

**User Guide**

Last Update: April 29, 2024

**What Is This Document For?**

This document serves three purposes:

* Transparency – Provide visibility into how the project’s end products were created. To answer questions about the data sources, calculations and analysis, and enabling code.
* Reproducibility – Provide guidance for technical users to reproduce the end products. To enable future Fish & Wildlife Service (F&WS) teams, GMU capstone teams, or other end users to customize or iterate this work (‘future work’ ideas are included where applicable).
* Usability – Provide instructions for nontechnical users to easily consume the end products. To enable them to integrate automated data creation and self-service analysis into their workflows.

**How Does This Document Differ from Other Project Documents?**

Though other documentation will accompany this project, this document differs in a few ways:

* A [Git Repo](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) includes all data, code, and files the team created for this project. This document helps connect the dots between these items, providing a sequential, logical guide on their purpose and how to use them.
* A project report goes into extensive tactical and technical detail about the data, analysis, and solution architecture, and includes findings and lessons learned. This document acts less as an ‘academic’ report and more as a ‘user guide’ – the goal is to enable easy access and use of these end products.

**What Are the End Products?**

Though the end products support a variety of use cases, the primary ones include:

* Automatic generation of the Flyway Databook's data tables.
  + **Part 2 of this document provides a user guide for this use case.**
* The ability for self-service data access, analysis, and visualization of the data underpinning these data tables.
  + **Part 3 of this document provides a user guide for this use case.**

Note: Additional information about these use cases can be found in the project report – notably, in 1.2 Problem Space and 1.5 Project Objectives.

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**Part 1: What Data Do I Need?**

There are three datasets needed. Two of the three datasets were sent by the F&WS via email – due to privacy issues, they could not provide GMU with direct access to the databases where the data resides. And due to the size of the datasets, GitHub's Large File Service (LFS) is utilized. Git LFS manages large files by storing a pointer file in the repository as a reference to the actual file, which is stored externally. These two datasets are [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) and [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv).

1. [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) – Background and Description

The F&WS conducts the Migratory Bird Parts Collection Survey, also known as the Wing Survey. They ask a sample of hunters from around the U.S. to send in one wing from each duck, dove/pigeon, and woodcock/rail that they shoot, and the wing tips and tail feathers from each goose. Before every hunting season, the F&WS provides survey participants with postage-paid wing envelopes to send in their parts. In mid-November (dove), February (waterfowl/pigeon), and early April (woodcock/rail), state and federal biologists examine the contributed parts at events called wingbees. Data from wingbees helps estimate the number of birds of distinct species, sex, and age in the year’s harvest. This helps inform how harvest is changing over time and among distinct locations.

Additional information about the survey can be found on the F&WS’s website [here](https://www.fws.gov/project/migratory-bird-parts-collection-survey). And a data dictionary for this dataset is below.

|  |  |  |
| --- | --- | --- |
| **Variable Name** | **Type** | **Description** |
| PartID | Integer | 10-digit internal identification code representing a single part (duck wing or goose tail) submitted by a hunter. |
| Season | Integer | Year representing the beginning of the hunting season. |
| PCSHunterID | Integer | Unique 9-digit internal identification number of an individual hunter. |
| harvest\_month | Integer | Month reported by the hunter in which the duck or goose was harvested. Blank if no month was provided. |
| harvest\_day | Integer | Day reported by the hunter when the duck or goose was harvested. Blank if no day was provided. |
| harvest\_year | Integer | Year reported by the hunter when the duck or goose was harvested. |
| flyway\_code | Integer | Integer code for the flyway associated with the location of the harvest. 1 = Atlantic; 2 = Mississippi; 3 = Central; 4 = Pacific; and 5 = Alaska. |
| flyway\_name | String | Flyway name associated with the location of the harvest. |
| flyway\_abbrev | String | Flyway abbreviation associated with the location of the harvest. |
| state\_code | Integer | Integer code for the state where the harvest occurred. |
| state\_name | String | Full state name where the harvest occurred. |
| state | String | 2-character abbreviation for the state in which the duck or goose was harvested. |
| aou\_number | Integer | American Ornithological Union (AOU) code used for uniquely identifying a species. |
| species\_aou | String | 4-character AOU code corresponding to the species of duck wing or goose tail submitted by the hunter. |
| species\_name | String | Common name of the species of duck wing or goose tail submitted by the hunter. |
| age\_code | integer | 1-digit code corresponding to the estimated age of the duck/goose whose wing/tail was submitted. 0 = unknown age; 1 = adult (after hatch year bird); and 2 = immature (hatch-year bird). |
| age\_char | String | Character code representing the age of the bird at harvest.  U = unknown age; A = adult (after hatch year bird); and I = immature (hatch-year bird). |
| sex\_code | Integer | 1-digit code corresponding to the sex of the duck/goose whose wing/tail was submitted.  0 = unknown sex; 4 = male; and 5 = female |
| sex\_char | String | A character code representing the sex of the species harvested.  U = unknown sex; M = male; and F = female. |
| cohort |  | An ID representing the age and sex cohort of the duck/goose whose wing/tail was submitted (a combination of Age and Sex variables). |
| harvest\_weight | Float | Weighted value reflecting the number of harvested birds of a given species represented by a particular duck wing or goose tail. The total estimated harvest of a species (by state and by year) is estimated as the sum of the weighted value of all wings/tails of that species submitted in each state and year. |
| is\_duck | Integer | Code representing the species that belong to the category ‘duck’ - 1= duck, 0 = not duck. |

2. [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) - Background and Description

This data provides harvest and hunting activity estimates for migratory game birds in 49 states, 4 flyways, and US totals. It contains the estimated retrieved and unretrieved harvest, days hunted, number of active hunters, and bag per hunter, along with confidence intervals (expressed as percent of the estimate) and variance, for 13 species or species groups of migratory game birds surveyed in the Migratory Bird Hunter Diary Survey from 1999 to 2020, by state and management unit.

Additional information about the survey can be found on the F&WS’s website [here](https://www.fws.gov/project/migratory-bird-hunter-survey-diary-survey). And a data dictionary for this dataset is below.

|  |  |  |
| --- | --- | --- |
| **Variable Name** | **Type** | **Description** |
| sp\_group\_surveyed | String | 4-character code representing the survey instrument, i.e., the group of species represented on the survey form: WATF (waterfowl survey), which includes ducks, geese, sea ducks and brant; DOVE (dove and band-tailed pigeon survey), which includes mourning doves, white-winged doves, and band-tailed pigeons; AMWO (woodcock survey), which includes American woodcock; SCRG (snipe, coot, rail and gallinule survey, which includes Wilson’s snipe, American coot, rails, and gallinules); and CRAN (sandhill crane survey) which includes sandhill cranes. |
| sp\_group\_estimated | String | Common name of species or species group for which harvest estimates are calculated. This includes the individual species: mourning dove, white-winged dove, band-tailed pigeon, American woodcock, sandhill crane, Wilson's snipe, and American coot; and species groups: ducks, geese, sea ducks, brant, rails, and gallinules. |
| season | Integer | Year representing the beginning of the hunting season. |
| mgmt\_unit | String | The management unit in which the state is located, which may differ depending upon the species. For waterfowl harvest estimates, the management units are defined as the flyways: AF = Atlantic Flyway, MF = Mississippi Flyway, CF = Central Flyway, PF = Pacific Flyway, AK = Alaska. For doves: EMU = eastern management unit, CMU = central management unit, WMU = western management unit. For band-tailed pigeons: FC = four corner’s states, PC = Pacific coast; for woodcock: EMR = eastern management region, CMR = central management region; US = continental United States (including Alaska). |
| survey\_state | String | 2-character abbreviation for the state for which the harvest estimate is calculated. This includes 49 states (all but Hawaii), as well as flyway and US totals. AF = Atlantic Flyway, MF = Mississippi Flyway, CF = Central Flyway, and PF = Pacific Flyway, and US totals. |
| survey\_state1 | String | Duplicate of survey\_state. |
| state\_frame\_size | Integer | The total number of HIP (Harvest Information Program) registrations submitted to the F&WS by each state each year. |
| days\_hunted | Float | Estimate of the total number of days hunters hunted for a particular species or species group. |
| CI\_ days\_hunted | Float | Confidence interval associated with the estimate of days hunted, expressed as a percentage of the estimate of days hunted. |
| Var\_ days\_hunted | Float | Estimate of variance associated with the estimate of days hunted. |
| retrieved | Float | Estimate of the number of birds shot and retrieved. |
| CI\_ retrieved | Float | Confidence interval associated with the estimate of retrieved birds, expressed as a percentage of the estimate of retrieved birds. |
| Var\_ retrieved | Float | Estimate of variance associated with the estimate of the number of retrieved birds. |
| unretrieved | Float | Estimate of the number of birds that were knocked down within sight but could not be retrieved. |
| CI\_ unretrieved | Float | Confidence interval associated with the estimate of unretrieved birds, expressed as a percentage of the estimate of unretrieved birds. |
| Var\_ unretrieved | Float | Estimate of variance associated with the estimate of the number of unretrieved birds. |
| active\_hunters | Float | Estimate of the number of active hunters (those who hunted that species or species group at least one day during the hunting season). |
| CI\_ active\_hunters | Float | Confidence interval associated with the estimate of active hunters, expressed as a percentage of the estimate of active hunters. |
| Var\_ active\_hunters | Float | Estimate of variance associated with the estimate of active hunters. |
| bag\_per\_hunter | Float | Estimate of the number of birds shot and retrieved per hunter. |
| CI\_bph | Float | Confidence interval associated with the estimate of bag per hunter, expressed as a percentage of the estimate of bag per hunter. |
| Var\_bph | Float | Estimate of variance associated with the estimate of bag per hunter. |
| status | Char | The status of the harvest estimate. P = Preliminary status\*, meaning that the estimate was calculated during the regulatory cycle following the hunting season, but has not been finalized. F = Finalized status, meaning that the estimate as well as the data used to produce it have been rigorously reviewed for errors, and corrected where necessary. |

3. [US Flyway Shapefiles](https://gis-fws.opendata.arcgis.com/datasets/857fe0c9f3fc4e848e905fb24c487d36_0/about) – Background and Description

The F&WS prescribes final late-season frameworks from which States may select season dates, limits, and other options for migratory bird hunting seasons. The effect of this final rule is to facilitate the States' selection of hunting seasons and to further the annual establishment of the late-season migratory bird hunting regulations. This dataset contains the following administrative waterfowl flyway delineations used by states in this process.

* Atlantic Flyway--includes Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, and West Virginia.
* Mississippi Flyway--includes Alabama, Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Ohio, Tennessee, and Wisconsin.
* Central Flyway--includes Colorado (east of the Continental Divide), Kansas, Montana (Counties of Blaine, Carbon, Fergus, Judith Basin, Stillwater, Sweetgrass, Wheatland, and all counties east thereof), Nebraska, New Mexico (east of the Continental Divide except the Jicarilla Apache Indian Reservation), North Dakota, Oklahoma, South Dakota, Texas, and Wyoming (east of the Continental Divide).
* Pacific Flyway--includes Alaska, Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, and those portions of Colorado, Montana, New Mexico, and Wyoming not included in the Central Flyway.

Additional information about the survey can be found on the F&WS’s website [here](https://gis-fws.opendata.arcgis.com/datasets/857fe0c9f3fc4e848e905fb24c487d36_0/about).

**Part 2: How Can I Automatically Generate the Flyway Databook's’ Data Tables?**

For each administrative Flyway (Atlantic, Mississippi, Central, and Pacific), the F&WS provides data summarized in Flyway-specific reports called "data books." These data books include summaries of species- and population-specific abundances, harvests, and other information derived from State-Federal Cooperative monitoring programs.

Examples can be found on the F&WS’s website [here](https://www.fws.gov/library/collections/migratory-bird-flyway-data-books) and can be used to find additional information or corroborate outputs for reproducibility.

Option 1: Automatically Generate Data Tables Via a Windows Executable File – For Nontechnical Users

This option enables nontechnical users to automatically generate data tables for the different data books. This is done via a Windows executable file (.exe) that can be run directly in Windows. These files are below:

* [HarvestTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HarvestTableGen.exe): File to automatically generate harvest data tables.
* [HunterTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HunterTableGen.exe): File to automatically generate hunter data tables.

To use these files:

1. Download and save them to a local directory, such as your Documents folder.
2. In Windows, perform a search by typing ‘cmd’ in the Windows search box and open the Windows Prompt console tool.
3. In the console tool, change the directory to the Windows folder to which the downloaded/saved file is located (in step 1).
4. Execute the script by typing the name of the script along with valid arguments and options. This is where users can specify the data or data table they wish to generate.
   1. Arguments and examples are included in a more detailed ‘how to’ guide, accessible via the [Table Generation Script User Guide](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/README.md):
5. An Excel Workbook (XLSX) file is generated in the same directory to which the file was downloaded/saved. Each Excel tab corresponds to a species or group.

Note: In the ‘Python Scripts’ folder in the project’s [Git Repo](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv), the scripts ending with the extension .py are the Python program scripts used to write/create the [HarvestTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HarvestTableGen.exe) and [HunterTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HunterTableGen.exe) files. These Python scripts are not needed to execute the .exe files and are made available for reference and/or future code development work to extend current functionalities. See below for more information.

Option 2: Automatically Generate Data Tables Via Python – For Technical Users

This option discusses the .py Python scripts, which (a) enables technical users to automatically generate data tables for the different data books using Python and (b) are the code scripts behind the [HarvestTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HarvestTableGen.exe) and [HunterTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HunterTableGen.exe) files mentioned in the prior section – these enable nontechnical users to automatically generate data tables for the different data books.

The .py scripts required to automatically generate data tables via Python are below:

* [FlywayTables.py](https://github.com/gjrsas/DAEN690/blob/main/Data/FlywayTables.py): This script creates the functions to create/output data tables to Excel worksheets, set the style/format of the output to replicate the look and feel of the F&WS’s data tables, and write the output. These functions are imported and used in the [HarvestTableGen.py](https://github.com/gjrsas/DAEN690/blob/main/Data/HarvestTableGen.py) and [HunterTableGen.py](https://github.com/gjrsas/DAEN690/blob/main/Data/HunterTableGen.py) scripts.
* [HarvestTableGen.py](https://github.com/gjrsas/DAEN690/blob/main/Data/HarvestTableGen.py): This script creates functions to parse and validate user inputs (e.g., column names, species selected) in the [HarvestTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HarvestTableGen.exe) and [HunterTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HunterTableGen.exe) files, perform the calculations needed to populate the harvest data tables, and generate/print the data tables via Excel.

* [HunterTableGen.py](https://github.com/gjrsas/DAEN690/blob/main/Data/HunterTableGen.py): This script creates functions to parse and validate user inputs (e.g., column names, species selected) in the [HarvestTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HarvestTableGen.exe) and [HunterTableGen.exe](https://github.com/gjrsas/DAEN690/blob/main/Products/Python%20Scripts/HunterTableGen.exe) files, perform the calculations needed to populate the hunter data tables, and generate/print the tables in Excel.

Note: Though the code itself can be read to understand what it’s doing, additional information about the Python code can be found and read in natural, non-technical language in the project report. Notably, the 'Data Quality Assessment’ and ‘Data Conditioning’ sections discuss the data preprocessing steps required and the ‘System Data Flows’ and ‘Algorithms & Analysis’ sections discuss the Python code used to create the .exe files.

**Future Work to Consider**: To automatically generate data tables, the F&WS pulled the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) and [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) from their SQL databases and sent it via email. Though Flyway Data Book data table creation is now automated, the ‘ETL’ (extract, transform, load) aspect of this process is still manual. Future work could include a solution that connects directly to F&WS data sources – this would further automate annual Flyway Data Book authoring efforts and potentially enable the F&WS to provide more frequent updates as the data comes in. Future work could also investigate automation opportunities to collect and preprocess the dozens, if not hundreds, of partner surveys before they are uploaded to their SQL databases.

**Part 3: How Can I Access, Re-Create, or Update the Prototype Self-Service Dashboards?**

There were three Tableau dashboards created: (1) a dashboard that enables users to explore and visualize the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) primarily by geography (flyway or state), species, and year; (2) a dashboard that enables users to explore and visualize the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) primarily by species, sex, and maturity; and (3) a dashboard that enables users to explore and visualize the [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv).

Broadly, Tableau offers public and private (e.g., Tableau Desktop) versions; differences between them and considerations on which to use are noted below.

* Privacy. Tableau dashboards pushed public are accessible to everyone; a private version is only visible to those a workbook is shared with, enabling control over user access. Considerations might include if analysis is confidential.
* Data sources. Tableau public has limited data connections, notably Excel and text files. Private versions offer connections to nearly unlimited data types. Considerations could include if future analysis will include data types not supported by Tableau public.
* Analysis functions. Though a public version enables analysis likely to suit most users/use cases, it should be noted that more advanced analytics features are available in private versions.
* Workflow management/iterating dashboards. To maintain a single-source-of-truth F&WS dashboard(s) for the public, a private version would first be created and then pushed public. However, these public versions can be downloaded and independently iterated, so there could be multiple harvest/hunter dashboards floating around the F&WS or publicly. This is not a bad thing, but again a consideration and worth noting.

Note: Instructions on how to publish ‘private’ versions ‘public’ can be found [here](https://help.tableau.com/current/pro/desktop/en-us/publish_workbooks_tableaupublic.htm#:~:text=With%20your%20workbook%20open%20in,to%20create%20a%20new%20one.). And examples of ‘public’ dashboards can be found [here](https://public.tableau.com/app/discover).

Option 1: Tableau ‘Public’

The public versions of the dashboards can be accessed via the following dashboard links (though provided, a username and password are only needed to maintain/change these dashboards, they are not needed to simply view or download them):

* Harvest 1 dashboard – To explore and visualize the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) primarily by geography (flyway or state), species, and year.
  + Dashboard link: [Click here!](https://public.tableau.com/app/profile/steven.olsen4966/viz/HarvestDashboard1/Dashboard1?publish=yes)
  + Username: dmbm.wildbirds@gmail.com
  + Password: Wildducks-123
* Harvest 2 dashboard – To explore and visualize the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) primarily by species, sex, and maturity.
  + Dashboard link: [Click here!](https://public.tableau.com/app/profile/steven.olsen4966/viz/HarvestDashboard2/Dashboard1?publish=yes)
  + Username: dmbm.wildbirds@gmail.com
  + Password: Wildducks-123
* Hunter dashboard – To explore and visualize the [Hunter Data.](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv)
  + Dashboard link: [Click here!](https://public.tableau.com/app/profile/steven.olsen4966/viz/HunterDataDashboard2023/Dashboard1?publish=yes)
  + Username: dmbm.wildbirds@gmail.com
  + Password: Wildducks-123

Note: A Gmail account was created to transfer GMU ownership of the Tableau Public dashboards to the F&WS. Account details are below; the F&WS can change the password post-project to maintain 100% ownership over them.

* Gmail Username: [dmbm.wildbirds@gmail.com](mailto:dmbm.wildbirds@gmail.com)
* Gmail Password: wildducks

To access/re-create these dashboards via a private (e.g., Tableau Desktop) version, see the instructions below.

Option 2: Tableau ‘Private’ (aka Tableau Desktop)

Tableau enables saving/sharing workbooks in two main formats: option 2(a), a .twbx file (aka packaged workbook) or option 2(b), a .twb file. Additional information on packaged workbooks can be found [here](https://help.tableau.com/current/pro/desktop/en-us/save_savework_packagedworkbooks.htm).

*Option 2(a): Tableau ‘Private’ via a .twbx file.*

A key difference in these file types is how they handle the data needed to recreate a dashboard. A .twbx file packages the data and dashboard into a single file – thus, to open/recreate the dashboard, the user ONLY needs to download the .twbx file and then open it, the data will be automatically contained/connected.

*Option 2(b): Tableau ‘Private’ via a .twb file.*

If the data is sent separately or in a .twb file, the user must download the data and dashboard separately and then connect the data to the dashboard. Instructions on how to do this are below and largely similar for all three dashboards.

(Dashboard 1) Harvest 1(a) dashboard – To explore and visualize the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) primarily by geography (flyway or state), species, and year.

To access/re-create this Harvest dashboard:

* Download and save the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) locally.
* Download and install [Tableau Desktop](https://www.tableau.com/support/releases/desktop/2023.1.11#esdalt) locally – there are free trials and paid options available.
* Download and save the Harvest.twb file locally.
* To open the Harvest.twb file, open Tableau Desktop and navigate to ‘File > Open’…then find the Harvest.twb file stored locally.
* Connect the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) to the Harvest.twb file.
  + After Tableau opens, there will likely be an error message (image below) that Tableau cannot connect to the data source (the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv)). This is because the path/name where it is saved locally differs. To resolve/connect the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) to the Harvest.twb file, click ‘Locate File’ or click ‘Data Source’ on the bottom left to select/connect to the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) where it is stored.

A screenshot of a computer error

Description automatically generated

* The output should look like below. *Note: The Flyway, Species, and State filters default to ‘(All).’*

A screenshot of a computer screen

Description automatically generated

From here-out, the dashboard should be fully functional. Users may customize the data and visualizations to meet their unique needs – this can be done by changing the four filters at the top right of the dashboard. Tableau offers free, online training and a broad range of analytics capabilities – useful links include:

* [Getting Started Instructions](https://www.tableau.com/learn/get-started)
* [Video Tutorials](https://www.tableau.com/learn/training/elearning)
* [eLearning Courses](https://www.tableau.com/learn/training/elearning)

(Dashboard 2) Harvest 1(b) dashboard – To explore and visualize the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) primarily by species, sex, and maturity.

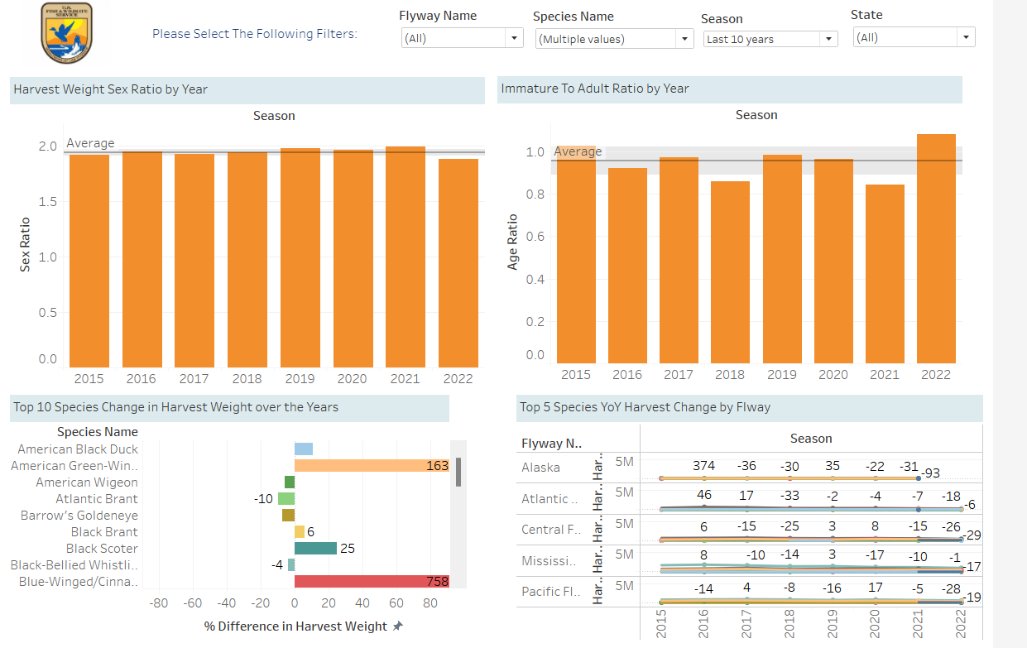
To access/re-create this Harvest dashboard:

* Download and save the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) locally.
* Download and install [Tableau Desktop](https://www.tableau.com/support/releases/desktop/2023.1.11#esdalt) locally – there are free trials and paid options available.
* Download and save the Harvest.twb file locally.
* To open the Harvest.twb file, open Tableau Desktop and navigate to ‘File > Open’…then find the Harvest.twb file stored locally.
* Connect the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) to the Harvest.twb file.
  + After Tableau opens, there will likely be an error message (image below) that Tableau cannot connect to the data source (the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv)). This is because the path/name where it is saved locally differs. To resolve/connect the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) to the Harvest.twb file, click ‘Locate File’ or click ‘Data Source’ on the bottom left to select/connect to the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) where it is stored.

A screenshot of a computer error

Description automatically generated

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* [Getting Started Instructions](https://www.tableau.com/learn/get-started)
* [Video Tutorials](https://www.tableau.com/learn/training/elearning)
* [eLearning Courses](https://www.tableau.com/learn/training/elearning)

(Dashboard 3) Hunter dashboard – To explore and visualize the [Hunter Data.](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv)

To access/re-create the Hunter dashboard:

* Download and save the [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) locally.
* Download and install [Tableau Desktop](https://www.tableau.com/support/releases/desktop/2023.1.11#esdalt) locally – there are free trials and paid options available.
* Download and save the Hunter.twb file locally.
* To open the Hunter.twb file, open Tableau Desktop and navigate to ‘File > Open’…then find the Hunter.twb file stored locally.
* Connect the [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) to the dashboard.
  + After Tableau opens, there will likely be an error message (image below) that Tableau cannot connect to the data source (the [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv)). This is because the path/name where it is saved locally differs. To resolve/connect the [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) to the Hunter.twb file, click ‘Locate File’ or click ‘Data Source’ on the bottom left to select/connect to the [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) where it is stored.

A screenshot of a computer error

Description automatically generated

* The output should look like below. *Note: The Flyway, Species, and State filters default to ‘(All).’*

A screenshot of a computer

Description automatically generated

From here-out, the dashboard should be fully functional. Users may customize the data and visualizations to meet their unique needs – this can be done by changing the four filters at the top right of the dashboard. Tableau offers free, online training and a broad range of analytics capabilities – useful links include:

* [Getting Started Instructions](https://www.tableau.com/learn/get-started)
* [Video Tutorials](https://www.tableau.com/learn/training/elearning)
* [eLearning Courses](https://www.tableau.com/learn/training/elearning)

**Future Work to Consider**: These dashboards enable F&WS and non-F&WS stakeholders (e.g., state partners, public) to access, analyze, and visualize data in new ways, notably outside of Flyway Data Book’s. Future work could more formally turn these dashboards into the go-to decision support tool used by these stakeholders for F&WS [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv), [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv), or other data. For instance, stakeholder surveys/interviews could be conducted to better understand the diversity of stakeholder questions and use cases – the dashboard could then be updated to accommodate them. Future work could also include efforts to make it easier for stakeholders to use these dashboards. This could be done using low-cost technologies like [natural language generation](https://www.tableau.com/blog/bringing-power-natural-language-tableau-58325) integration in Tableau, which would enable users to search and ‘Q&A’ the dashboards in natural language (like Google Search).

**Appendix: Additional Code and Files**

This section highlights additional code and files in the project’s [Git Repo](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv).

1. [Forecasting models](https://github.com/gjrsas/DAEN690/tree/main/Forecasting%20Models)

The [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) and [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) are historical. Because F&WS uses the data to set policy for future years, experiments were made to forecast key data points (e.g., harvest weight and total hunters) to provide forward-looking perspectives. The links below provide access to the Jupyter Notebook’s that contain the Python code used to forecast – the autoregressive integrated moving average (ARIMA) technique was used.

* [Harvest Weight Forecast by Species](https://github.com/gjrsas/DAEN690/blob/main/Forecasting%20Models/HarvestWeightForecastbySpecies.ipynb): This Jupyter Notebook includes Python code used to predict harvest weight for the next season based on species.
* [Harvest Weight Forecast by Species and Flyway](https://github.com/gjrsas/DAEN690/blob/main/Forecasting%20Models/HarvestWeightForecastbySpeciesandFlyway.ipynb): This Jupyter Notebook includes Python code used to predict harvest weight for the next season based on species and flyway.
* [Total Hunters by Species](https://github.com/gjrsas/DAEN690/blob/main/Forecasting%20Models/TotalHuntersbySpecies.ipynb): This Jupyter Notebook includes Python code used to predict the total number of hunters for the next season based on species.
* [Total Hunters by Species and State](https://github.com/gjrsas/DAEN690/blob/main/Forecasting%20Models/TotalHuntersbyStateandSpecies_ARIMA.ipynb): This Jupyter Notebook includes Python code used to predict the total number of hunters for the next season based on species and state.

Note: The ‘Machine Learning’ section of the project report provides additional information about these models, including data preparation, ARIMA methodology, findings, and lessons learned.

**Future Work to Consider**: Though the ARIMA forecasts demonstrated the potential (at the species level) to predict harvest weight and total hunters, results varied across species and there remains significant opportunities to reduce error rates across all species. The team attributed this to the lack of variables in the [Harvest Data](https://github.com/gjrsas/DAEN690/blob/main/Data/WingData.csv) and [Hunter Data](https://github.com/gjrsas/DAEN690/blob/main/Data/vw_harvest_estimates.csv) that are likely to drive forecasts (e.g., weather or hunter demographic information). Future work could include working with subject material experts to hypothesize/understand what might drive harvest weight and total hunters and subsequently collect the new data from the F&WS or external sources.