallus anthracinus	Gavia stellata	Parkesia motacilla	Tringa flavipes
Calidris alba	Geothlypis trichas	Parkesia noveboracensis	Tringa melanoleuca
Calidris alpina	Grus americana	Pelecanus erythrorhynchos	Tringa semipalmata
Calidris bairdii	Haliaeetus leucocephalus	Phalacrocorax auritus	Tringa solitaria
Calidris canutus	Histrionicus histrionicus	Phalacrocorax brasilianus	Xanthocephalus xanthocephalus
Calidris fuscicollis	Hydrocoloeus minutus	Phalaropus fulicarius	Xema sabini

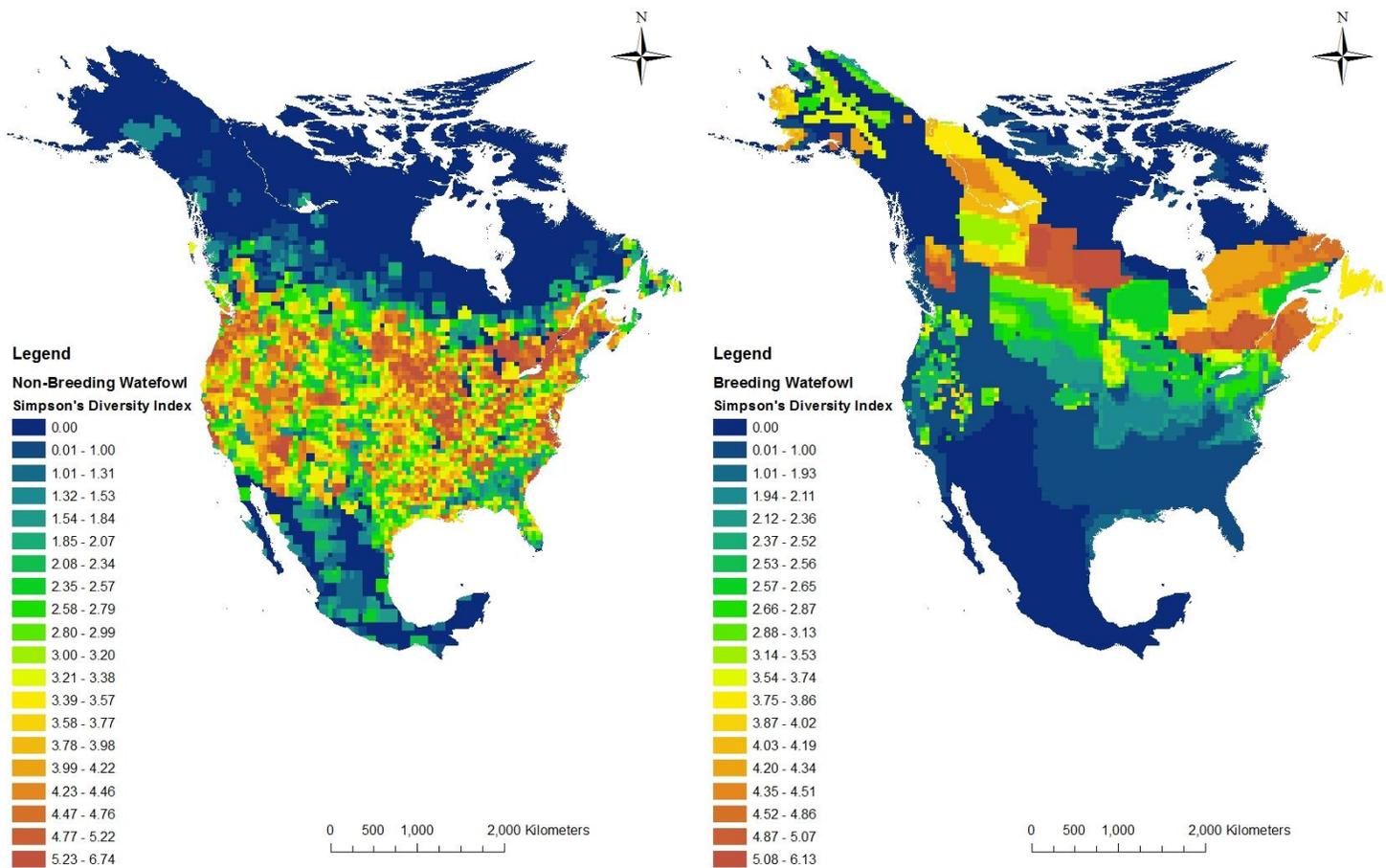
Breeding and Non-Breeding Waterfowl Simpson's Reciprocal Index of Species Diversity

Human Dimensions Working Group preliminary results indicated that waterfowl diversity was a contributing factor to waterfowl hunter satisfaction. The PLC reasoned that focusing waterfowl habitat conservation resources in geographies of high breeding and non-breeding waterfowl diversity would, in theory, increase hunter satisfaction and thus promote retention, recruitment and reactivation (an untested assumption). We have already calculated breeding waterfowl abundance at the continental scale for 9 species/guilds and duck use days for the same species/guilds at the 50×50 km scale (See Supplement 1 and 2). The PLC decided that the Simpson's Reciprocal Index of Species Diversity (which also accounts for species composition) would be an appropriate performance measure to identify geographies of high breeding and non-breeding waterfowl diversity. However, since this is a social objective the diversity index needed to be calculated at the 10×10 km scale. The methods for calculating these performance measures are described below.

Developing the Breeding and Non-Breeding Waterfowl Simpson's Reciprocal Index of Species Diversity

- 1) Using spatial layers created in Supplement 1, [50_ABDU_Breeding2.shp](#), [50_MALL_Breeding2.shp](#), [50_NOPI_Breeding2.shp](#), [50_WODU_Breeding2.shp](#), [50_SCAU_Breeding2.shp](#), [50_DaddGrN_Breeding2.shp](#), [50_DivinCaN_Breeding2.shp](#), [50_DivinOvN_Breeding2.shp](#), and [50_DivinGrN_Breeding2.shp](#), we used the [Export Data](#) function of the attribute table to create 9, temporary, Excel (.csv) spreadsheets, titled with their respective species/guild name.
- 2) Next, the columns from each of the 9 Excel spreadsheets, were first sorted by ascending order of the Grid_ID (representing the individual 50×50 km grid blocks) and then combined into one file, [Waterfowl_SDI](#), in tab [Breeding_Waterfowl_SDI](#).
 - a. First, the SUM of all species/guild per 50×50 km grid block was calculated in a separate column in the spreadsheet. Then, the individual species/guild abundance was divided by the SUM for that particular 50×50 km grid block. That value was then squared. Finally, the squared values were summed, and an inverse of the sum calculated.
 - b. This inverse value is the Simpson's Reciprocal Index of Species Diversity per unique 50×50 km grid block.
- 3) Using spatial layers created in Supplement 2, [50_ABDU_NonBreeding2.shp](#), [50_MALL_NonBreeding2.shp](#), [50_NOPI_NonBreeding2.shp](#), [50_WODU_NonBreeding2.shp](#), [50_SCAU_NonBreeding2.shp](#), [50_DaddGrN_NonBreeding2.shp](#), [50_DivinCaN_NonBreeding2.shp](#), [50_DivinOvN_NonBreeding2.shp](#), and [50_DivinGrN_NonBreeding2.shp](#), we used the [Export Data](#) function within the attribute table to create 9, temporary, Excel (.csv) spreadsheets, titled with their respective species/guild name.
- 4) Next, the columns from each of the 9 Excel spreadsheets, were first sorted by ascending order of the Grid_ID (representing the individual 50×50 km grid blocks) and were then combined into one file, [Waterfowl_SDI](#), in tab [NonBreeding_Waterfowl_SDI](#).
 - a. First, the SUM of all species/guild Duck Use Days per 50×50 km grid block was calculated in a separate column in the spreadsheet. Then, the individual

- species/guild DUD was divided by the SUM for that particular 50×50 km grid block. That value was then squared. Finally, the squared values were summed, and an inverse of the sum calculated. (*Duck Use Days can be first converted to abundance measures by dividing the DUD values by 242, the planning period. However, this will not change the SDI value results).
- b. This inverse value is the Simpson's Reciprocal Index of Species Diversity per unique 50×50 km grid block.
- 5) We used the **Fishnet_50km.shp** as the join file to display the breeding and non-breeding waterfowl SDI values.
 - a. We created two new fields, 'SDI_Breed' and 'SDI_NonBre', both with 'Float' type metric parameter, in the **Fishnet_50km.shp** file.
 - b. Next, making sure the 'FID' field is sorted in ascending order, we used the edit function to manually copy and paste values from the two SDI columns (highlighted in yellow) in **Waterfowl_SDI** Excel spreadsheet into the fields of the **Fishnet_50km.shp** file. Edits were saved.
 - 6) Next, we used the **Intersect** tool to extract values from the **Fishnet_50km.shp** file to **10km_Fishnet_centerPNTS.shp** file. This process created a new point file, **10km_Fishnet_centerPNTS_withSDI_values.shp**, which contained both, the Breeding SDI value and the Non-Breeding SDI value for each center point of the 10×10 km grid blocks center points.
 - 7) We used the **Export Data** function of the attribute table to create a new Excel file (.csv), **10km_Fishnet_centerPNTS_withSDI_values**.
 - 8) The resulting table, **10km_Fishnet_centerPNTS_withSDI_values** was joined to the **Fishnet_10km.shp** file using the 'Id' attribute header of the shapefile and the 'ORIG_FID' attribute header of the table. To save the data, we used **Export Data** function and created two new files, **Breeding_WaterfowlSDI_FINAL.shp** and **NonBreeding_WaterfowlSDI_FINAL.shp**.
 - a. Finally, we deleted the field 'SDI_NonBre' and 'SDI_Breed' from **Breeding_WaterfowlSDI_FINAL.shp** and **NonBreeding_WaterfowlSDI_FINAL.shp**, respectively.
 - 9) The final two spatial layers, **Breeding_WaterfowlSDI_FINAL.shp** and **NonBreeding_WaterfowlSDI_FINAL.shp**, represent the Simpsons Reciprocal Index of Species Diversity of Breeding Waterfowl and Non-Breeding Waterfowl objectives, respectively, at the 10×10 km grid scale. The visuals for the final spatial layers are provided below.



Hunter Days Afield

The number of duck and goose hunter days afield is a baseline for current hunting demand in North America. The PLC reasoned that focusing resources in geographies where hunter days afield is high, would increase opportunity for hunters and thus encourage recruitment, reactivation and retention of waterfowl hunters (an untested assumption). The data to develop this spatial layer were provided by U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Branch of Harvest Surveys. Harvest data are collected by several surveys in the United States (i.e., National Duck Hunter Survey, Harvest Diary Survey, and Parts Collection Survey, USFWS, unpublished data) and duck and goose hunter days afield are reported separately at the county level. For Canada, National Harvest Survey data were used and can be downloaded from Government of Canada website (<https://wildlife-species.canada.ca/harvest-survey/?do=def&lang=e>). In Canada, hunter days afield is reported as total waterfowl hunting days at the Province hunting zone scale. Comparable data for Mexico were not available. Due to the discrepancies in the data for the three nations, this performance measure was treated with caution as a representation of waterfowl hunting demand.

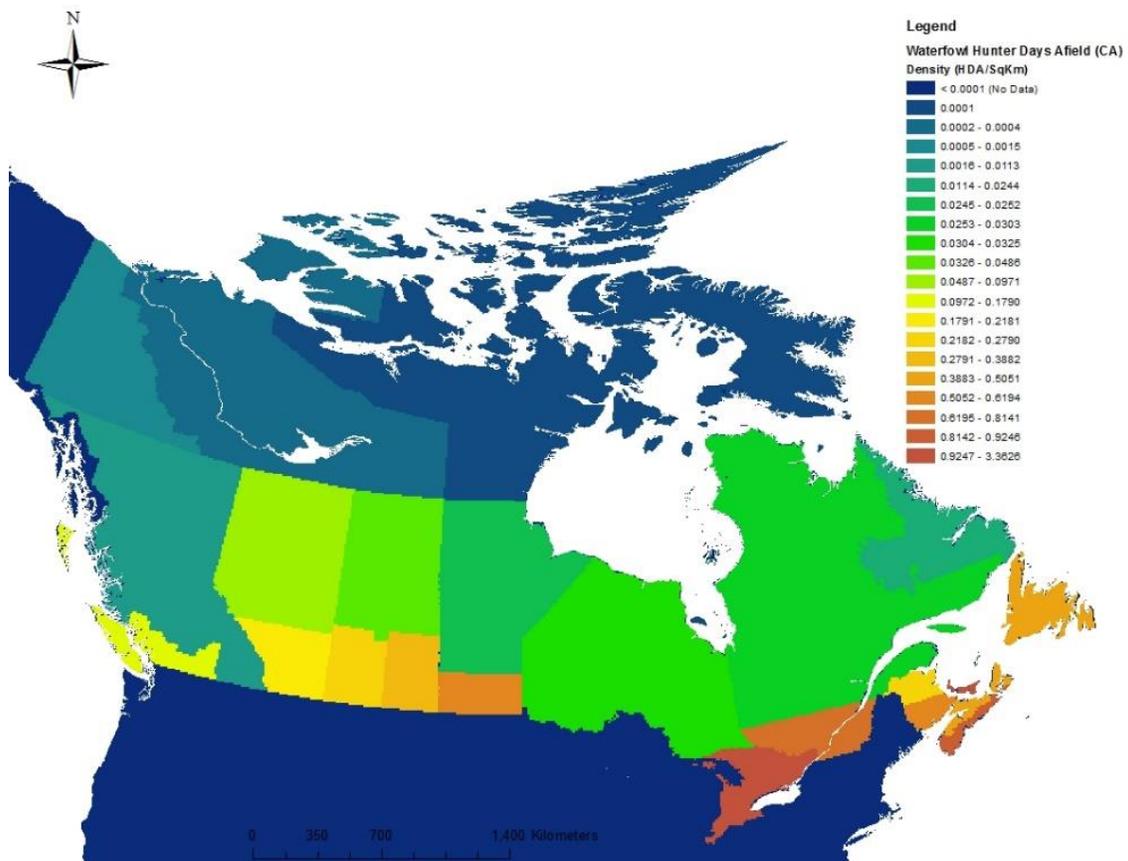
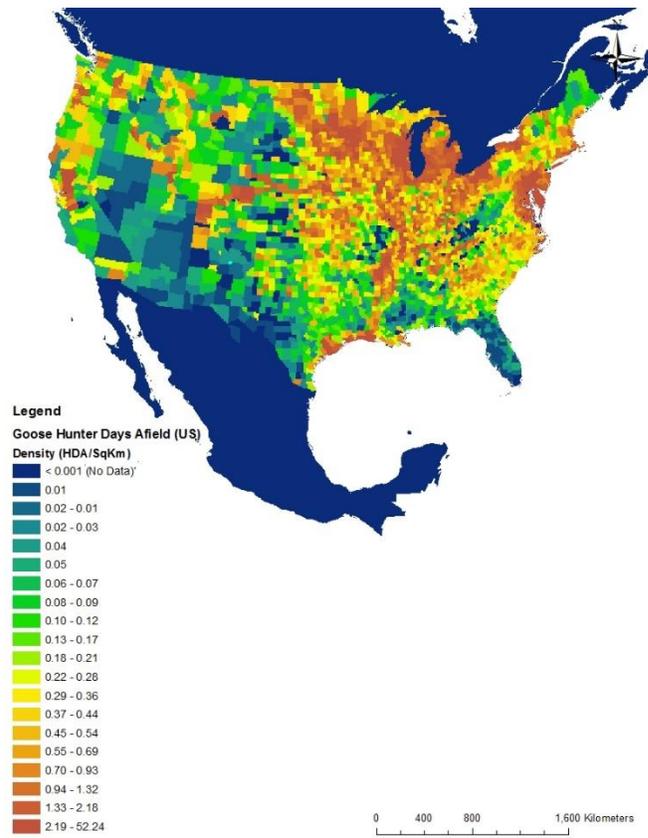
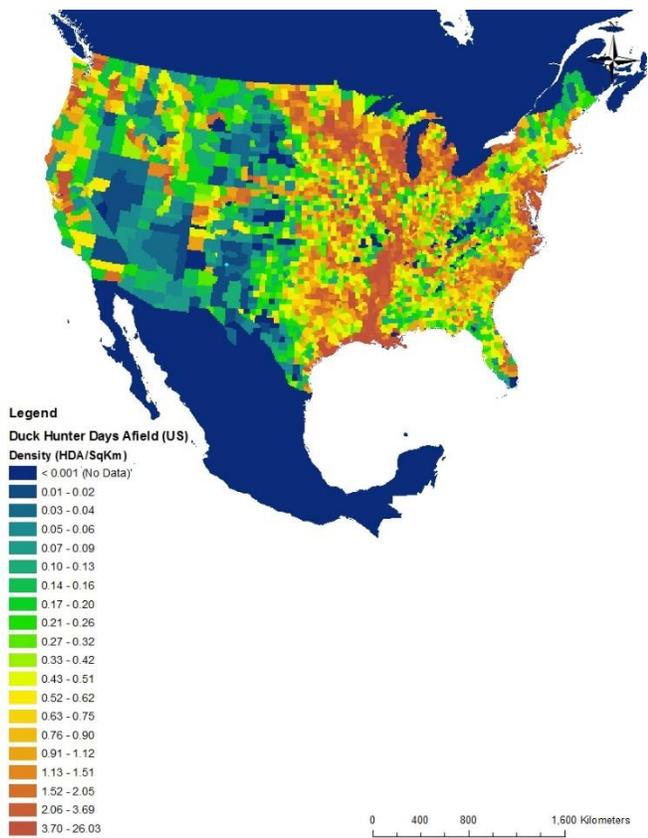
Developing the Hunter Days Afield Spatial Layer

- 1) Original data of Hunter Days Afield for ducks and geese for the United States, provided by the US Fish and Wildlife Service, and was stored in **US_HDA_DucksNGeese** Excel spreadsheet, **CountyDays** tab.

- a. Data for Duck HDA and Goose HDA was separated into two new tabs, **US_Duck_HDA** and **US_Goose_HDA**, respectively, and sorted by year. Data range spanned from 2005 to 2016, representing the current baseline.
 - b. We calculated the average for each county, represented by a unique identifier (i.e., FIPS), across all year were data were available for booth Duck HDA and Goose HDA.
 - c. Next, we created two new Excel (.csv) spreadsheets, **US_Duck_HDA2** and **US_Goose_HDA2** and copied and pasted the data from **US_HDA_DucksNGeese** with 'FIPS', Duck_HDA, and Goose_HDA fields (average value fields), respectively, into the new spreadsheets. These spreadsheets, **US_Duck_HDA2** and **US_Goose_HDA2**, were saved in the **8_HunterDaysAfield** folder in the geodatabase for subsequent use.
- 2) Original data of Waterfowl Hunting Days (Ducks and Geese combined) for Canada was downloaded from Government of Canada website and stored in **CA_HDA_AllHunters** Excel spreadsheet, **DaysHunting_watefowl** tab.
 - a. Data included categories for 'All hunters', 'Canadian Hunters', and 'Non-Canadian Hunters' from 2001 to 2016, representing the current baseline.
 - b. We calculated the average for each Hunting Zone, represented by a unique identifier, using only data for 'All Hunters' across all years where data were available.
 - c. Next, we created a new Excel (.csv) spreadsheet, **CA_HDA**, and copied and pasted the columns for Hunting Zone, renaming it 'FIPS' and the average values of waterfowl HDA, renaming the column 'CA_HDA'. The **CA_HDA** file was saved in the **8_HunterDaysAfield** folder in the geodatabase for subsequent use.
- 3) In ArcGIS, we merged the **US_Counties.shp** file, which had a 'FIPS' attribute as unique identifier of each county, and the **CA_HuntignZones.shp** file, which used 'pzone' field as unique identifier of each hunting zone. This process created a new file, **CA_US_merge.shp**.
 - a. Next, we created a new field in the **CA_US_merge.shp** file, labeling it 'FIPS2' and assigning it a text type with 10 characters. We populated the field with the 'FIPS' values for the US counties and the 'pzone' values for Canadian hunting zones.
- 4) We imported the Excel tables for **US_Duck_HDA2**, **US_Goose_HDA2**, and **CA_HDA** and joined each Excel table to the **CA_US_Merge.shp** file using the 'FIPS2' field and the 'FIPS' field identified in the tables. We saved the joined data by exporting the shapefile to create, **CA_US_HDA.shp**. Then, we deleted the irrelevant 'FIPS' fields, leaving only the 'FIPS2' field and the 'Duck_HDA', 'Goose_HDA', and 'CA_HDA' fields.
 - a. We also deleted all entries for which 'Duck_HDA', 'Goose_HDA', and 'CA_HDA' values were equal to 0. These indicated counties in the US for which there was no HDA data reported in the survey years from 2005-2016.
- 5) We then used the Erase tool to erase all areas with values for HDA, file **CA_US_HDA.shp**, from the spatial boundary of North America, file **North_America_Boundary.shp**. The created file, **North_America_Boundary2.shp**, was then merged with the **CA_US_HDA.shp** to create **CA_US_HDA2.shp**. This process affectively filled in the areas where no HDA data were available (including Mexico) and

assigned those areas a value of 0 for 'Duck_HDA', 'Goose_HDA', and 'CA_HDA' attributes.

- a. We added four new fields to the **CA_US_HDA2.shp** file, 'Area_sqkm', 'D_HDA_Dens', 'G_HDA_Dens', and 'W_HDA_Dens', each with a 'Float' type parameter.
 - b. We calculated area in square kilometers in the 'Area_sqkm' field using **Calculate Geometry**, and the Density of Duck, Goose, and Waterfowl Hunter Days Afield in the 'D_HDA_Dens', 'G_HDA_Dens', and 'W_HDA_Dens', respectively, using the 'Field Calculator' feature of the attribute table.
- 6) Next, we used the **Intersect** tool to extract values from the **CA_US_HDA2.shp** file to **10km_Fishnet_centerPNTS.shp** file. This process created a new point file, **10km_Fishnet_centerPNTS_withHDA_values.shp**, which contained the US Duck HDA Density, US Goose HDA Density, and Canadian Waterfowl HDA Density values for each center point of the 10×10 km grid blocks.
- 7) We used the **Export Data** function of the attribute table to create a new Excel file (.csv), **10km_Fishnet_centerPNTS_withHDA_values**.
- 8) The resulting table, **10km_Fishnet_centerPNTS_withHDA_values**, was joined to the **Fishnet_10km.shp** file using the 'Id' field of the shapefile and the 'ORIG_FID' field of the table. To save the data, we used the **Export Data** function and created three new files, **US_DuckHDA_FINAL.shp**, **US_GooseHDA_FINAL.shp**, and **CA_WaterfowlHDA_FINAL.shp**.
- a. Finally, we deleted all fields except 'ORIG_FID', 'D_HDA_Dens', 'G_HDA_Dens', and 'W_HDA_Dens' from **US_DuckHDA_FINAL.shp**, **US_GooseHDA_FINAL.shp**, and **CA_WaterfowlHDA_FINAL.shp**, respectively.
- 9) The final three spatial layers, **US_DuckHDA_FINAL.shp**, **US_GooseHDA_FINAL.shp**, and **CA_WaterfowlHDA_FINAL.shp**, represent the Hunter Days Afield objective (Broken up by Nation due to data discrepancies), at the 10×10 km grid scale. The visuals for the final spatial layers are provided below.



Supplement 5.

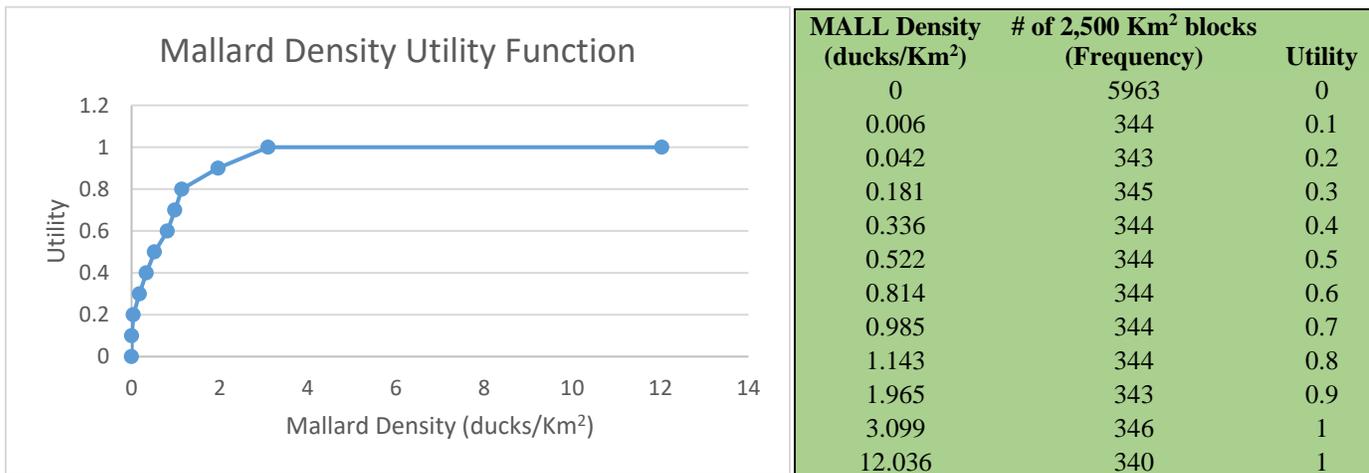
Utility Functions and Spatial Layer Standardization for Biological and Social Objectives

Following the framework of Multi Attribute Utility Theory (MAUT) the aggregation of multiple objectives, each with a different performance measure metric, requires the standardization of all performance measures to the same scale (0 to 1). Utility functions (also called value functions, Keeney and Raiffa, 1993; Edwards and others, 2007) are used to standardize performance measures of multiple objectives on the same scale, which reflect the preference of the decision maker along a gradient of possible outcomes in the decision space. The PLC determined utility functions for each objective (i.e., performance measure) through a series of discussions.

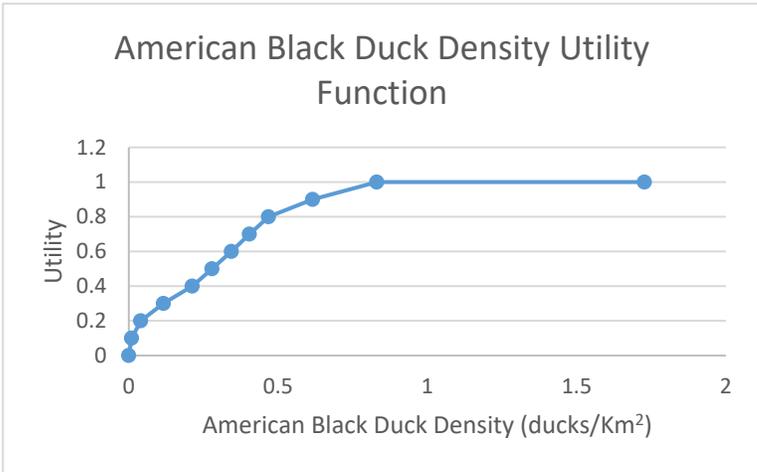
Breeding Waterfowl Utility Functions

The spatial layer of breeding waterfowl distribution and density (and abundance) are not readily comparable to one another (for different species/guilds). For breeding waterfowl, utility functions were developed based on the deciles of each species' distribution of breeding densities. Utility functions were based on densities, although they would be similar to those developed based on abundance, because the density spatial layers were chosen for the aggregation process into several final products. For each species/guild the utility function used to standardize densities are presented below. Generally, for breeding waterfowl densities, preference for higher breeding density increases sharply and plateaus once a threshold is reached (the threshold differs for each breeding species/guild). Additionally, the inflection points for each decile are presented in the table to the right of the utility function along with the number of 2,500 km² block that fall into that percentile range. Area of each density category can be calculated by multiplying the frequency by 2,500 km².

Mallard

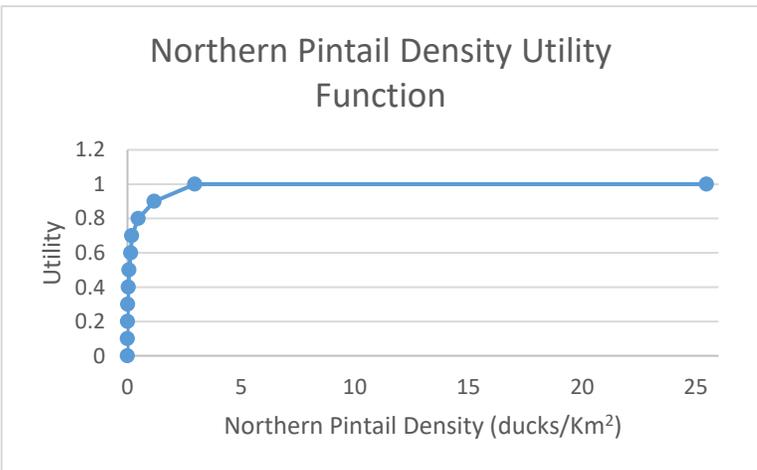


American Black Duck



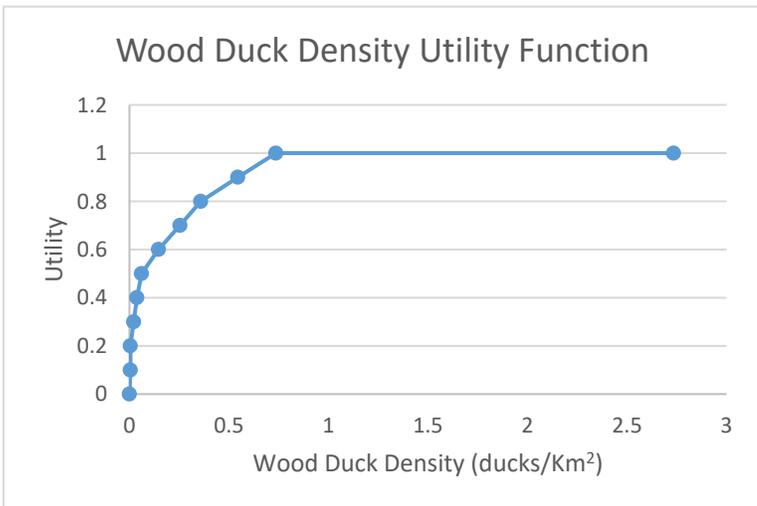
ABDU Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	8485	0
0.0097	115	0.1
0.040	115	0.2
0.116	115	0.3
0.213	83	0.4
0.279	148	0.5
0.344	118	0.6
0.404	68	0.7
0.468	223	0.8
0.616	44	0.9
0.831	172	1
1.727	58	1

Northern Pintail



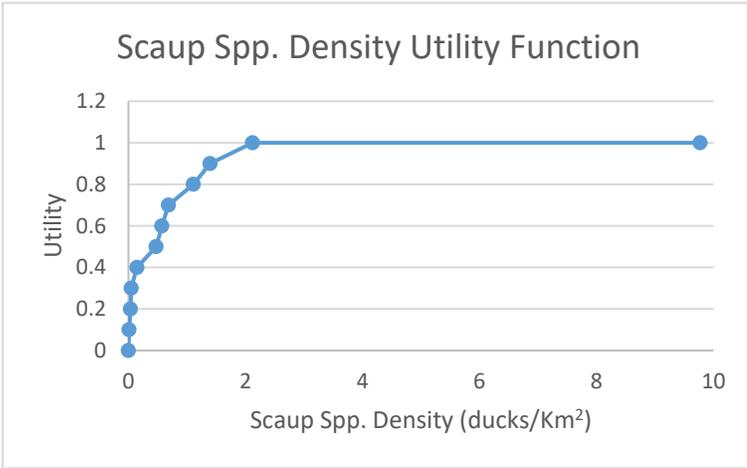
NOPI Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	7584	0
0.001	252	0.1
0.007	191	0.2
0.016	191	0.3
0.042	191	0.4
0.074	192	0.5
0.147	191	0.6
0.194	191	0.7
0.480	191	0.8
1.181	200	0.9
2.966	185	1
25.477	185	1

Wood Duck



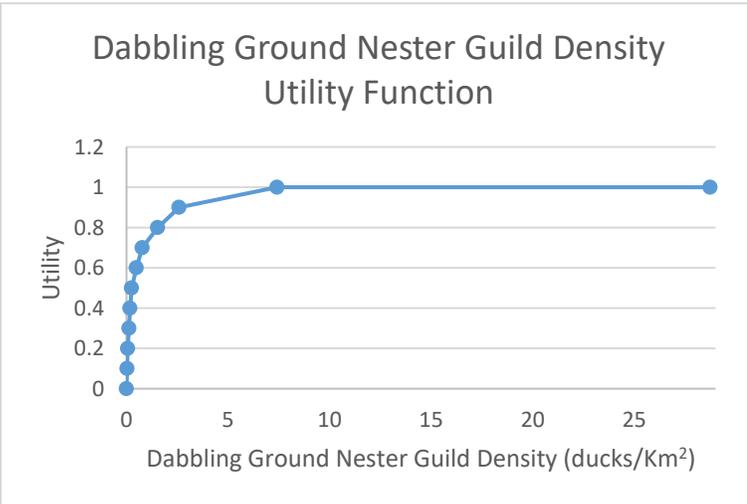
WODU Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	5048	0
0.005	265	0.1
0.006	739	0.2
0.021	376	0.3
0.037	436	0.4
0.061	533	0.5
0.146	264	0.6
0.254	503	0.7
0.359	437	0.8
0.545	365	0.9
0.736	394	1
2.734	384	1

Scaup Spp.



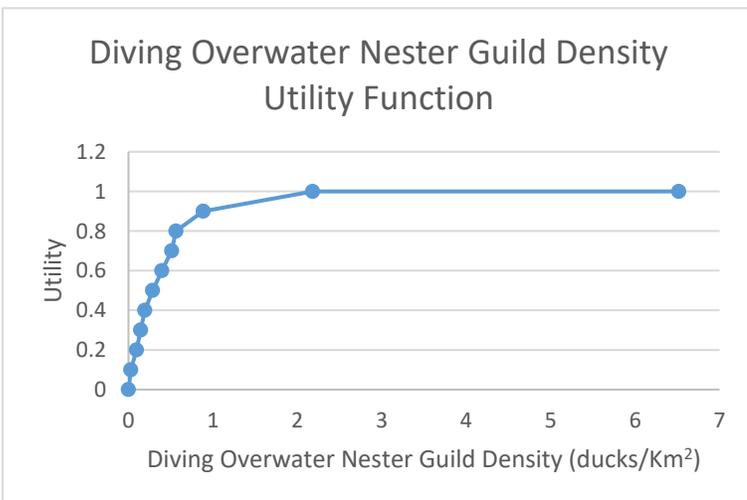
SCAU Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	7625	0
0.011	192	0.1
0.036	192	0.2
0.047	209	0.3
0.146	191	0.4
0.473	191	0.5
0.572	192	0.6
0.685	191	0.7
1.110	191	0.8
1.396	190	0.9
2.123	188	1
9.772	192	1

Dabbling Ground Nesters



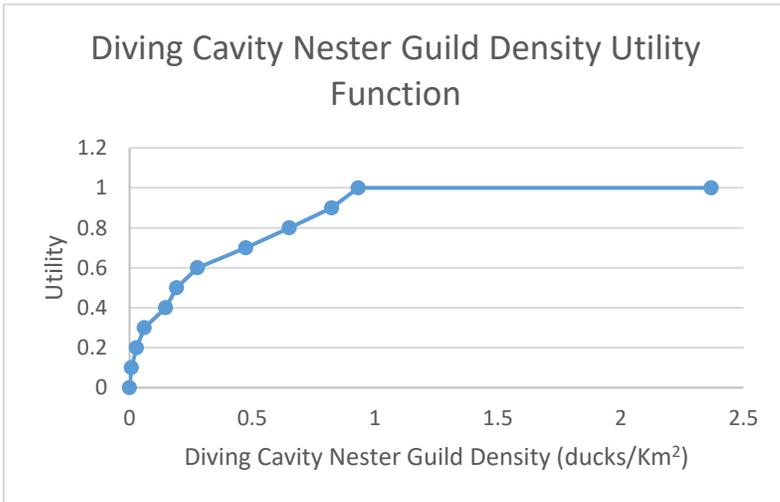
DabbGrN Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	5920	0
0.030	347	0.1
0.064	348	0.2
0.124	349	0.3
0.177	348	0.4
0.256	414	0.5
0.492	337	0.6
0.774	337	0.7
1.541	336	0.8
2.591	364	0.9
7.416	320	1
28.740	324	1

Diving Overwater Nesters



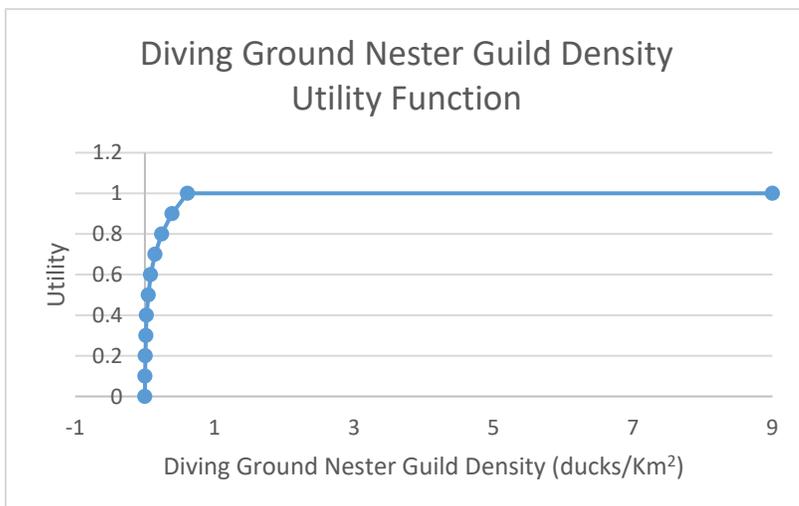
DivinOvN Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	6505	0
0.029	294	0.1
0.095	297	0.2
0.145	294	0.3
0.194	358	0.4
0.287	299	0.5
0.399	372	0.6
0.511	265	0.7
0.562	305	0.8
0.885	252	0.9
2.181	269	1
6.516	234	1

Diving Cavity Nesters



DivinCaN Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	6491	0
0.008	298	0.1
0.029	296	0.2
0.060	296	0.3
0.148	296	0.4
0.192	296	0.5
0.277	296	0.6
0.474	295	0.7
0.651	300	0.8
0.823	297	0.9
0.932	316	1
2.369	267	1

Diving Ground Nesters

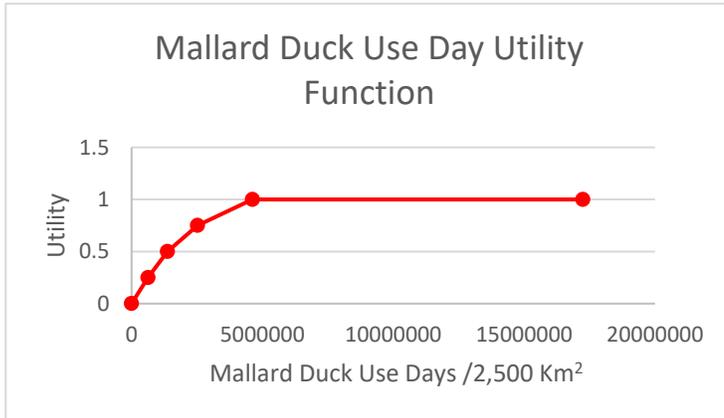


DivinGrN Density (ducks/Km ²)	# of 2,500 Km ² blocks (Frequency)	Utility
0	7116	0
0.003	243	0.1
0.007	238	0.2
0.015	239	0.3
0.022	132	0.4
0.051	335	0.5
0.082	326	0.6
0.145	223	0.7
0.241	248	0.8
0.389	198	0.9
0.612	241	1
9.0	205	1

Non-Breeding Waterfowl Utility Functions

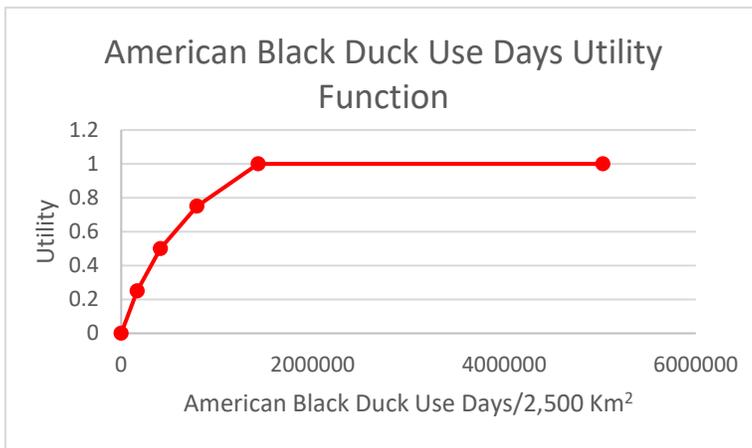
The spatial layers of non-breeding waterfowl Duck Use Days are not readily comparable to one another (for different species/guilds). For non-breeding waterfowl, utility functions were developed based on the cumulative percent of DUD for each species/guild. Utility Functions were based on total amount of DUD at the 2,500 km² scale. For each species/guild the utility function used to standardize DUD are presented below. Generally, for non-breeding waterfowl, preference for higher DUD increases sharply and plateaus once a threshold is reached (the threshold differs for each breeding species/guild). Additionally, the inflection points for each percentile bin are presented in the table to the right of the utility function along with the number of 2,500 km² block that fall into that percentile bin. Area of each DUD range can be calculated by multiplying the frequency by 2,500 km².

Mallard



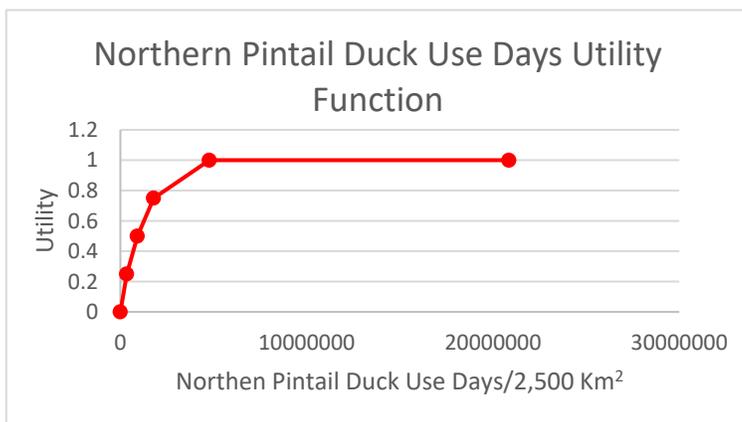
DUD Inflection Points	Percentile Bins	# of 2,500 Km² blocks (Frequency)	Utility
0	0	4960	0
628,665.7	20	3785	0.25
1,370,517.0	40	519	0.5
2,520,510.0	60	266	0.75
4,619,588.0	80	144	1
17,243,002.01	100	70	1

American Black Duck



DUD Inflection Points	Percentile Bins	# of 2,500 Km² blocks (Frequency)	Utility
0	0	8210	0
167,057.3	20	1205	0.25
409,349.4	40	178	0.5
790,751.4	60	85	0.75
1,429,966.8	80	45	1
5,030,523.2	100	21	1

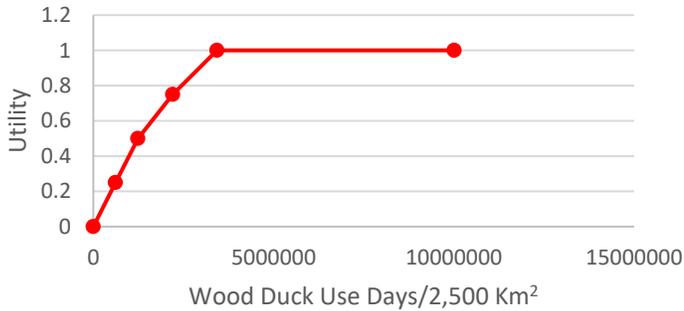
Northern Pintail



DUD Inflection Points	Percentile Bins	# of 2,500 Km² blocks (Frequency)	Utility
0	0	5823	0
346,550.3	20	3268	0.25
919,129.5	40	376	0.5
1,789,863.0	60	169	0.75
4,780,199.9	80	82	1
20,858,524.0	100	26	1

Wood Duck

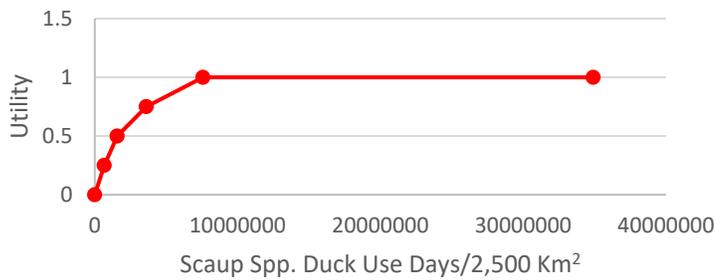
Wood Duck Use Days Utility Function



DUD Inflection Points	Percentile Bins	# of 2,500 Km ² blocks (Frequency)	Utility
0	0	6307	0
614,542.4	20	2851	0.25
1,237,445.1	40	291	0.5
2,203,573.7	60	154	0.75
3,429,331.6	80	91	1
10,009,749.8	100	50	1

Scaup Spp.

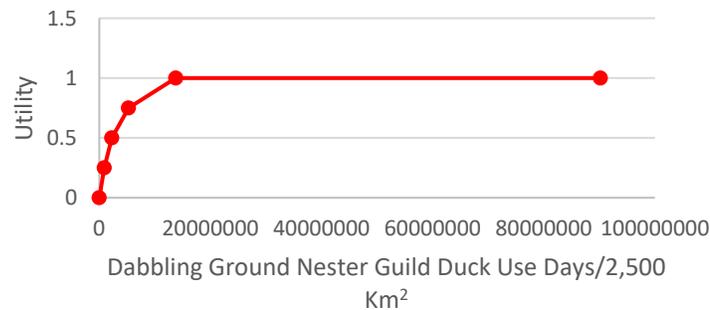
Scaup Spp. Duck Use Days Utility Function



DUD Inflection Points	Percentile Bins	# of 2,500 Km ² blocks (Frequency)	Utility
0	0	5900	0
665,351.0	20	3321	0.25
1,575,579.2	40	302	0.5
3,609,064.7	60	134	0.75
7,582,694.3	80	61	1
34,905,282.3	100	26	1

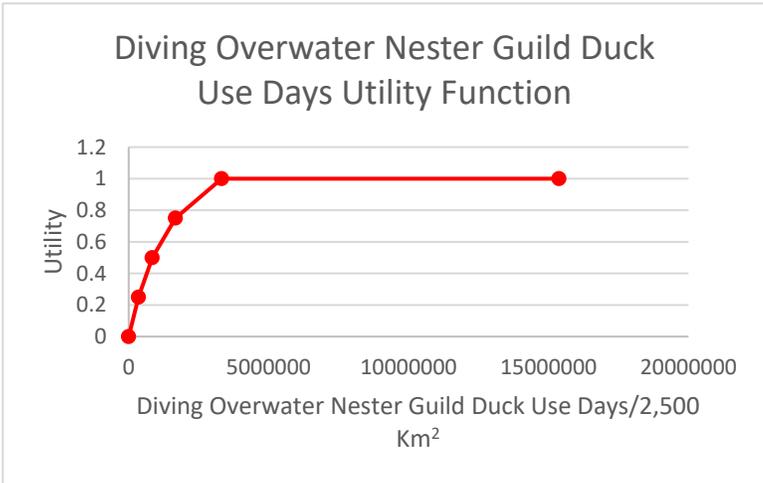
Dabbling Ground Nesters

Dabbling Ground Nester Guild Duck Use Days Utility Function



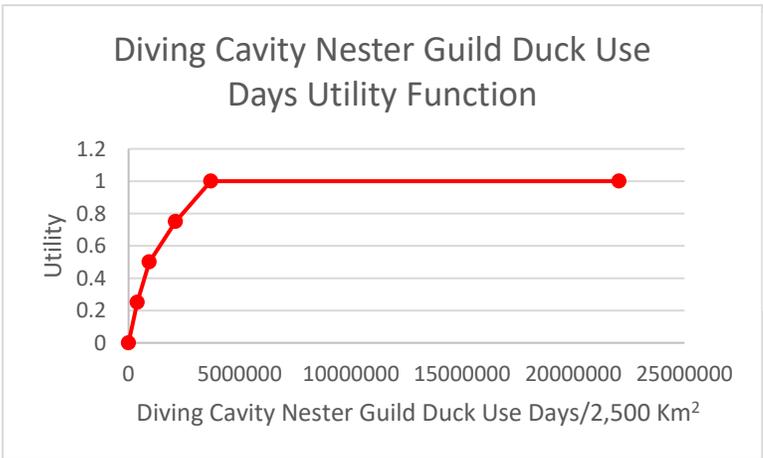
DUD Inflection Points	Percentile Bins	# of 2,500 Km ² blocks (Frequency)	Utility
0	0	4858	0
902,327.6	20	4186	0.25
2,263,077.3	40	422	0.5
5,263,196.5	60	181	0.75
13,762,867.2	80	74	1
90,191,800.0	100	23	1

Diving Overwater Nesters



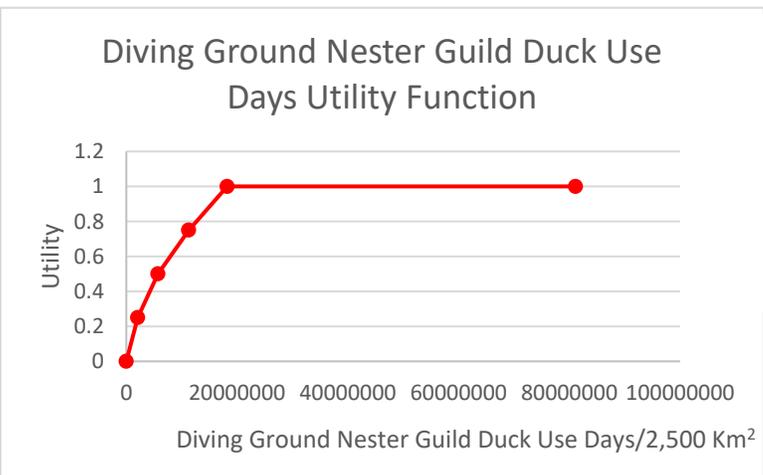
DUD Inflection Points	Percentile Bins	# of 2,500 Km ² blocks (Frequency)	Utility
0	0	5335	0
350,954.0	20	3679	0.25
842,659.0	40	402	0.5
1,670,014.0	60	188	0.75
3,321,606.8	80	101	1
15,373,500.0	100	39	1

Diving Cavity Nesters



DUD Inflection Points	Percentile Bins	# of 2,500 Km ² blocks (Frequency)	Utility
0	0	5969	0
391,253.2	20	3003	0.25
930,442.7	40	440	0.5
2,112,668.8	60	196	0.75
3,700,078.4	80	94	1
22,058,949.4	100	42	1

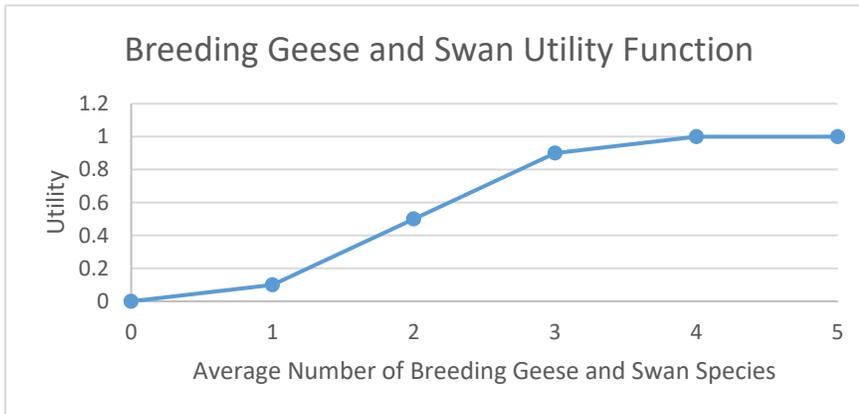
Diving Ground Nesters



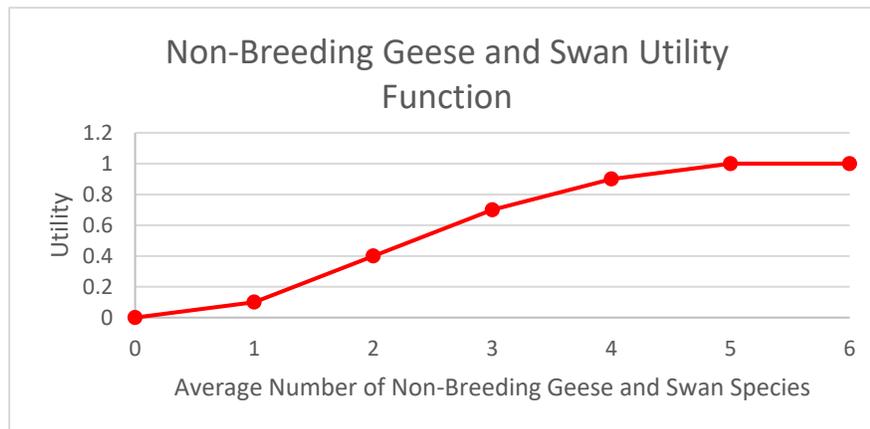
DUD Inflection Points	Percentile Bins	# of 2,500 Km ² blocks (Frequency)	Utility
0	0	8611	0
2,070,255.4	20	1033	0.25
5,721,500.0	40	57	0.5
11,285,440.0	60	24	0.75
18,229,585.9	80	13	1
81,128,894.0	100	6	1

Geese and Swans

Goose and Swan breeding and non-breeding spatial layers are not readily comparable to the density and DUD spatial layers of other breeding and non-breeding waterfowl. When performance measures differ (i.e., density for breeding waterfowl and average number of breeding geese and swan species), they are difficult to compare. This is one of the primary reasons for standardization based on a utility function. Below are utility functions for breeding and non-breeding goose and swan species



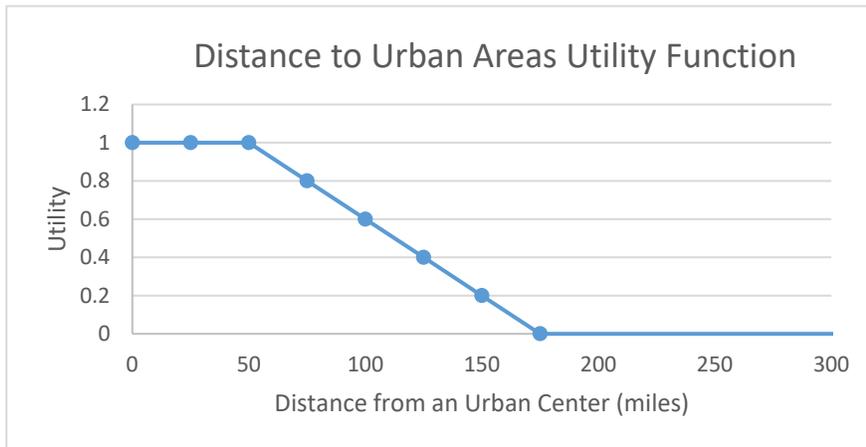
# of Breeding Species	# of 2,500 Km ² blocks (Frequency)	Utility
0	2767	0
1	5154	0.1
2	1441	0.5
3	363	0.9
4	17	1
5	2	1



# of Breeding Species	# of 2,500 Km ² blocks (Frequency)	Utility
0	2336	0
1	3056	0.1
2	2038	0.4
3	1282	0.7
4	922	0.9
5	96	1
6	14	1

Distance to Urban Centers

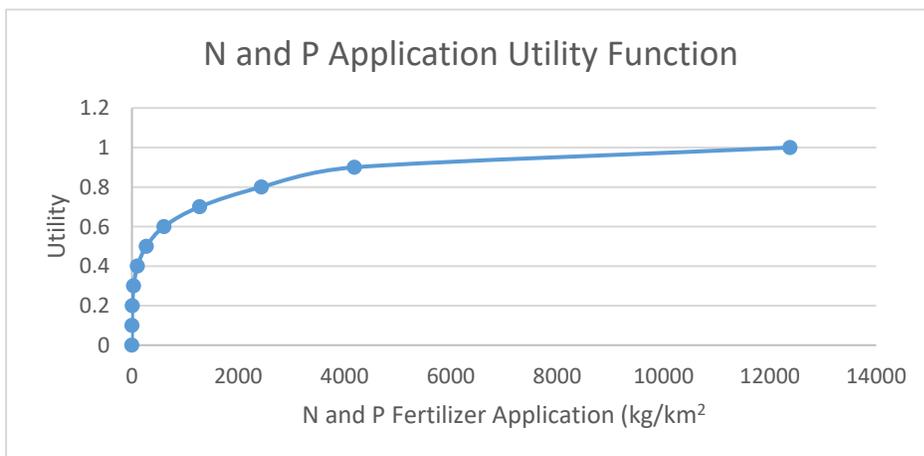
The HDWG preliminary results indicate that willingness to travel for waterfowl hunting decreases as hunters have to travel further than 50 miles from the urban centers. Therefore, the PLC committee reasoned that distances within 50 miles of urban centers are priority areas for waterfowl habitat conservation initiatives. As distance from urban centers increases the importance of that landscape to contribute to waterfowl hunter satisfaction decreases (an untested assumption). The piece-wise linear regression utility function for the distance to urban centers performance measure is presented below, as it was agreed upon by the PLC



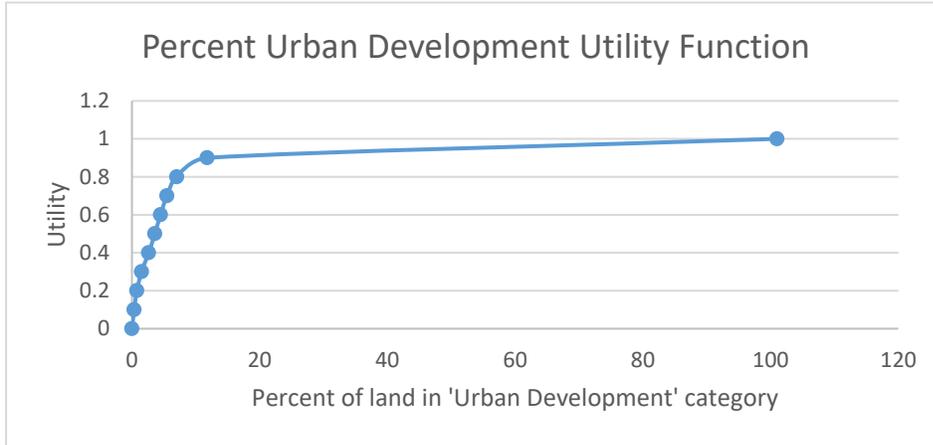
Watershed Impairment Status

It was the consensus of the PLC that impaired watersheds, generally, could provide greater ecosystem goods and services, which the general public relies on, if managed properly. To gain political and financial support for waterfowl habitat conservation initiatives, from the general public, the PLC reasoned that focusing resources in areas where the watershed impairment status (based on amount of agricultural fertilizer application and percent of developed landscape) is high would increase the benefits provided by wetland ecosystem goods and services (an untested assumption). Therefore, the PLC believes that as the amount of fertilizer application and urban development increases, the priority of that area for waterfowl habitat conservation resource investment should also increase. The utility functions for the two components of watershed impairment status are provided below. The spatial layers were standardized based on the preferences illustrated below.

Fertilizer Application

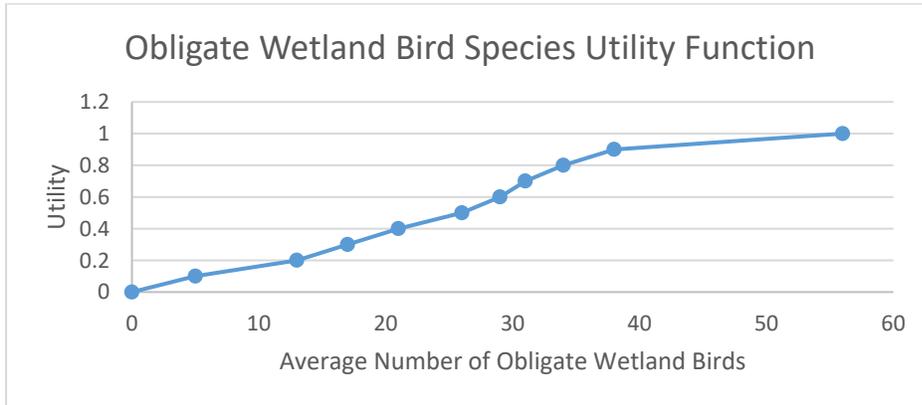


Percent Land-cover in Urban Development



Obligate Wetland Bird Diversity

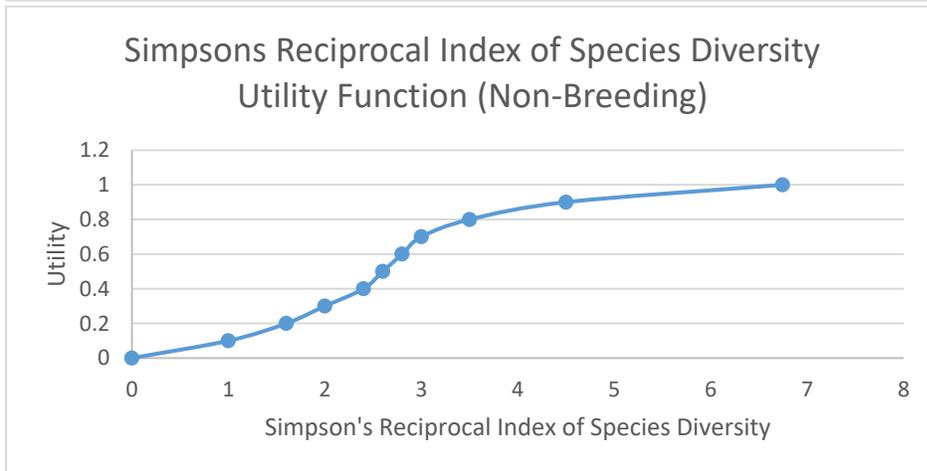
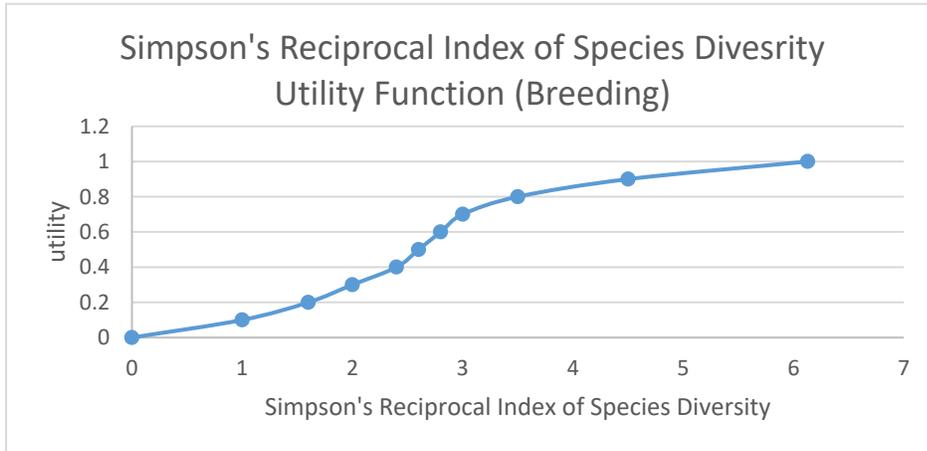
Bird watcher satisfaction increases with the average number of birds that can be seen in a given area. The HDWG found that bird diversity was an important factor in bird watcher willingness to take day trips and support conservation. The PLC reasoned that waterfowl habitat conservation initiatives should be focused in areas that have high wetland bird diversity. Wetland birds were chosen as a representative of bird diversity because the decisions of waterfowl habitat conservation's generally focus on wetland conservation and management.



Waterfowl Simpson's Reciprocal Index of Species Diversity

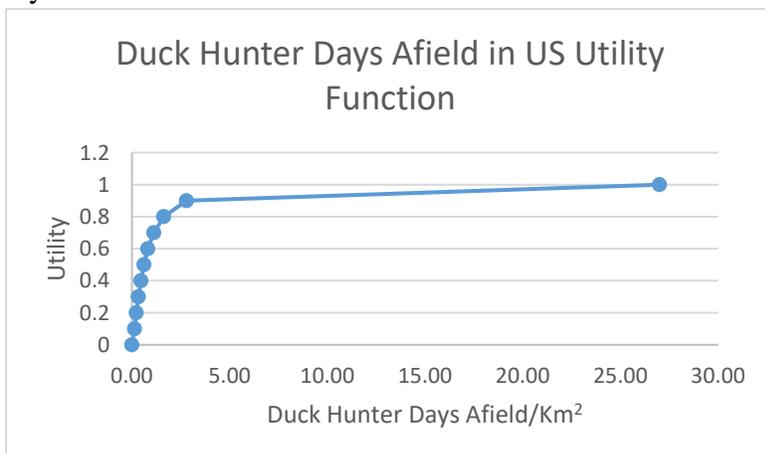
The HDWG preliminary results indicate that waterfowl hunter satisfaction generally increases as waterfowl diversity increases. It was found that waterfowl hunters prefer to see large abundances of waterfowl while being able to harvest different species. The PLC, reasoned that focusing waterfowl habitat conservation resources in areas that have a high breeding and non-breeding diversity of waterfowl would increase local hunter satisfaction and thus encourage recruitment, retention and reactivation (an untested assumption). The utility function was based

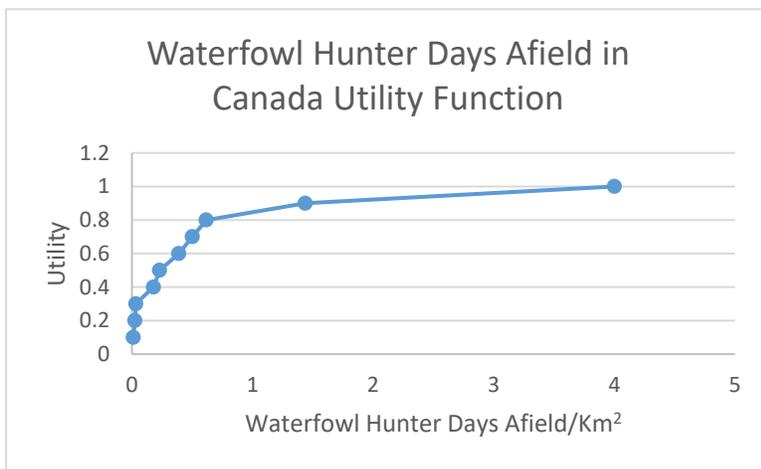
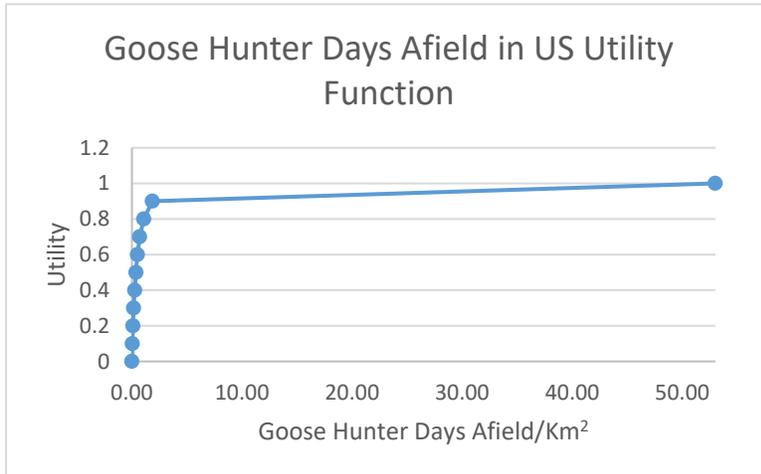
on the calculated Simpson's Reciprocal Index of Species Diversity for breeding and non-breeding waterfowl and is presented below.



Hunter Days Afield

Hunter days afield is assumed to be a representation of current waterfowl hunting demand. Since we had three datasets, we developed three utility functions. In general, preference for investing waterfowl habitat conservation resources is low in areas where hunter days afield is low. However, preference increases rapidly to a threshold point, after which, preference plateaus. There were no comparable data provided for Mexico, therefore it is not represented in the spatial layer.





Standardizing Spatial Layers

To create the new spatial layers that are standardized on a Utility Scale of 0 to 1, we used the above piece-wise linear regression functions and their respective spatial layers created in Supplement 1,2,3, and 4. All standardized spatial layers were stored in [Standardized_SpatialLayers](#) folder in the file geodatabase.

- 1) Utility Functions for breeding waterfowl densities were developed and stored in [Breeding_Watefowl_UtilityFunctions_50kmGrid](#) Excel spreadsheet. The Utilities were developed based on breeding densities and are displayed highlighted in blue in each tab of the spreadsheet (species-specific).
- 2) In ArcGIS Desktop, we imported all breeding waterfowl final spatial layers, [50_MALL_Breeding2.shp](#), [50_ABDU_Breeding2.shp](#), [50_NOPI_Breeding2.shp](#), [50_WODU_Breeding2.shp](#), [50_SCAU_Breeding2.shp](#), [50_DabbGrN_Breeding2.shp](#), [50_DivinCaN_Breeding2.shp](#), [50_DivinOvN_Breeding2.shp](#), and [50_DivinGrN_Breeding2.shp](#).
 - a. In each spatial file, we created a new field with the header ‘Utility’ and a ‘Float’ type.
 - b. Next, we used the edit feature to copy and paste the calculated utilities (highlighted blue columns in

- Breeding_Watefowl_UtilityFunctions_50kmGrid Excel spreadsheet) in each of the newly created fields for each species/guild, respectively, making sure the Grid Id attribute is sorted in ascending order.
- 3) Utility Functions for non-breeding waterfowl densities were developed and stored in [NonBreeding_Watefowl_UtilityFunctions_50kmGrid](#) Excel spreadsheet. The Utilities were developed based on total Duck Use Days and are displayed highlighted in blue in each tab of the spreadsheet (species-specific).
 - 4) In ArcGIS Desktop, we imported all non-breeding waterfowl final spatial layers, [50_MALL_NonBreeding2.shp](#), [50_ABDU_NonBreeding2.shp](#), [50_NOPI_NonBreeding2.shp](#), [50_WODU_NonBreeding2.shp](#), [50_SCAU_NonBreeding2.shp](#), [50_DabbGrN_NonBreeding2.shp](#), [50_DivinCaN_NonBreeding2.shp](#), [50_DivinOvN_NonBreeding2.shp](#), and [50_DivinGrN_NonBreeding2.shp](#).
 - a. In each spatial file, we created a new field with the header ‘Utility’ and a ‘Float’ type.
 - b. Next, we used the edit feature to copy and paste the calculated utilities (highlighted blue columns in [NonBreeding_Watefowl_UtilityFunctions_50kmGrid](#) Excel spreadsheet) in each of the newly created fields for each species/guild, respectively, making sure the Grid Id attribute is sorted in ascending order.
 - 5) Utility Functions for Social Objectives were developed and stored in [HD_UtilityFunctions_10kmGrid](#) Excel spreadsheet.
 - 6) In ArcGIS Desktop, we imported all social objectives final spatial layers, [Breeding_WaterfowlSDI_FINAL.shp](#), [NonBreeding_WaterfowlSDI_FINAL.shp](#), [Distance_to_UrbanCenters_FINAL.shp](#), [Wetland_Bird_Diversity_FINAL.shp](#), [N_P_FertilizerApplied_FINAL](#), [PRCNT_Developed_FINAL.shp](#), [CA_WatefowlHDA_FINAL.shp](#), [US_DuckHDA_FINAL.shp](#), and [US_GooseHDA_FINAL.shp](#).
 - a. In each spatial file, we created a new field with the header ‘Utility’ and a ‘Float’ type.
 - b. Next, we used the edit feature to copy and paste the calculated utilities (highlighted blue columns in [HD_UtilityFunctions_10kmGrid](#) Excel spreadsheet) in each of the newly created fields for each objective, respectively, making sure the Grid Id attribute is sorted in ascending order.
 - 7) Utility Functions for Goose and Swan Objectives were developed and stored in [Utility_Functions_Breeding_N_NonBreeding](#) Excel spreadsheet in [3_Geese_Swans](#) Folder.
 - 8) In ArcGIS Desktop, we imported the final spatial layers for breeding and non-breeding geese and swans, [Breeding_Geese_n_Swans_50km2.shp](#) and [NonBreeding_Geese_n_Swans_50km2.shp](#).
 - a. In each spatial file, we created a new field with the header ‘Utility’ and a ‘Float’ type.
 - b. Next, we used the edit feature to copy and paste the calculated utilities (highlighted blue columns in [Utility_Functions_Breeding_N_NonBreeding](#) Excel spreadsheet) in each

of the newly created fields for each objective, respectively, making sure the Grid Id attribute is sorted in ascending order.

- 9) All spatial layers (29) are stored in **Standardized_SpatialLayers** and can now be displayed using the Utility field, which is a consistent measure from 0 to 1 of the importance of geographies towards meeting that specific objective.

Literature Cited

Edwards, W., Miles, R.F., and von Winterfeldt, D., 2007, *Advances in decision analysis: From foundations to applications*: New York, NY., USA, Cambridge University Press, 623 p.

Keeney, R.L., and Raiffa, H., 1993, *Decisions with multiple objectives*: Cambridge, MA., USA, Cambridge University Press, 592 p.

Supplement 6.

Assigning Objective Weights and Aggregation of Spatial Elements to Final Products

In Structured Decision Making there are several ways to assign weights to objectives. Weights represent the preference of the decision maker for one objective over another, and as such the process of assigning weights is subjective. Generally, expert opinion supported by empirical data are used to determine objective weights. The PLC determined that weights for each objective should be equal to avoid regional biases in preference for certain species, seasons, or social dimensions. Since this project focused on identifying geographies of significance at the continental level, the PLC chose to follow a default weighting approach, where each objective is equally as important as another to the decision maker. In the first three spatial products the distribution of weights is equal and straight forward. However, there are empirical data to support that breeding and non-breeding seasons differ in their importance (i.e., contribution) to waterfowl population dynamics. Although this non-equal weighing method is not explored herein, it is suggested as an exploratory analysis in the discussion. In the second two spatial products, where social objectives are aggregated with biological objectives, the weighting process is performed by first defining equal weights for the main objectives and then defining weights for each sub-objective. In the spatial products that include the Hunter Days Afield objective deserves a special note. Data for Canada and the United States do not overlap and therefore a weight assigned to Canada is equal to the weight assigned to the United States, but the Goose and Duck Hunter Days Afield were developed as separate sub-objectives and therefore get one half of the assigned weight of the Canada spatial layer. Additionally, Hunter Days Afield data were not available for Mexico, therefore there are fewer spatial layers that make up the overall scores within the Mexican national boundary. This should be viewed with caution and noted that the maximum overall score for a spatial layer cell will not be 1 in Mexico. Below are the weights used in the development of each of the 5 spatial products.

Relative importance of geographies to waterfowl during the breeding and non-breeding period

Biological Spatial Layers	Weight
Breeding Duck Densities	
Mallard	0.05
American Black Duck	0.05
Northern Pintail	0.05
Wood Duck	0.05
Scaup Spp.	0.05
Dabbling Ground Nesters	0.05
Diving Cavity Nesters	0.05
Diving Overwater Nesters	0.05
Diving Ground Nesters	0.05
Average Number of Breeding Geese and Swan Species	0.05
Non-Breeding Duck Use Days	
Mallard	0.05
American Black Duck	0.05
Northern Pintail	0.05

Wood Duck	0.05
Scaup Spp.	0.05
Dabbling Ground Nesters	0.05
Diving Cavity Nesters	0.05
Diving Overwater Nesters	0.05
Diving Ground Nesters	0.05
Average Number of Non-Breeding Geese and Swan Species	0.05
TOTAL	1.0

Relative importance of geographies to waterfowl during the breeding period

Biological Spatial Layers	Weight
Breeding Waterfowl Densities	
Mallard	0.1
American Black Duck	0.1
Northern Pintail	0.1
Wood Duck	0.1
Scaup Spp.	0.1
Dabbling Ground Nesters	0.1
Diving Cavity Nesters	0.1
Diving Overwater Nesters	0.1
Diving Ground Nesters	0.1
Average Number of Breeding Geese and Swan Species	0.1
TOTAL	1.0

Relative importance of geographies to waterfowl during the non-breeding period

Biological Spatial Layers	Weight
Non-Breeding Duck Use Days	
Mallard	0.1
American Black Duck	0.1
Northern Pintail	0.1
Wood Duck	0.1
Scaup Spp.	0.1
Dabbling Ground Nesters	0.1
Diving Cavity Nesters	0.1
Diving Overwater Nesters	0.1
Diving Ground Nesters	0.1
Average Number of Breeding Geese and Swan Species	0.1
TOTAL	1.0

Relative importance of geographies to waterfowl habitat conservation supporters

Social Spatial Layers	Weight
Distance to Urban Centers	0.2
Obligate Wetland Bird Diversity	0.2
Waterfowl Diversity	
Breeding Simpson's Reciprocal Index of Species Diversity	0.1
Non-Breeding Reciprocal Index of Species Diversity	0.1
Impaired Watershed Stats	
N and P Fertilizer Application	0.1
Percent of Developed and Built Up Landscape	0.1
Hunter Days Afield (*CA and US spatial layers do not overlap)	
Hunting Days Afield for Waterfowl (CA)	0.2
Hunting Days Afield for Ducks (US)	0.1
Hunting Days Afield for Geese (US)	0.1
TOTAL	1.0

Relative importance of geographies to waterfowl during the breeding and non-breeding period and to waterfowl habitat conservation supporters

Spatial Layers	Weight
Breeding Duck Densities	
Mallard	0.025
American Black Duck	0.025
Northern Pintail	0.025
Wood Duck	0.025
Scaup Spp.	0.025
Dabbling Ground Nesters	0.025
Diving Cavity Nesters	0.025
Diving Overwater Nesters	0.025
Diving Ground Nesters	0.025
Non-Breeding Duck Use Days	
Mallard	0.025
American Black Duck	0.025
Northern Pintail	0.025
Wood Duck	0.025
Scaup Spp.	0.025
Dabbling Ground Nesters	0.025
Diving Cavity Nesters	0.025
Diving Overwater Nesters	0.025
Diving Ground Nesters	0.025
Geese and Swan	
Average Number of Breeding Geese and Swan Species	0.025

Average Number of Non-Breeding Geese and Swan Species	0.025
Distance to Urban Centers	0.100
Obligate Wetland Bird Diversity	0.100
Waterfowl Diversity	
Breeding Simpson's Reciprocal Index of Species Diversity	0.050
Non-Breeding Simpson's Reciprocal Index of Species Diversity	0.050
Impaired Watershed Status	
N and P Fertilizer Application	0.050
Percent of Developed and Built up Landscape	0.050
Hunter Days Afield	
Hunting Days Afield for Waterfowl (Canada)	0.100
Hunting Days Afield for Ducks (US)	0.050
Hunting Days Afield for Geese (US)	0.050
TOTAL	1.0

Developing Final Spatial Products

- 1) In ArcGIS Desktop, we imported all breeding waterfowl final spatial layers, (50_MALL_Breeding2.shp, 50_ABDU_Breeding2.shp, 50_NOPI_Breeding2.shp, 50_WODU_Breeding2.shp, 50_SCAU_Breeding2.shp, 50_DabbGrN_Breeding2.shp, 50_DivinCaN_Breeding2.shp, 50_DivinOvN_Breeding2.shp, and 50_DivinGrN_Breeding2.shp), all non-breeding waterfowl final spatial layers, (50_MALL_NonBreeding2.shp, 50_ABDU_NonBreeding2.shp, 50_NOPI_NonBreeding2.shp, 50_WODU_NonBreeding2.shp, 50_SCAU_NonBreeding2.shp, 50_DabbGrN_NonBreeding2.shp, 50_DivinCaN_NonBreeding2.shp, 50_DivinOvN_NonBreeding2.shp, and 50_DivinGrN_NonBreeding2.shp), and all social objectives final spatial layers, (Breeding_WaterfowlSDI_FINAL.shp, NonBreeding_WaterfowlSDI_FINAL.shp, Distance_to_UrbanCenters_FINAL.shp, Wetland_Bird_Diversity_FINAL.shp, N_P_FertilizerApplied_FINAL, PRCNT_Developed_FINAL.shp, CA_WatefowlHDA_FINAL.shp, US_DuckHDA_FINAL.shp, and US_GooseHDA_FINAL.shp).
 - a. In each spatial file, we created a new field with the header 'Weighted_U' and a 'Float' type.
 - b. Next, we used the attribute calculator feature to calculate the "Weighted_U" value by multiplying the value in the 'Utility' field (in each of the spatial layers), by the weight assigned to that specific objective.
- 2) Next, we used the [Polygon to Raster](#) tool to convert each of the spatial layers into rasters with raster cell value equal to 'Weighted_U' and cell size of 1×1 km.
 - a. This process was repeated for each of the five spatial products (using the differing weights assigned to each objective for each of the spatial products).
 - b. The raster files specific to each spatial product were saved in folders [Bio_Map](#), [Bio_Breeding_Map](#), [Bio_NonBreeding_Map](#), [Soc_Map](#), and [AllObj_Map](#).

- 3) We used the Cell Statistics tool to add the values (at the raster cell scale) for each of the spatial layers included in each of the five spatial products (refer to above tables for product specific elements to include).
 - a. This process was repeated five times to create the final five spatial products, **bio_allobj**, **bio_breed**, **bio_nbreed**, **social_map**, and **allobj_map**, each stored in their respective folder.

Supplement 7.

Breeding Waterfowl Surveys Metadata Report

Data Inputs – Existing waterfowl surveys and breeding data collections

Existing collections include data that were used for the purposes of creating the final products and/or project deliverables. The data sets were obtained from various federal and state agencies as well as conservation focused organizations and have not been collected during the course of this project.

Data Set: Waterfowl Breeding Population and Habitat Survey (TSA)

Data Source: <https://migbirdapps.fws.gov/mbdc/databases/mas/maydb.asp?opt=maydb> (U.S. Fish and Wildlife Service, Division of Migratory Bird Management) *data center URL is likely to change in the near future

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Description: The Waterfowl Breeding Population and Habitat Survey became operational in 1955. It has been conducted annually since. The primary purpose of the survey is to provide information on spring population size and trajectory for certain North American duck species. These data are used in the annual establishment of hunting regulations in the United States and Canada and in researching bird-environment relationships critical to effective conservation planning for waterfowl. Survey procedures and analytical methods follow Smith (1995). Includes over 50 strata that are delineated based on habitat differences and political boundaries. The total number of birds in each stratum is estimated by the product of the density observed by the aerial crew, the visibility correction factor, and the area of the stratum. Annual population estimates of breeding duck species is housed in a database which is open to the public online (see above link).

Species in the survey that were used in analysis: MALL, NOPI, SCAU, AMWI, BWTE, GADW, AGWT, NSHO, BUFF, GOLD, CANV, REDH, RNDU, RUDU

Survey Strata: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 75, 76, 77

Time frame analyzed: 2001-2015

Data Set: Waterfowl Breeding Population and Habitat Survey (ESA)

Data Source: <https://migbirdapps.fws.gov/mbdc/databases/mas/maydb.asp?opt=maydb> (U.S. Fish and Wildlife Service, Division of Migratory Bird Management)

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Description: The Eastern Survey is very similar to the Traditional Survey but was not implemented until 1990. At first only 10 strata were surveyed consistently (51, 52, 63, 64, 66, 67, 68, 70, 71, and 72). The US Fish and Wildlife Service began implementing a transect-based survey in 1990 that covered strata 51 through 56. The area was expanded to include stratum 62 in 1995, strata 63 through 68 in 1996, and strata 69 and 70 in 1998. Several strata were inconsistently surveyed (see website for details). These data are used in the annual establishment of hunting regulations in the United States and Canada and in researching bird-environment relationships critical to effective conservation planning for waterfowl. Survey procedures and analytical methods follow Smith (1995). The total number of birds in each stratum is estimated from a Bayesian hierarchical modeling approach (Link and Sauer 2002). Hierarchical estimates are integrated into a single population index in strata with both US Fish and Wildlife Service and Canadian Wildlife Service surveys (i.e., strata 51, 52, 63, 64, 66, 67, 68, and 70) and are based on single survey data in strata with no overlap between the two surveys (i.e., 53, 54, 55, 56, 57, 58, 59, 62, 65, and 69 have US Fish and Wildlife Service surveys only, whereas strata 71 and 72 have Canadian Wildlife Service surveys only). *Note: (1) Because the eastern estimates are based on a hierarchical model, the entire time series is updated annually and past estimates will change slightly each year. (2) We only provide population size estimates for species for which the hierarchical models reached convergence.* Annual population estimates of breeding duck species is housed in a database which is open to the public online (see above link).

Species in the survey that were used in analysis: MALL, ABDU, AWGT, GOLD, MERG, RNDU

Survey Strata: 51, 52, 53, 54, 55, 56, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Time frame analyzed: 2001-2015

Data Set: Atlantic Flyway Plot Survey

Data Source: U.S. Fish and Wildlife Service. 2017. Atlantic Flyway Breeding Waterfowl Plot Survey report 2017. U.S. Department of the Interior, Washington D.C. USA.

Heusmann, H.W. and Sauer, J.R. 2000. The Northeastern States' Waterfowl Breeding Population Survey. *Wildlife Society Bulletin*. 28(2): 355-364.

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Description: In 1993, all plot (1 km²) locations became fixed and were all sampled annually. Survey of ground plots are taken by vehicle, boat, or on foot. Duck observations were measured as pairs, lone drake, flock of 2, 3, or 4 males, lone female, and group of five or more males. A female with a brood was marked as a pair as male may have left by time of survey. Mixed-sex flocks of six or fewer birds indicated pairs based on the number of males. Groups of five or more males were thought to be pre-molt flock, and mixed-sex flock of six or more birds were called migrants. For details on the species population estimates see the cited sources above.

Species in the survey that were used in analysis: MALL, ABDU, WODU, AGWT, BWTE, GADW, MERG

Survey Strata: (BBS Strata) 3, 4, 9, 10, 11, 12, 13, 16, 18, 22, 23, 24, 26, 27, 28, 99, 24.1, 24.2, 24.3

Time frame analyzed: 2001-2015

Data Set: British Columbia Central Interior Waterfowl Aerial Survey Program

Data Source: Breault, A., Harrison, B., Kroeker, D., and Watts, P. 2006. 2006-17 Waterfowl Breeding Population Survey of the Central Interior Plateau of British Columbia. Canadian Wildlife Service, U.S. Fish and Wildlife Service and Ducks Unlimited Canada.

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Description: Follows procedures found in the “Standard Operating Procedures for Aerial Breeding Ground and Habitat Survey.” Transects were flown following pre-determined transects with 200 m buffer on either side. The survey crew was made up of two or three observers. The front-left and rear seat observer(s) recorded their observation by species/group within the buffers. Observations were recorded as singles, pairs, and flocked birds. The rotary-wing aircraft would occasionally circle around a transect portion to positively identify unknown birds in order to minimize observations within the unknown category. Each of these sightings was geo-referenced and associated with a habitat type (lake, wetland, stream, river, agricultural field). These data were used to calculate waterfowl breeding populations and densities across survey strata and habitat types and is used to model waterfowl distribution and abundance at the landscape scale. Transect counts were converted to total indicated breeders per square mile and multiplied by ratio of transect length to mean length of all transects in that ecoregion. Provides weighted counts. These counts were not adjusted using visibility correction factors.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, WODU, AGWT, AMWI, BWTE, CITE, GADW, NSHO, BUFF, GOLD, MERG, CANV, REDH, RNDU, RUDU, SCOT

Survey Strata: (BC1) Babine Upland, (BC2) Bulkley Basin, (BC3) Nechako Lowland, (BC5), Nazco Upland, (BC6) Quesnel Lowland, (BC7) Western Chilcotin Upland, (BC9) Chilcotin Plateau, (BC10) Cariboo Basin

Time frame analyzed: 2006-2017

Data Set: Washington State Breeding Waterfowl Population Survey

Data Source: Evenson, J.R. 2015. Washington State Breeding Waterfowl Population Survey Report, 2015. Washington Department of Fish and Wildlife.

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Description: This survey follows the procedures found in the “Standard Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys in North America.” (1987) A helicopter was used with onboard display of transect lines and survey strip boundaries. Strips were surveyed completely assuming detection rate of 1. There were two observers per flight. Observations recorded using digital voice recorders and times of the observations were

noted with digital watch synced with the time of the GPS. Observations were later transcribed and location matched with the track log time from GPS. Population estimate, percent change from previous year, and the long term average estimates were determined according to methodology cited above. Also looks at the mean ducks and mallards per water feature. There have been some changes to the placement of transects – more details can be found in the survey document. A review of the strata boundaries was performed and standardized in 2013. In response to this, some transects were extended or shortened to match the standardized strata.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, WODU, AGWT, AMWI, BWTE, CITE, GADW, NSHO, BUFF, GOLD, MERG, CANV, REDH, RNDU, RUDU

Survey Strata: Chehalis Valley, Hood Canal, Dungeness, South Puget Lowlands, North Puget Lowlands, Irrigated, Potholes, North Eastern Highlands

Time frame analyzed: 2010-2017

Data Set: Oregon Breeding Waterfowl Population Survey

Data Source: Walton, K. and Reishus, B. 2016. Oregon Breeding Waterfowl Population Report 2016. Oregon Department of Fish and Wildlife, Migratory Game Bird Program.

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Description: Survey procedures and analytical methods follow Smith (1995) until 2004. After 2004, helicopters are exclusively used and survey procedures and analytical methods follow the "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Populations and Habitat Surveys in North America" (USFWS/CWS 1987) where detection is assumed to be 1. For detailed methodology and population estimation procedures see Walton and others (2016). Five regions with significant breeding waterfowl habitat were delineated as strata and randomly placed transects are laid across. These transects are flown and waterfowl surveyed. Observers count all waterfowl seen within 200 yards on either side of the aircraft, which creates a census of ¼ mile wide strip along transect. These transects cover four to six percent of each stratum and waterfowl observations are expanded to account for portions of the strata that were not surveyed. VCFs were calculated by flying fixed wing surveys and then repeat flying sample transects with a helicopter till 2004. After 2004, helicopters are exclusively used for surveying and detection is assumed to be 100%.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, WODU, AGWT, AMWI, BWTE, CITE, GADW, NSHO, BUFF, GOLD, MERG, CANV, REDH, RNDU, RUDU

Survey Strata: Lower Columbia River, Willamette Valley, Forested Wetlands, Northeast Seasonal Marsh, Southeast Seasonal Marsh

Time frame analyzed: 2002-2016

Data Set: California Waterfowl Breeding Population Survey

Data Source: Skalos, D. and Weaver, M. 2016. 2016 California Waterfowl Breeding Population Survey. California Department of Fish and Wildlife, Wildlife Branch/Waterfowl Program.

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Description: This survey generally follows the procedures by the United States Fish and Wildlife Service protocol or the “Standard Operating Procedures for the Waterfowl Breeding Population and Habitat Conditions Survey.” Flights begin no later than two hours after sunrise and commence no later than 2 PM. There is one pilot and two observers for this survey. For a fixed-wing aircraft, an air speed between 90 and 110 miles per hour. is maintained and an altitude of 45 m above ground level. Observers count within 200 m on each side of the aircraft (total sample width of ¼ mile or 400 m. This survey uses a double-sampling procedure which incorporates a complete count subsample of selected segments to correct detection bias. The helicopter follows the fixed-wing aircraft segments in all strata. The helicopter is flown at 40-45 miles per hour at an altitude of 30 m. Observers use same procedure as in the fixed-wing aircraft. Observers record observations as single, pair, or group directly into a computer using the Survey Record Program. This is linked to GPS and records the coordinates associated with each observation. For each species a total indicated birds is calculated on each survey segment using fixed-wing and helicopter data. Mean density for each species within each stratum. A visibility correction factor is also calculated for each species.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, WODU, AGWT, AMWI, BWTE, CITE, GADW, NSHO, BUFF, GOLD, MERG, CANV, REDH, RNDU, RUDU

Survey Strata: Sacramento Valley, East Valley, West Valley, East Valley, Napa/Santa Rosa, Suisan Marsh, San Joaquin Delta, San Joaquin Dessert, Northeastern CA

Time frame analyzed: 2001-2017

Data Set: Nevada Waterfowl Breeding Survey

Data Source: Nicolai, C.A., Mortimore, C.A., Neil, K.M., Saake, N.P. and Phenix, R.J. 2009. Redesign of the Nevada Waterfowl Breeding Survey. Nevada Department of Wildlife

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Description: In 2009 the survey methodology was redesigned to meet federal standards and therefore we only used population estimates starting with the 2010 survey. Species density and stratum specific density were calculated using a mixed linear model (density was dependent variable and stratum was fixed). For detailed methodology and population estimation procedures see Nicolai and others (2009). Survey has been redesigned from previous years in order to meet federal standards. Two observers, one in right-front seat and other in rear-left seat. Front observer notified rear observer when entering/exiting transects. Recorded the polygon name, transect number, species, groupings and number of waterfowl using voice recorders. Followed federal definitions of single, pair, and group. GIS was used to calculate the area of each polygon, (marsh and agriculture were in km²). VCFs were not calculated in 2009 so species specific values were used. Species density and stratum specific density were calculated using a mixed linear

model (density was dependent variable and stratum was fixed). Also determined species and stratum specific estimates of abundance.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, WODU, AGWT, AMWI, CITE, GADW, NSHO, BUFF, GOLD, MERG, CANV, REDH, RNDU, RUDU

Survey Strata: Agriculture, Marsh

Time frame analyzed: 2010-2016

Data Set: Utah Breeding Duck Aerial Survey

Data Source: Utah Division of Wildlife Resources, Unpublished data

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Description: Survey is conducted using fixed-wing aircraft. Was previously based on 21 transects covering 85% of wetlands in Utah. Visibility bias correction standardization is based on 1977-79 study. Salt Lake County was dropped in 1990 but is an important area not to be sampled. Great Salt Lake has a very dynamic elevation and a fixed expansion factor. This is a large migration area and because of that has large annual variation which is not reflective of the local breeding population. Also, this survey does not calculate SEs or CVs.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, AGWT, AMWI, CITE, GADW, NSHO, CANV, REDH, RUDU

Survey Strata: Box Elder, Weber, Rich, Cache, Davis, and Greater Salt Lake counties

Time frame analyzed: 2001-2015

Data Set: Minnesota Waterfowl Breeding Population Survey

Data Source: 2016 Waterfowl Breeding Population Survey Minnesota, Minnesota Department of Natural Resources and U.S. Fish and Wildlife Service, Internal Report

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Description: Survey procedures and analytical methodology follow those outlined in "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Populations and Habitat Surveys in North America" (USFWS/CWS 1987). Changes in survey methodology were described in the 1989 Minnesota Waterfowl Breeding Population Survey report. For details on the methodology and population estimation procedures see MNDNR (2016). During flight, wetlands are counted

on the observer's side of the fixed-wing aircraft (0.125-mile wide transect). In previous years the observer counted wetlands on both sides of the aircraft (0.25-mile wide transect) so a correction factor was used to adjust those years of wetland abundance. Three strata are defined based on counts of wetlands. The three strata represent areas with high, medium and low density of wetlands. Wetland and waterfowl data are recorded using a digital voice recorder and then transcribed. Fourteen of the routes had intensive ground surveys done as well. Observations from both the ground and aerial crews were used to calculate visibility correction factors. Population estimates are produced based on counts of birds and corrected for visibility.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, AGWT, AMWI, BWTE, GADW, NSHO, BUFF, GOLD, MERG, CANV, REDH, RNDU, RUDU

Survey Strata: 1 = high density (21+ lake basins per township), 2 = moderate density (11-20 lake basins per township), 3 = low density (2-10 lake basins per township)

Time frame analyzed: 2001-2015

Data Set: Western Gulf Coast Mottled Duck Survey

Data Source: Joint U.S Fish and Wildlife Service, Division of Migratory Birds; Louisiana Department of Wildlife and Fisheries; Texas Parks and Wildlife Department 2010 (2011, 2012, 2013, 2014, 2015, 2016) Western Gulf Coast Mottled Duck Survey, Unpublished data.

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Description: The Survey is flown early to mid-April of every year in Texas and Louisiana. Survey area covered approximately 10,111 mi² in LA and 16,659 mi² in TX (may vary slightly annually). Survey transects were flown by airplane crews in each state, with a subsample of transects reflighted by helicopter crews. Airplanes flew each transect at approximately 100 mph at 100-150 ft altitude. Two observers, one in the front right seat and one behind the pilot, recorded all mottled ducks seen within 656 ft (200 m) of the transect. Helicopters containing a pilot and two observers surveyed a subsample of transects after the airplane, using a "beat out" pattern of flying tight curves low to the ground to flush birds from the vegetation. Observers on either side of the helicopter recorded all ducks seen within the same transect strip width. The helicopter

observations were used to calculate a visibility-correction factor (VCF), to account for birds missed by the airplane observers. Population estimates are made at the strata level using Total Indicated Birds and VCF following Smith (1995).

Species in the survey that were used in analysis: MODU

Survey Strata: Core Marsh (TX), Core Other (TX), Peripheral (TX), Laguna Madre Peripheral (TX), Marsh (LA), Other (LA)

Time frame analyzed: 2008-2016

Data Set: Sandhills of Nebraska Waterfowl Survey

Data Source: Vrtiska, M.P. and Powell, L.A. 2011. Estimates of Duck Breeding Populations in the Nebraska Sandhills using Double Observer Methodology. *Waterbirds*. 41(1): 96-101.

Contact Person: NONE

Description: See citation above for methods

Species in the survey that were used in analysis: MALL, NOPI, BWTE, GADW, NSHO

Survey Strata: Sandhills

Time frame analyzed: 2003-2005

Data Set: Upper Mississippi River and Great Lakes Region JV Breeding waterfowl estimates

Data Source: Soulliere, G.J., Al-Saffar, M.A., Coluccy, J.M., Gates, R.J., Hagy, H.M., Simpson, J.W., Straub, J.N., Pierce, R.L., Eichholz, M.W. and Luukkonen, D.R. 2017. Upper Mississippi River and Great Lakes Region Joint Venture Waterfowl Habitat Conservation Strategy – 2017 Revision. U.S. Fish and Wildlife Service, Bloomington, Minnesota, USA.

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Description: Density estimates for BCRs 12 and 23 were generated from recent (2006–2015) Waterfowl Breeding Population and Habitat Surveys (WBPHS) conducted in Wisconsin, Michigan, and the JV portion of Minnesota (i.e., data from BCR 23 outside JV region not included in density calculation). Density estimates for BCRs 13, 22, and 24 generated using "relative abundance" calculations from Breeding Bird Survey (BBS) normalized to BCR 23 densities for each species. *Note:* BCR-scale breeding duck density estimates divided into smaller units (State x BCR polygons) may not accurately reflect densities within each smaller unit as species abundance varies with land-cover. For example, WODU breeding densities are generally higher in the east and more forested portion of BCR 23 (i.e., Michigan 23) and Blue-winged Teal densities are higher in the west and less forested portion of BCR 23 (i.e., Minnesota 23)..

Species in the survey that were used in analysis: MALL, WODU, BWTE, RNDU

Survey Strata: BCR 12, BCR 13, BCR 22, BCR 23, BCR 24

Time frame analyzed: 2006-2015

Data Set: Aerial Scoter and Scaup Monitoring Survey of the Yukon Flats, Alaska

Data Source: Mallek, E. J. 2006. Aerial Scoter and Scaup Monitoring Survey of the Yukon Flats, Alaska –2005. U.S. Fish and Wildlife Service

Guldager, N. and Bertram, M. 2008. Aerial Scoter and Scaup Monitoring Survey of the Yukon Flats, Alaska –2007. U.S. Fish and Wildlife Service

Guldager, N. and Bertram, M. 2010. Aerial Scoter and Scaup Monitoring Survey of the Yukon Flats, Alaska –2000-2009. U.S. Fish and Wildlife Service

Guldager, N. and Bertram, M. 2011. Aerial Scoter and Scaup Monitoring Survey of the Yukon Flats, Alaska –2010. U.S. Fish and Wildlife Service

*reports through 2017. All have similar citations.

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Description: This survey began in 2001 and Scaup were added in 2002. The survey is flown at 100-150 feet above ground level and at 90-105 mph. Navigation and altitude are maintained during the flight using GPS and a radar altimeter. Circling maneuvers are used to identify scoters to the species level if necessary. Observations were recorded into a computer as a sound file and each laptop computer was linked into the aircraft GPS. Observations followed the breeding pair survey protocols. Lone male scoters and scaup were recorded as singles. Male scoters or scaups (drakes) in flocks were counted as flocked drakes. When a male scoter or scaup was in close association with a female of the same species it was recorded as a pair. Scoters and scaup in mixed-sex groupings of three or more of the same species were recorded as groups. Females not accompanied by a drake were not counted. Data analysis follows the standard Waterfowl Breeding Population Survey Data Protocols.

Species in the survey that were used in analysis: WWSC, SUSC

Survey Strata: West, East, South Central, North Central

Time frame analyzed: 2008-2017

Data Set: Pacific Black Scoter Breeding Survey

Data Source: Stehn, R.A. 2012. Pacific black scoter breeding survey: Annual project summary for Sea Duck Joint Venture endorsed projects. Unpublished data. U.S. Fish and Wildlife Service Report. Anchorage, AK

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Description: The survey design of this study was based on the analysis of aerial surveys flown in 1989-97 to inventory the distribution of waterfowl in the tundra wetlands of western AK. Transects were flown at 30-46 m in altitude and a speed of 135-157 km/hr. All large waterbirds sighted within 200 m of the aircraft were recorded by the left-seat observer (pilot) and a rear right-seat observer. These data were combined with those flown in 1989-97. The combined data set has 46,344 sightings with species, group size, and geographic location. GPS receiver maintained accurate positioning and altitude was monitored using a radar altimeter. Observations were voice recorded and captures time along with GPS coordinates of the aircraft. Data

transcription of this provides transect, date, time, geographic coordinates, species, group size, and any descriptive notes. There were no Visibility correction factors applied and no population estimates made. The data consists of Total Indicated Birds as per strata.

Species in the survey that were used in analysis: BLSC

Survey Strata: Bristol Bay High, Bristol Bay Low, YKD High, YKD Low, Seward Peninsula, Selawik

Time frame analyzed: 2004-2012

Data Set: Alaska's Yukon-Kuskokwim Delta Coast Aerial Waterfowl Survey

Data Source: Swaim, M. A. 2017. Abundance and trend of waterbird populations on the Yukon-Kuskokwim Delta, Alaska, 1988-2016. Unpublished data. U.S. Fish and Wildlife Service Report. Anchorage, AK.

Platte, RM., and Stehn, R.A. 2015. Abundance and Trend of Waterbirds on Alaska's Yukon Kuskokwim Delta Coast based on 1988 to 2014 Aerial Surveys. U.S. Fish and Wildlife Service, Waterfowl Management Branch.

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Description: Survey design has changed several times over the years of this survey. The survey was initiated to monitor cackling geese, but other waterfowl species were also recorded during flights. In 2012, area surrounding villages were omitted which decreased the total survey area. The survey area was originally 12,832 km² of tundra wetlands from Norton Sound to Kuskokwim Bay, which extended about 50 km inland from the west coast. This area was divided in 18 strata that generally had homogeneous physiographic features visible using LANDSAT imagery. GIS software was used to generate the systematic transects from a random coordinate within the survey area, and transects are oriented east to west. The spacing of the transects is smaller where waterfowl densities are higher. A second rotation began in 2002 with the same transects as 1998. In 2014 the first year of the fifth rotation began with the same transects being flown as in 2002, 2006, and 2010. This survey follows the standard protocols for waterfowl breeding surveys provided by USFWS and CWS. The surveys occurred at 145-170 km/hr at an altitude of 30-46 m. Navigation of transects was maintained using GPS within the aircraft. Since 1998, the Record Program has been used. Observers recorded waterfowl to the species or group level and recorded group size as single, pair, or number of birds in flocks. For other discrepancies throughout the years, please reference the citation above.

Species in the survey that were used in analysis: SPEI, COEI, BLSC, LTDU

Survey Strata: *All strata were combined into one area, the YKD strata

Time frame analyzed: 2001-2016

Data Set: Arctic Coastal Plain (ACP) Waterfowl Population Survey

Data Source: Wilson, H.M. and Swaim, M.A. 2018. Update Report: Aerial survey indices of waterbird populations on the Arctic Coastal Plain, 1986-2017. Unpublished data. U.S. Fish and Wildlife Service Report. Anchorage, AK.

Stehn, R.A., Larned, W.W. and Platte, R.M. 2013. Analysis of aerial survey indices monitoring waterbird populations of the Arctic Coastal Plain, Alaska, 1986-2012. Unpublished data. U.S. Fish and Wildlife Service Report. Anchorage, AK.

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Description: This survey follows the flight and recording protocols of the North American Waterfowl Breeding Population and Habitat Survey, using fixed wing aircraft for survey counts of breeding waterfowl. 4 strata are based on homogeneous physiographic features. The ACP was redesigned in 2007 and made changes to timing, stratification, sampling allocation, and area. The average 2007-2012 observed sampling fractions were 8.2% for TESH, 4.2% for High, 2.1% for Medium, and 1.3% for Low. This presented greater observation effort where more birds were present, which increased the number of bird observations compared to previous survey design. For more detail about survey design and methodology, see citation above.

Species in the survey that were used in analysis: MALL, NOPI, SCAU, AGWT, AMWI, NSHO, MERG, LTDU, KIEI, COEI, STEI, SPEI, SUSC, WWSC, BLSC

Survey Strata: ACP-1, ACP-2, ACP-3, ACP-4

Time frame analyzed: 2008-2017

Data Set: Canadian Central Arctic Survey (*Original data for this survey is not available in the geodatabase. Currently, there is ongoing work being conducted to refine the survey and provide population estimates. For original data, please contact one of the contact sources)

Data Source: Funders: Mississippi and Central Flyway Councils, Sea Duck Joint Venture, unpublished data, Arctic Goose Joint Venture, U.S. Fish and Wildlife Service, Canadian Wildlife Service.

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Timothy Moser
Division of Migratory Bird Management
U.S. Fish and Wildlife Service
Retired

Description: Data were provided in the form of multiple spatial layers. Estimates of density were calculated at the strata and segment level for the species listed below. Not all species were surveyed in every strata year the survey was conducted. For information of the full methodology of the survey and the population estimate calculations, contact the persons listed above.

Species in the survey that were used in analysis: LTDU, COEI, KIEI, SUSC, WWS, BLSC
Survey Strata Codes: A, AP, B, Banks1, Banks2, Banks3, Banks4, BB, C, CP, D, K, KP, KW, P, QL, QM, RL, T, TA, TP, V, W, BIC, BIN, BIS, CIN, CIS, CIW, SHIB, SHIBE, SHIBEAR, SHIC, SHIEB, SHIELL, SHIH, SHII, SHIK

Time frame analyzed: 2005-2011

Data Set: Breeding Bird Survey

Data Source: Zimmerman, G.S., Sauer, J.R., Boomer, G.S., Devers, P.K., Garrettson, P.R. 2017. Integrating Breeding Bird Survey and demographic data to estimate Wood Duck population size in the Atlantic Flyway. *Condor*. 119(3): 616-628

Contact Person:

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Description: Chandler Robbins and colleagues at the Patuxent Wildlife Research Center developed the North American Breeding Bird Survey to monitor bird populations over large geographic areas.

Today, the BBS continues to monitor bird populations across North America and informs researchers and wildlife managers of significant changes in bird population levels. If significant declines are detected, their causes can then be identified and appropriate actions taken to reverse them before populations reach critically low levels. Each year during the height of the avian breeding season, June for most of the U.S. and Canada, participants skilled in avian identification collect bird population data along roadside survey routes. Each survey route is approximately 24.5 miles long with stops situated ideally 0.5-mile apart. At each stop, a 3-minute point count is

conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. Over 4100 survey routes are located across the continental U.S. and Canada. Once analyzed, BBS data provide an index of population abundance that can be used to estimate population trends and relative abundances at various geographic scales. Trend estimates for more than 420 bird species and all raw data are currently available via the BBS web site.

Species in the survey that were used in analysis: WODU

Survey Strata:

Time frame analyzed: 2001-2015

Data Set: Upper Mississippi River and Great Lakes Region waterfowl surveys

Data Source: Upper Mississippi River and Great Lakes Region JV Waterfowl Habitat Conservation Strategy (2007)

http://www.uppermissgreatlakesjv.org/docs/UMRGLR_JV_WaterfowlHCS.pdf

Contact Person: NONE

Description: See citation above for methods

Species in the survey that were used in analysis: ABDU

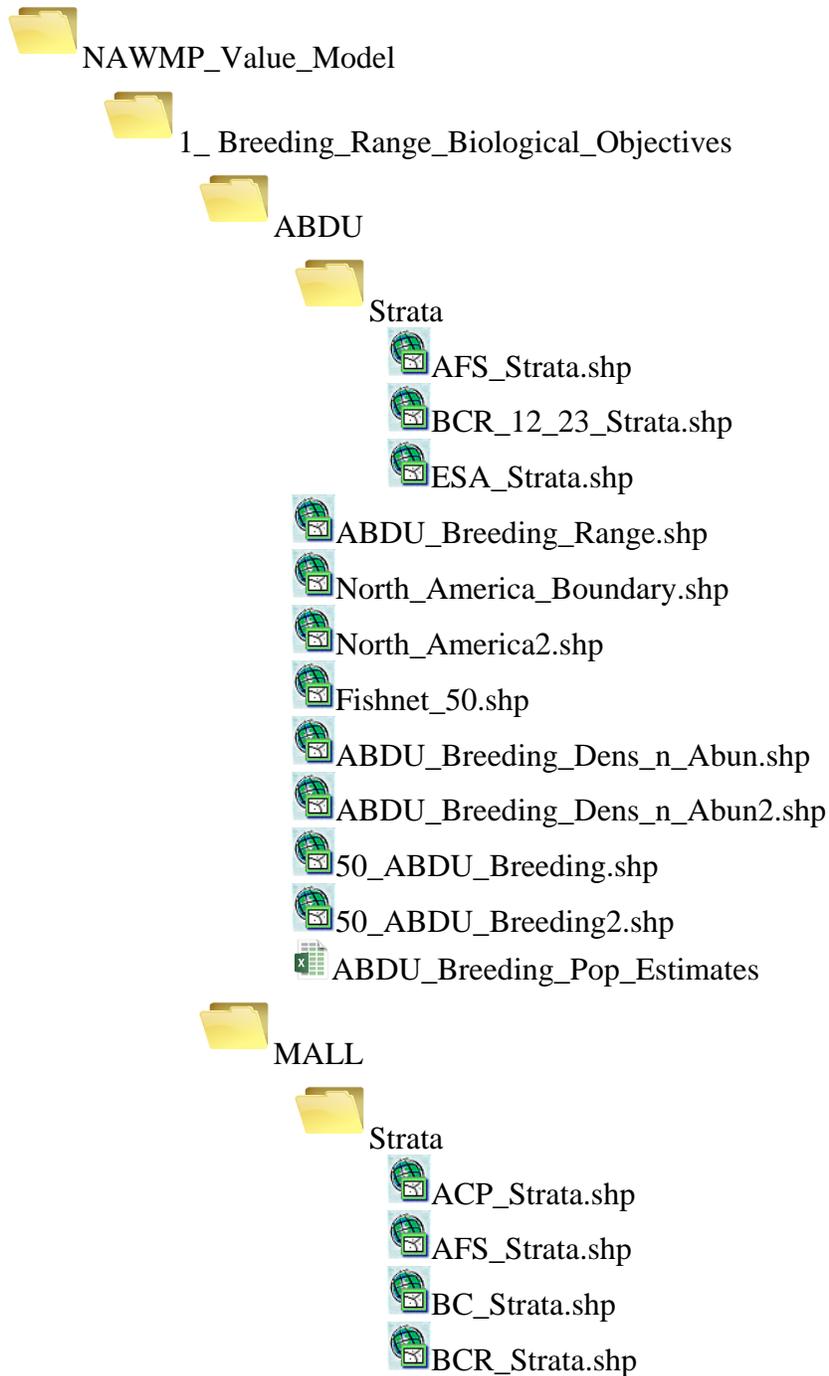
Survey Strata: BCR 12, BCR 23 in UPRGLJV

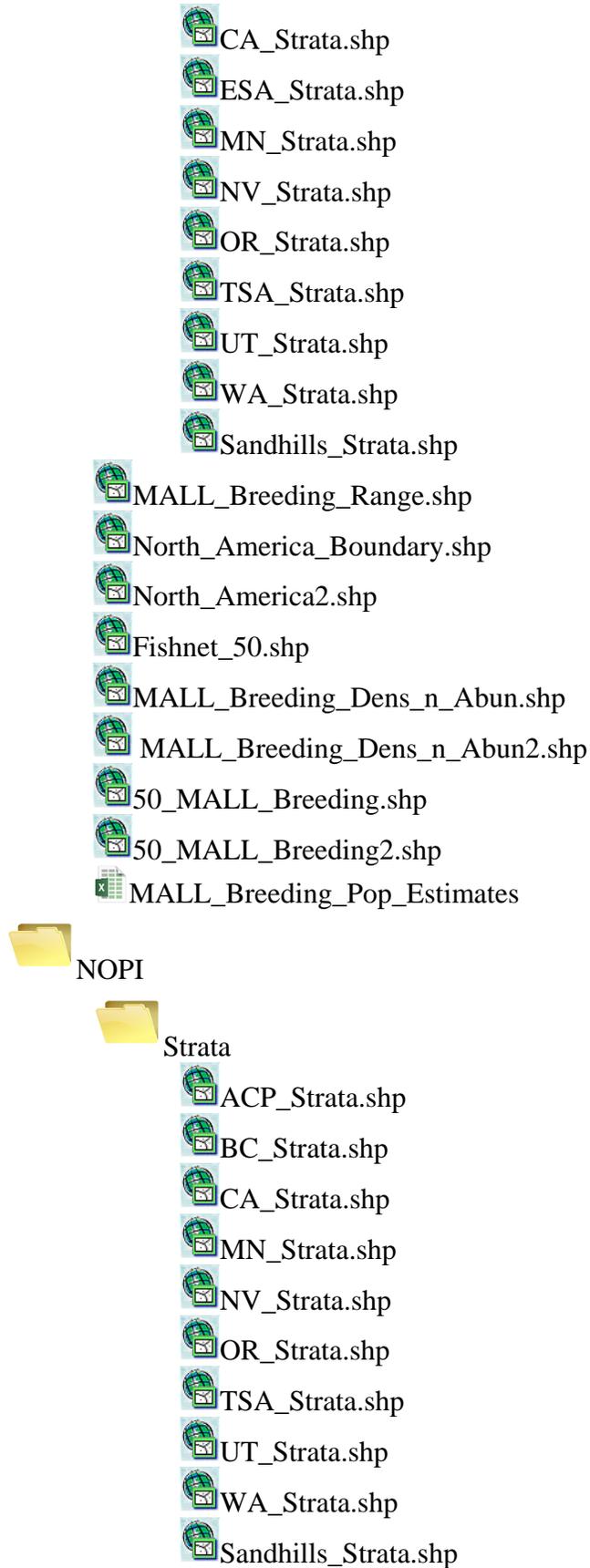
Time frame analyzed: 2003-2007

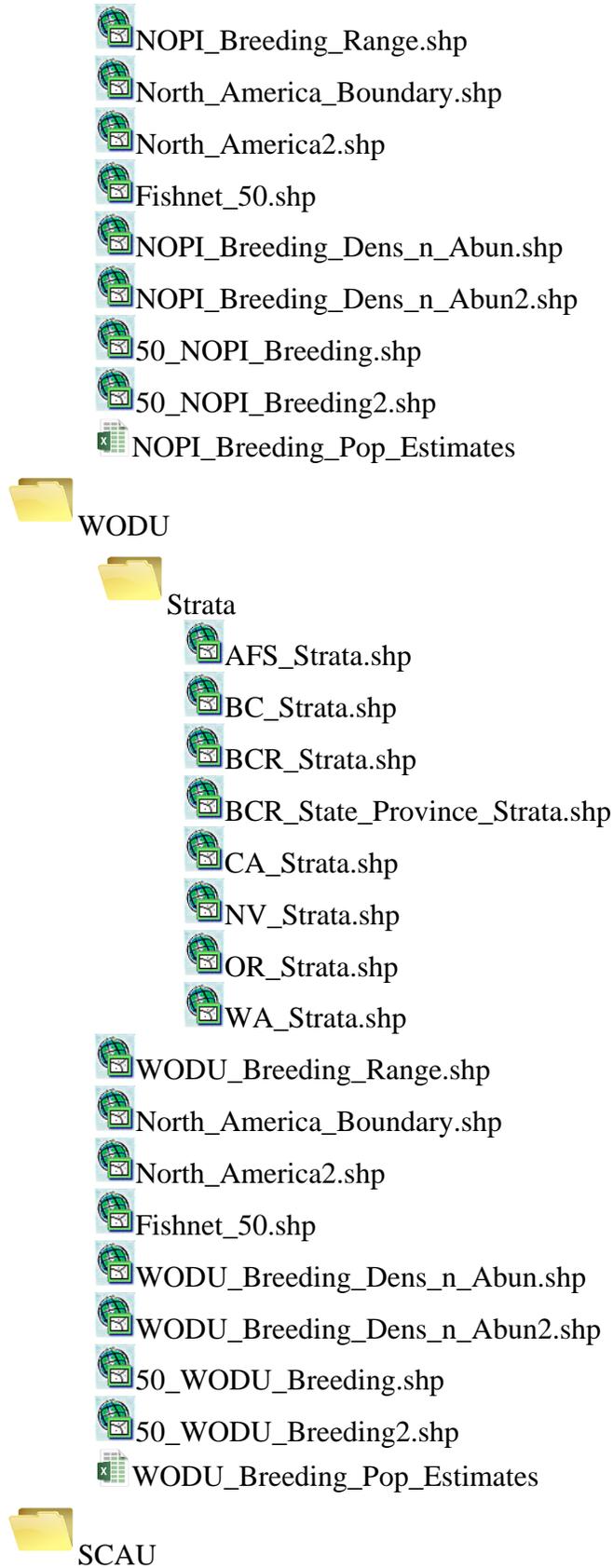
Supplement 8.

Geodatabase File Directory

A geodatabase is provided as supplement to this report. All spatial layers, including intermediate steps and models, used to create the five spatial products described in this report can be found in this geodatabase. Any data or spatial products used from the geodatabase should be cited according to their original source (Supplement 7).









Strata

-  ACP_Strata.shp
-  BC_Strata.shp
-  CA_Strata.shp
-  MN_Strata.shp
-  NV_Strata.shp
-  OR_Strata.shp
-  TSA_Strata.shp
-  UT_Strata.shp
-  WA_Strata.shp



SCAU_Breeding_Range.shp



North_America_Boundary.shp



North_America2.shp



Fishnet_50.shp



SCAU_Breeding_Dens_n_Abun.shp



SCAU_Breeding_Dens_n_Abun2.shp



50_SCAU_Breeding.shp



50_SCAU_Breeding2.shp



SCAU_Breeding_Pop_Estimates

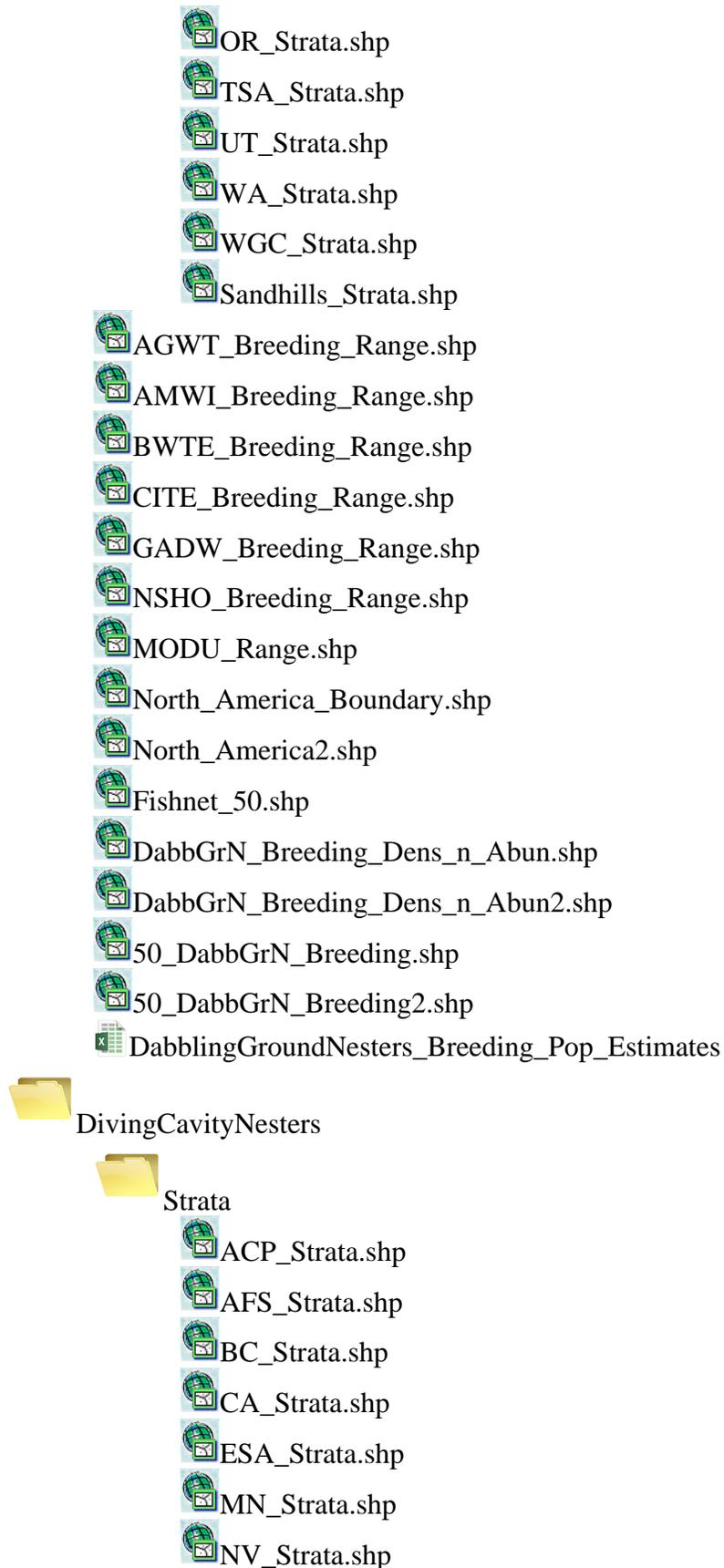


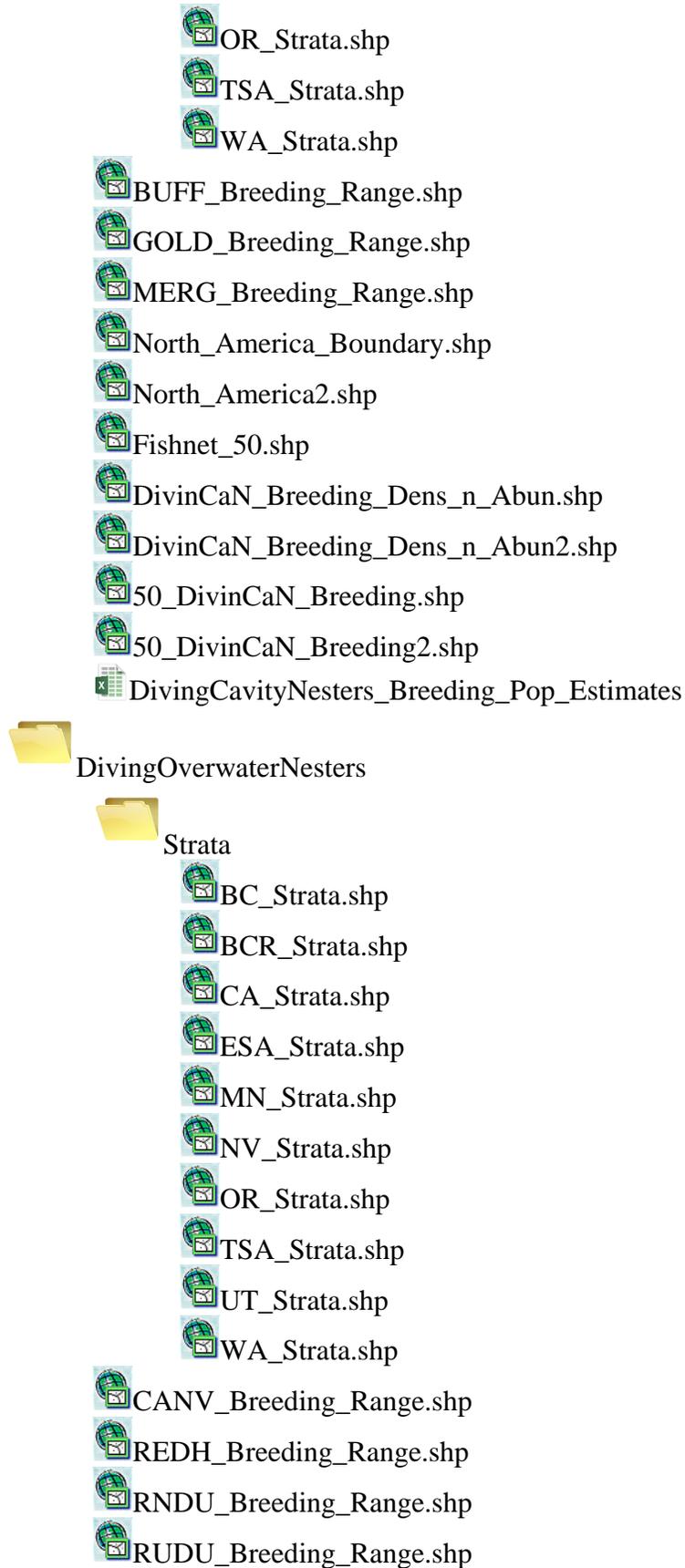
DabblingGroundNesters



Strata

-  ACP_Strata.shp
-  AFS_Strata.shp
-  BC_Strata.shp
-  BCR_Strata.shp
-  CA_Strata.shp
-  ESA_Strata.shp
-  MN_Strata.shp
-  NV_Strata.shp





-  North_America_Boundary.shp
-  North_America2.shp
-  Fishnet_50.shp
-  DivinOvN_Breeding_Dens_n_Abun.shp
-  DivinOvN_Breeding_Dens_n_Abun2.shp
-  50_DivinOvN_Breeding.shp
-  50_DivinOvN_Breeding2.shp
-  DivingOverwaterNesters_Breeding_Pop_Estimates



DivingGroundNesters



Strata

-  ACP_Strata.shp
-  BC_Strata.shp
-  BLSC_Survey_Strata.shp
-  TSA_Strata.shp
-  ESA_Strata.shp
-  YF_Strata.shp
-  CenCAArctic_Strata.shp
-  EasCAArctic_Strata.shp
-  YKD_Strata.shp
-  EIDER_Breeding_Range.shp
-  HADU_Breeding_Range.shp
-  LTDU_Breeding_Range.shp
-  SCOT_Breeding_Range.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  Fishnet_50.shp
-  DivinGrN_Breeding_Dens_n_Abun.shp
-  DivinGrN_Breeding_Dens_n_Abun2.shp
-  50_DivinGrN_Breeding.shp
-  50_DivinGrN_Breeding2.shp

 DivingGroundNesters_Breeding_Pop_Estimates

 2_Non_Breeding_Range_Biological_Objectives

 ABDU

-  ABDU_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  ABDU_Non_Breeding_DUD.shp
-  ABDU_Non_Breeding_DUD_Final.shp
-  50_ABDU_NonBreeding.shp
-  50_ABDU_NonBreeding2.shp

 MALL

-  MALL_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  MALL_Non_Breeding_DUD.shp
-  MALL_Non_Breeding_DUD_Final.shp
-  MALL_Non_Breeding_DUD2.shp
-  MALL_Non_Breeding_DUD_mex.shp
-  50_MALL_NonBreeding.shp
-  50_MALL_NonBreeding2.shp

 NOPI

-  NOPI_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  NOPI_Non_Breeding_DUD.shp
-  NOPI_Non_Breeding_DUD_Final.shp

-  NOPI_Non_Breeding_DUD2.shp
-  NOPI_Non_Breeding_DUD_mex.shp
-  50_NOPI_NonBreeding.shp
-  50_NOPI_NonBreeding2.shp



WODU

-  WODU_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  WODU_Non_Breeding_DUD.shp
-  WODU_Non_Breeding_DUD_Final.shp
-  50_WODU_NonBreeding.shp
-  50_WODU_NonBreeding2.shp



SCAU

-  SCAU_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  SCAU_Non_Breeding_DUD.shp
-  SCAU_Non_Breeding_DUD_Final.shp
-  SCAU_Non_Breeding_DUD2.shp
-  SCAU_Non_Breeding_DUD_mex.shp
-  50_SCAU_NonBreeding.shp
-  50_SCAU_NonBreeding2.shp



DabblingGroundNesters

-  AGWT_Non_Breeding_Range.shp
-  AMWI_Non_Breeding_Range.shp
-  BWTE_Non_Breeding_Range.shp
-  CITE_Non_Breeding_Range.shp

-  GADW_Non_Breeding_Range.shp
-  NSHO_Non_Breeding_Range.shp
-  MODU_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  DabbGrN_Non_Breeding_DUD.shp
-  DabbGrN_Non_Breeding_DUD_Final.shp
-  DabbGrN_Non_Breeding_DUD2.shp
-  DabbGrN_Non_Breeding_DUD2_Diss.shp
-  DabbGrN_Non_Breeding_DUD_mex.shp
-  50_DabbGrN_NonBreeding.shp
-  50_DabbGrN_NonBreeding2.shp



DivingCavityNesters

-  BUFF_Non_Breeding_Range.shp
-  GOLD_Non_Breeding_Range.shp
-  MERG_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  DivinCaN_Non_Breeding_DUD.shp
-  DivinCaN_Non_Breeding_DUD_Final.shp
-  DivinCaN_Non_Breeding_DUD_Diss.shp
-  50_DivinCaN_NonBreeding.shp
-  50_DivinCaN_NonBreeding2.shp



DivingOverwaterNesters

-  CANV_Non_Breeding_Range.shp
-  REDH_Non_Breeding_Range.shp
-  RNDU_Non_Breeding_Range.shp

-  RUDU_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  DivinOvN_Non_Breeding_DUD.shp
-  DivinOvN_Non_Breeding_DUD_Final.shp
-  DivinOvN_Non_Breeding_DUD2.shp
-  DivinOvN_Non_Breeding_DUD2_Diss.shp
-  DivinOvN_Non_Breeding_DUD_mex.shp
-  50_DivinOvN_NonBreeding.shp
-  50_DivinOvN_NonBreeding2.shp



DivingGroundNesters

-  EIDER_Non_Breeding_Range.shp
-  HADU_Non_Breeding_Range.shp
-  LTDU_Non_Breeding_Range.shp
-  SCOT_Non_Breeding_Range.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  North_America2.shp
-  DivinGrN_Non_Breeding_DUD.shp
-  DivinGrN_Non_Breeding_DUD_Final.shp
-  DivinGrN_Non_Breeding_DUD_Diss.shp
-  50_DivinGrN_NonBreeding.shp
-  50_DivinGrN_NonBreeding2.shp



DUD_AllSpecies_MX.shp



DUD_AllSpecies_US_n_CA.shp



3_ Geese_Swans



Breeding



Rasters



geese_swans_breeding.shp



geese_swans_breeding2.shp



North_America2.shp



brnt_g



cand_g



empr_g



grwf_g



mute_s



ross_g



snow_g



trmp_s



tund_s



gs_breed



Brant_Goose.shp



Canada_Goose.shp



Emperor_Goose.shp



Greater_White_Fronted_Goose.shp



Mute_Swan.shp



Ross_Goose.shp



Snow_Goose.shp



Trumpeter_Swan.shp



Tundra_Swan.shp



Breeding_Geese_n_Swans_50km.shp



Breeding_Geese_n_Swans_50km2.shp



Non_Breeding



Rasters



geese_swans_nonbreeding.shp



geese_swans_nonbreeding2.shp



North_America2.shp



brnt_g



cand_g



empr_g



grwf_g

-  mute_s
-  ross_g
-  snow_g
-  trmp_s
-  tund_s
-  gs_nobreed

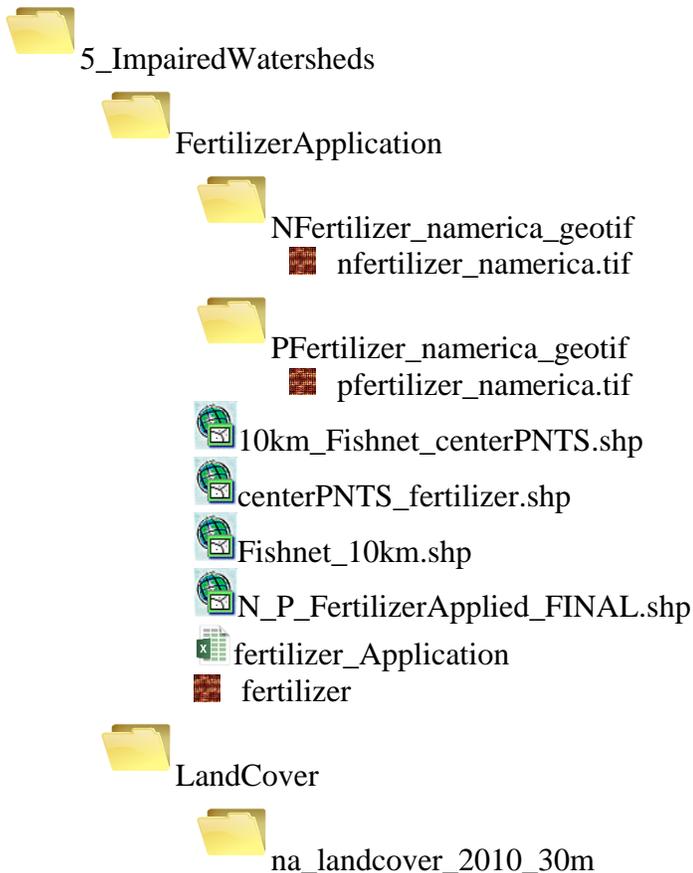
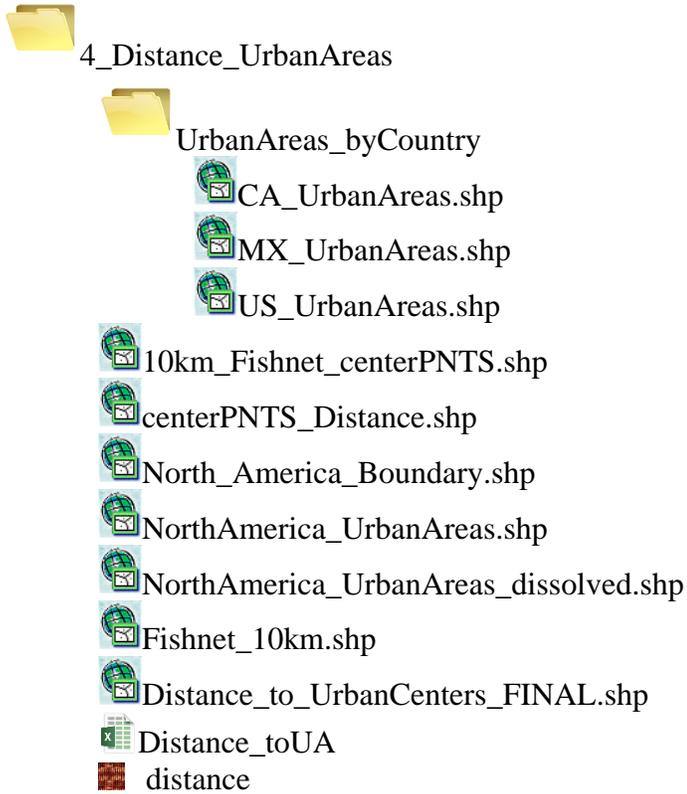
-  Brant_Goose.shp
-  Canada_Goose.shp
-  Emperor_Goose.shp
-  Greater_White_Fronted_Goose.shp
-  Mute_Swan.shp
-  Ross_Goose.shp
-  Snow_Goose.shp
-  Trumpeter_Swan.shp
-  Tundra_Swan.shp
-  NonBreeding_Geese_n_Swans_50km.shp
-  NonBreeding_Geese_n_Swans_50km2.shp



Individual_Spp

-  Brant_Goose.shp
-  Canada_Goose.shp
-  Emperor_Goose.shp
-  Greater_White_Fronted_Goose.shp
-  Mute_Swan.shp
-  Ross_Goose.shp
-  Snow_Goose.shp
-  Trumpeter_Swan.shp
-  Tundra_Swan.shp

-  All_Species.shp
-  All_Species_NA.shp
-  Fishnet_50.shp
-  North_America_Boundary.shp
-  Utility_Functions_Breeding_N_NonBreeding



-  NA_NALCMS_LC_30m_LAEA_mmu12_urb05.tif
-  NALCMS_legend_19class_english.lyr
-  Accuracy_FINAL_NorthAmericaSummary

 Extract_Reclass_Process

 Extract_LandCover.gdb – this geodatabase is linked to an extract by mask model, which contains 146 raster files of the Land Cover raster layer broken up using a 500×500 km spatial layer

 Reclassified_LandCover.gdb – this geodatabase is linked to the reclassify model, which contains 146 raster files, each reclassified where ‘Developed and build up’ class is equal to 1 and all other land cover classes are equal to 0.

 Extract_LandCover_Model
 Model

 Reclassify_LandCover_Model
 Model

-  Extract_Fishnet2.shp
-  Fishnet_10km.shp
-  PRCNT_Developed_FINAL.shp
-  zonal_10kmgrid
-  Landcover
-  LC_rec.tif

 6_WetlandBird_Diversity

 Output.gdb – this geodatabase is linked to ‘model’, which contains 156 shapefiles, each of which is the distribution of an obligate wetland bird species

 Output2.gdb – this geodatabase is linked to ‘model1’, which contains 156 shapefiles, each reprojected into a new coordinate system

 Output3.gdb – this geodatabase is linked to ‘model2’, which contains 156 raster files that have been created from the shapefiles in Output2.gdb

-  model
-  Model
-  Model1
-  Model2

-  All_birds.shp
-  All_birds2.shp
-  All_wet_birds.shp
-  NorthAmerica.shp
-  Wet_Bird_Div_toCenterPNTS.shp
-  Wetland_Bird_Diversity_FINAL.shp
-  Wetland_Bird_Diversity
-  ref_State_of_Birds_2011_original
-  wet_bird_div



7_SimpsonsDiversityIndex

-  10km_Fishnet_centerPNTS.shp
-  10km_Fishnet_centerPNTS_withSDI_values.shp
-  Fishnet_10km.shp
-  Fishnet_50km.shp
-  Breeding_WaterfowlSDI_FINAL.shp
-  NonBreeding_WaterfowlSDI_FINAL.shp
-  Waterfowl_SDI
-  10km_Fishnet_centerPNTS_withDSI_values



8_HunterDaysAfield

-  10km_Fishnet_centerPNTS.shp
-  10km_Fishnet_centerPNTS_withHDA_values.shp
-  CA_HuntingZones.shp
-  CA_US_HDA.shp
-  CA_US_HDA2.shp
-  CA_US_merge.shp
-  CA_WaterfowlHDA_FINAL.shp
-  Fishnet_10km.shp
-  North_America_Boundary.shp
-  North_America_Boundary2.shp
-  US_Counties.shp

-  US_DuckHDA_FINAL.shp
-  US_GooseHDA_FINAL.shp
-  CA_HDA
-  10km_Fishnet_centerPNTS_withHDA_values
-  CA_HDA_AllHunters
-  US_Duck_HDA2
-  US_Goose_HDA2
-  US_HDA_DucksNGeese

 Standardized_SpatialLayers

 Bio_Map *each raster layer in this folder (n=20) has a weight of 0.05, therefore the cell value range is 0-0.05. The aggregation of these spatial layers can result in a maximum utility of 1. This folder also contains one of the 5 spatial layers (Fig. 3), [bio_allobj](#).

 Bio_Breeding_Map *each raster layer in this folder (n=10) has a weight of 0.1, therefore the cell value range is 0-0.1. The aggregation of these spatial layers can result in a maximum utility of 1. This folder also contains one of the 5 spatial layers (Fig. 4), [bio_breed](#).

 Bio_NonBreeding_Map *each raster layer in this folder (n=10) has a weight of 0.1, therefore the cell value range is 0-0.1. The aggregation of these spatial layers can result in a maximum utility of 1. This folder also contains one of the 5 spatial layers (Fig. 5), [bio_nbreed](#).

 Soc_Map *each raster layer in this folder (n=9) has a unique weight (Supplement 6) based on equal weighting of the 5 main objectives. The aggregation of these spatial layers can result in a maximum utility of 1. This folder also contains one of the 5 spatial layers (Fig. 6), [social_map](#).

 AllObj_Map *each raster layer in this folder (n=29) has a unique weight (Supplement 6) based on equal weighting of the Biological and Social Objectives (0.05) and the sub-objectives being weighted accordingly with equal weights. The aggregation of these spatial layers can result in a maximum utility of 1. This folder also contains one of the 5 spatial layers (Fig. 7), [allobj_map](#).

-  50_ABDU_Breeding2.shp
-  50_ABDU_NonBreeding2.shp
-  50_MALL_Breeding2.shp

 50_MALL_NonBreeding2.shp
 50_NOPI_Breeding2.shp
 50_NOPI_NonBreeding2.shp
 50_WODU_Breeding2.shp
 50_WODU_NonBreeding2.shp
 50_SCAU_Breeding2.shp
 50_SCAU_NonBreeding2.shp
 50_DabbGrN_Breeding2.shp
 50_DabbGrN_NonBreeding2.shp
 50_DivinCaN_Breeding2.shp
 50_DivinCaN_NonBreeding2.shp
 50_DivinOvN_Breeding2.shp
 50_DivinOvN_NonBreeding2.shp
 50_DivinGrN_Breeding2.shp
 50_DivinGrN_NonBreeding2.shp
 Breeding_Geese_n_Swans_50km2.shp
 NonBreeding_Geese_n_Swans_50km2.shp
 Breeding_WaterfowlSDI_FINAL.shp
 NonBreeding_WaterfowlSDI_FINAL.shp
 Distance_to_UrbanCenters_FINAL.shp
 Wetland_Bird_Diversity_FINAL.shp
 N_P_FertilizerApplied_FINAL.shp
 PRCNT_Developed_FINAL.shp
 US_DuckHDA_FINAL.shp
 US_GooseHDA_FINAL.shp
 CA_WaterfowlHDA_FINAL.shp