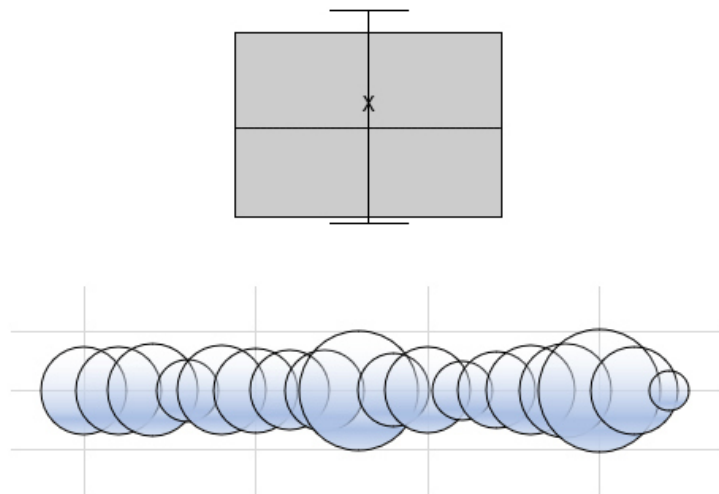


Christmas Bird Counts in North Central Washington

A look at winter bird diversity on the ancestral lands
of the p'squosa-Wenatchi people



Bruce McCammon
North Central Washington Audubon Society
March 2021
V1.5



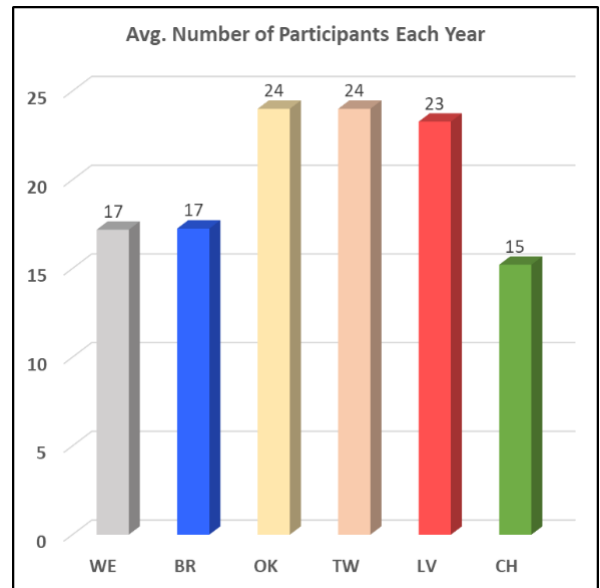
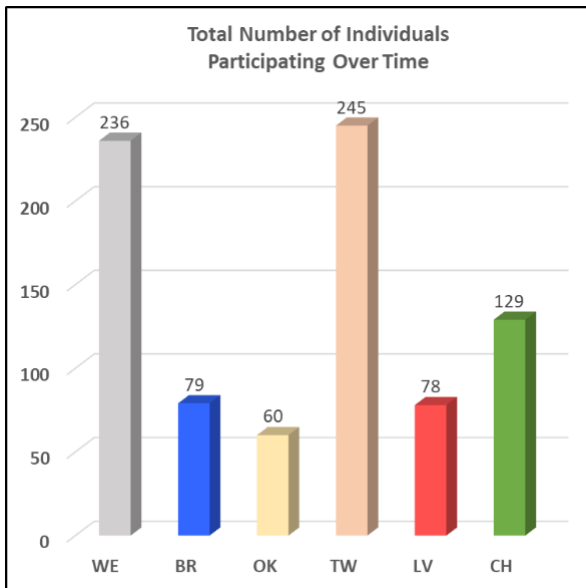
Acknowledgements

After talking to several people who have volunteered to count winter birds in a Christmas Bird Count (CBC) effort, I realized that I did not know much about the who, where, when, and how of these annual events. The “why” is easily assumed - people are inspired to see and learn about birds as well as help in their conservation. CBC offers a once-a-year opportunity to be part of “community science.”

I began researching the history of the CBC in north central Washington. I learned about the six active count circles in our area and found my way into the National Audubon CBC data archives. I was pretty astonished to learn that the Wenatchee record spans sixty years. I read a few short text summaries about the surveys in the NCW Audubon newsletters but I wanted more - so off I went, down the data rabbit hole.

This paper is dedicated to the 691 volunteers who have participated in Christmas Bird Counts in the six active “CBC count circles” located in north central Washington. I have included a list of all participants over time at the end of this paper. Your names are recorded in the historic records and I hope that your participation in the surveys was fun and meaningful for you. I know that you dealt with a variety of weather and logistical challenges as you recorded over 1.7 million birds during the life of the counts in our area. Your efforts are appreciated. I hope this paper informs you about the great diversity of birds in our area during the winter. My exploration of the data has provided me insights and inspired more questions.

208 species
1,736,584 birds
That’s a LOT of birds to count!



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3. Mallard	11	19. Northern Flicker (Red shafted)	27
4. Ring-necked Duck	12	20. American Kestrel	28
5. Bufflehead	13	21. Northern Shrike	29
6. Common Goldeneye	14	22. Steller's Jay	30
7. Ruddy Duck	15	23. Black-billed Magpie	31
8. California Quail	16	24. Common Raven	32
9. Great Blue Heron	17	25. Black-capped Chickadee	33
10. Golden Eagle	18	26. Red-breasted Nuthatch	34
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12. Red-tailed Hawk	20	28. Bohemian Waxwing	36
13. Ring-billed Gull	21	29. White-crowned Sparrow	37
14. Eurasian Collared-Dove	22	30. Spotted Towhee	38
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1. Canada Goose, American Wigeon, Mallard, Ring-necked Duck	5. Belted Kingfisher, Downy Woodpecker, Northern Flicker, American Kestrel
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3. Great Blue Heron, Golden Eagle, Bald Eagle, Red-tailed Hawk	7. Black-capped Chickadee, Red-breasted Nuthatch, European Starling, Bohemian Waxwing
4. Ring-billed Gull, Eurasian Collared-Dove, Mourning Dove, Great Horned Owl	8. White-crowned Sparrow, Spotted Towhee, Red-winged Blackbird, House Finch

List of all participants over time	51
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A Look at the Data

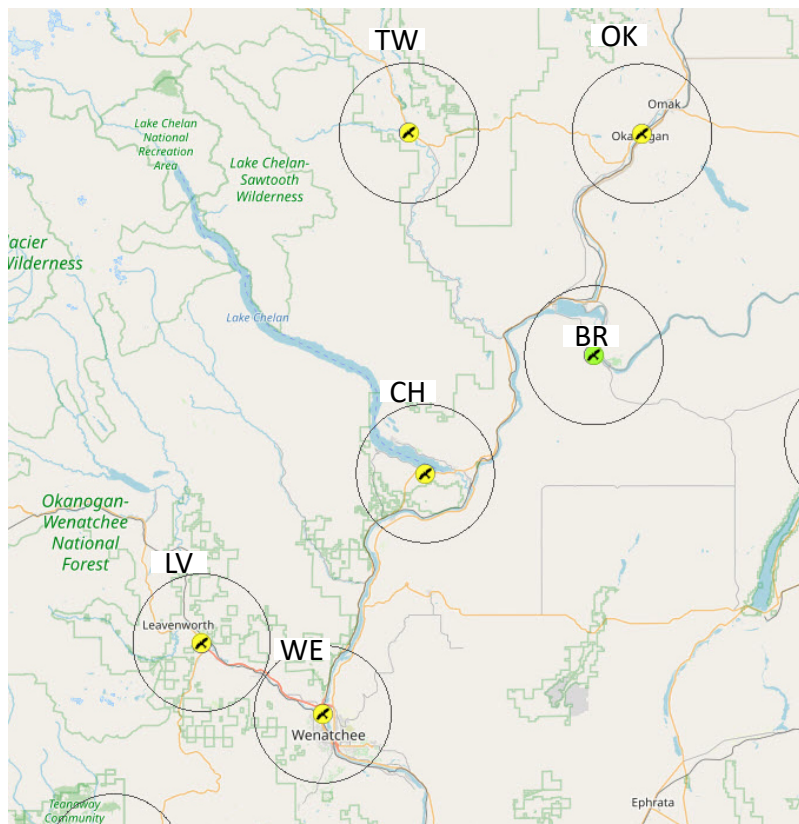
Thirty One Bird Species Inventoried during Christmas Bird Counts 1960-2019

Introduction

The Christmas Bird Count (CBC) began in 1900 and represents a long-term “community science” effort. Today, the surveys provide a valuable data set that allows evaluation of long-term trends in early winter bird populations. The National Audubon Society provides many narrative and statistical summaries of the data on the CBC website (<https://www.audubon.org/conservation/science/christmas-bird-count>). The CBC annual reports, (<https://www.audubon.org/content/american-birds-annual-summary-christmas-bird-count>) though a bit challenging to access and read, offer robust summaries of all the people, birds, hours and bird observations for each year.

Survey Design

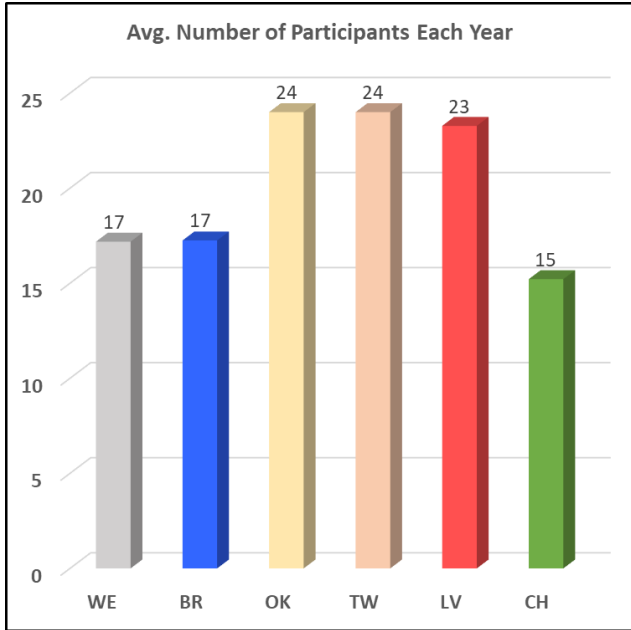
CBC surveys use 15-mile diameter count circles as the geographic containers for the surveys. Counts can be held on any single day from December 14 to January 5, inclusive. Small groups of volunteers spread out on different routes within each count circle to take inventory of birds over a 24-hour period on the count day. This report summarizes the data collected between 1960 - 2019 in the six count circles located in north central Washington: Wenatchee (**WE**), Bridgeport (**BR**), Omak-Okanogan (**OK**), Twisp (**TW**), Leavenworth (**LV**), and Chelan (**CH**).



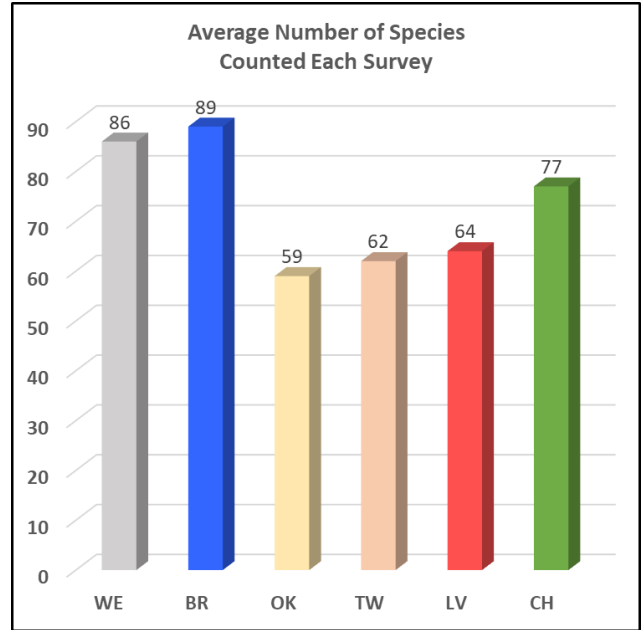
Count circles in north central Washington

Team members in each count circle may perform different roles: birder, recorder, compiler. After compilation, the data is submitted to the CBC archives at the National Audubon Society. It is common for the same people to be part of many surveys over time in a circle, but each group’s composition can vary from year to year. Survey methods for tabulation and transfer of data to the compiler may vary between routes within a circle and between circles.

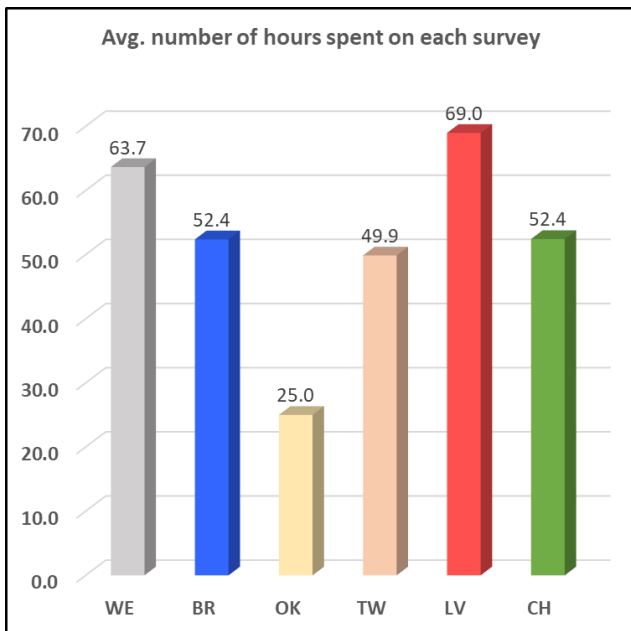
How many people, on average, participate on a survey in each circle?



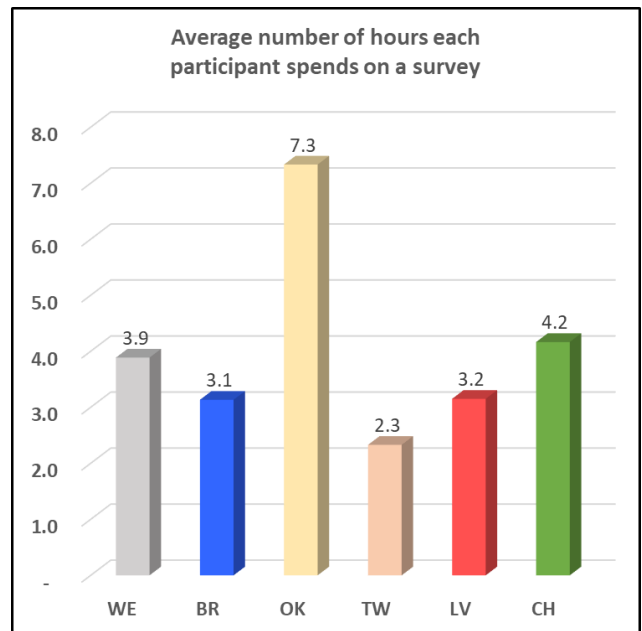
What is the average number of species counted in each circle each year?



On average, how many hours do the participants in each circle spend on each survey?



How many hours does each participant spend, on average?



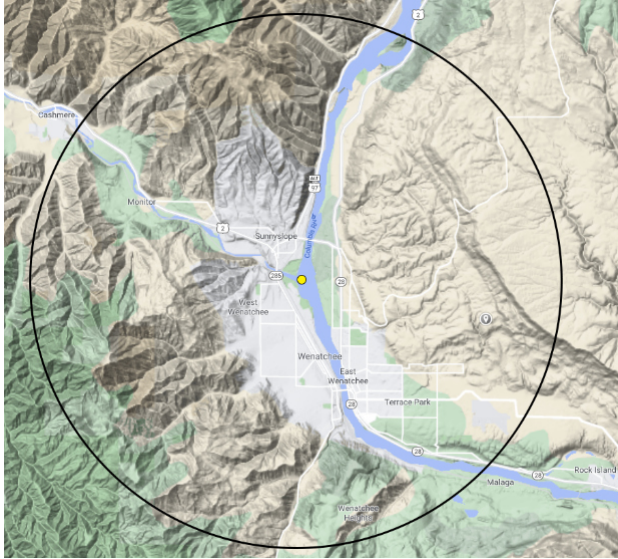
Data for the period of record through 2019

One way to summarize the charted information below:

In an average year, 17 people volunteer to conduct a Christmas Bird Count in the Wenatchee count circle. Each individual spends about 4 hours in the field. Collectively, the 17 volunteers spend about 64 hours to count 86 species of birds in the circle.

The topography of the CBC circles

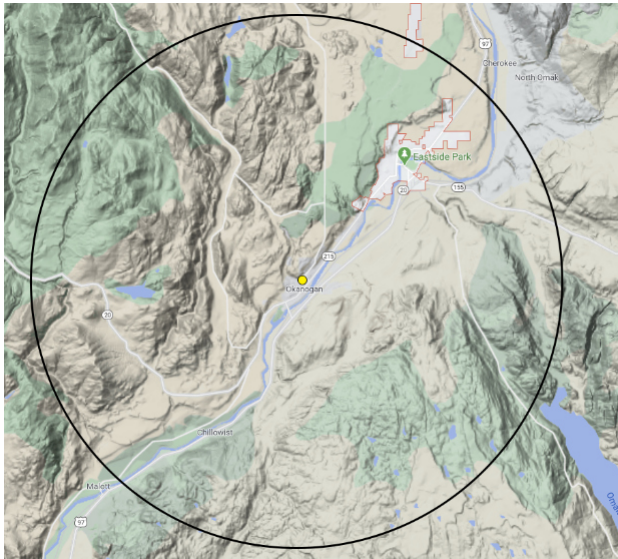
Wenatchee



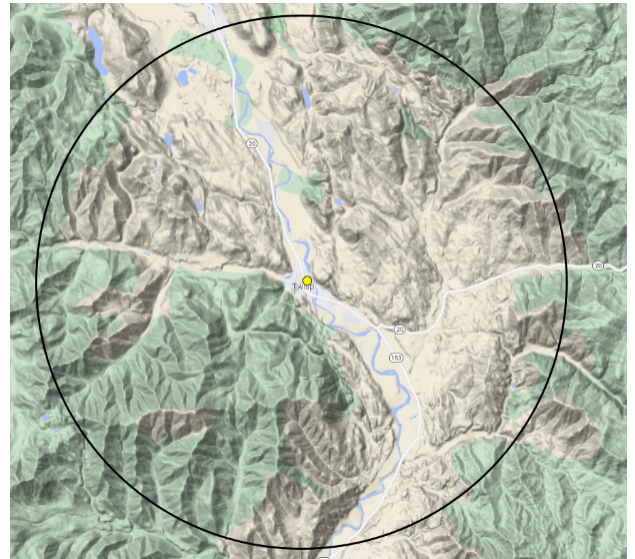
Bridgeport



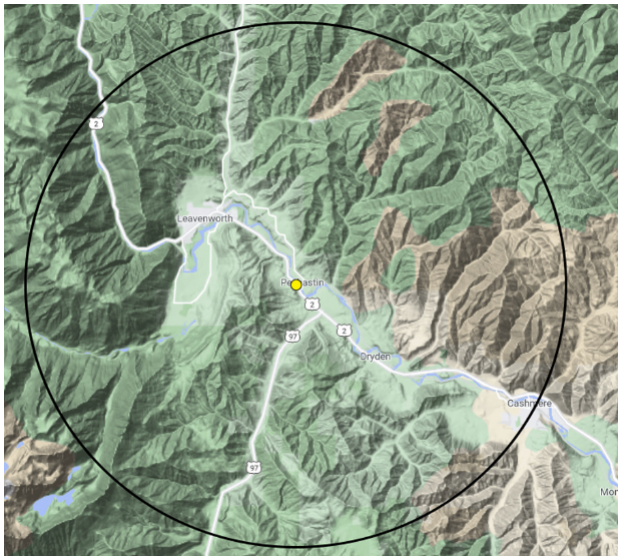
Okanogan



Twisp



Leavenworth



Chelan



North Central Washington CBC factoids

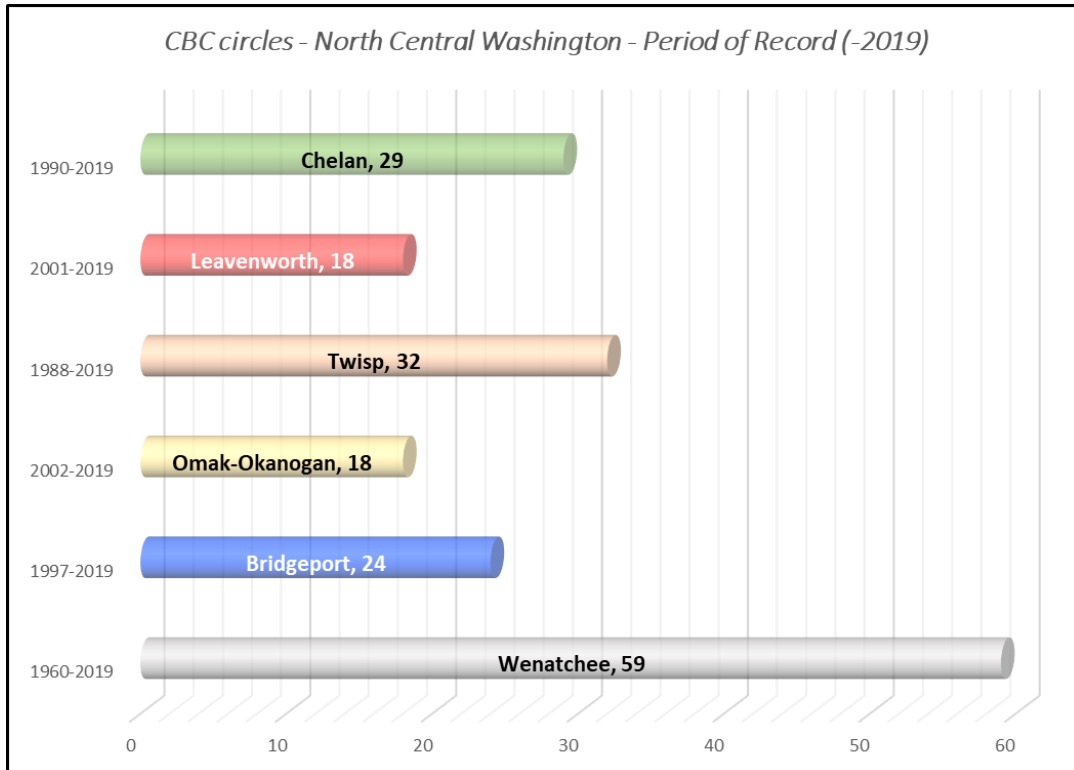
638 volunteers

209 bird species seen*

1,736,584 birds counted

Each circle is 176.71 sq. miles (45,768 hectares)

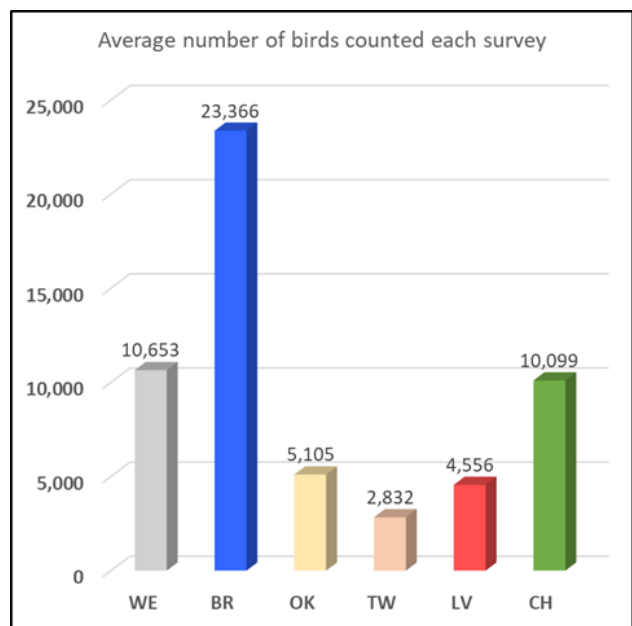
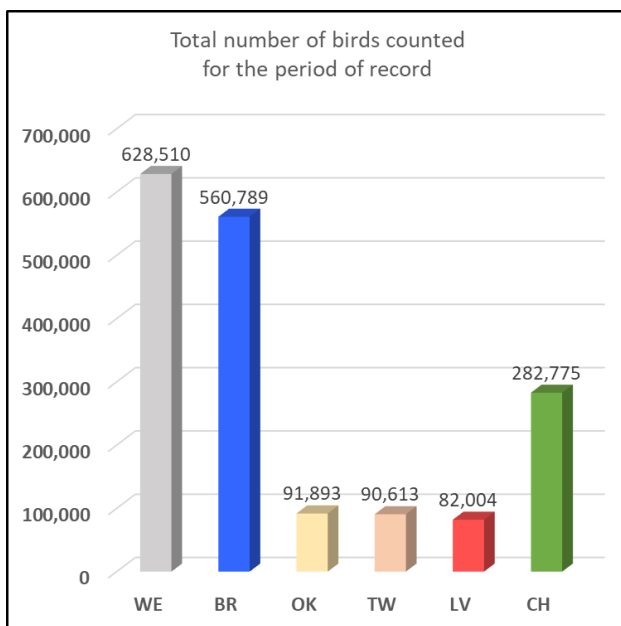
Period of Record - years



Note:

Each CBC count circle is shown using a specific color. These colors are used throughout the paper to facilitate comparison without reliance on labels.

* The total number of species includes variations such as Gull (sp.) or Wilsons/Common Snipe



The Data

The entire period of record for each count circle was downloaded from the National Audubon website in spreadsheet format. The downloaded spreadsheets do not allow direct manipulation of the data. For example, there is no ability to sum the counts of a species across all the years represented. Each column of yearly data needed to be converted to allow standard calculations. Once converted, the data were summarized to show the total birds for each species over the period of record. The summary is shown in the tables on pages *vi-ix*. The species included in this report are shown in a ***bold, italicized, blue font***.

Of the 208 species listed in the data, thirty-two were selected for graphical presentations. The selection of which birds to include was a bit arbitrary but, in general, species were selected if they were represented in each count circle. Species with higher counts were favored over those that showed sparse counts in the count circles. The species selected for presentation are:

Canada Goose	Downy Woodpecker
American Wigeon	Northern Flicker (Red-shafted) ^[1]
Mallard	
Ring-necked Duck	American Kestrel
Bufflehead	
Common Goldeneye	Northern Shrike
Ruddy Duck	
	Steller's Jay
California Quail	Black-billed Magpie
Great Blue Heron	Common Raven
Golden Eagle	Black-capped Chickadee
Bald Eagle	Red-breasted Nuthatch
Red-tailed Hawk	
	European Starling
Ring-billed Gull	
	Bohemian Waxwing
Eurasian Collared-Dove	
Mourning Dove	White-crowned Sparrow
	Spotted Towhee
Great Horned Owl	
	Red-winged Blackbird
Belted Kingfisher	
	House Finch

^[1] Northern Flicker counts have been recorded as Northern Flicker, Northern Flicker (Yellow-shafted), and Northern Flicker (Red-shafted). In the OK circle, only "Northern Flicker" was used while the other circles preferred to record "Northern Flicker (Red-shafted)". I included the OK "Northern Flicker" values in the graphs with the Red-shafted counts from the other circles.

TABLE 1

North Central Washington Christmas Bird Count Summary

The table contains the total number of birds for the period of record up to and including 2019

	WF	BR	OK	TW	IV	CH	TOTAL
Greater White-fronted Goose	0	12	0	1	1	5	19
Snow Goose	32	3	0	0	0	2	37
Brant	1		0	0	0	0	1
Cackling Goose	140	134	0	0	1	6	281
<i>Canada Goose</i>	49,655	21,469	6,290	89	1,326	26,527	105,356
Trumpeter Swan	42	23	24	1	0	38	128
Tundra Swan	22	23	0	6	0	16	67
Wood Duck	28	2	0	4	0	10	44
Gadwall	1,337	3,809	1	9	0	905	6,061
Eurasian Wigeon	28	0	0	0	0	6	34
<i>American Wigeon</i>	21,257	44,210	31	122	0	8,217	73,837
<i>Mallard</i>	20,378	24,925	5,433	4,718	2,621	16,539	74,614
Blue-winged Teal	2	12	0	0	0	2	16
Cinnamon Teal	6	1	0	0	0	0	7
Northern Shoveler	37	5	0	1	0	129	172
Northern Pintail	54	241	2	2	1	12	312
Green-winged Teal	390	274	50	136	17	80	947
Canvasback	1,393	9,253	2	4	0	734	11,386
Redhead	316	10,602	120	0	0	2,813	13,851
<i>Ring-necked Duck</i>	10,831	9,328	653	88	3	13,344	34,247
Greater Scaup	1,591	7,076	0	44	0	6,957	15,668
Lesser Scaup	4,308	18,653	9	44	0	10,810	33,824
Greater/Lesser Scaup	478	358	0	0	0	905	1,741
Surf Scoter	4	1,020	1	0	0	0	1,025
White-winged Scoter	4	0	0	0	0	0	4
Long-tailed Duck	0	6	0	0	0	2	8
<i>Bufflehead</i>	2,823	6,626	193	140	179	4,298	14,259
<i>Common Goldeneye</i>	6,609	4,496	1,109	849	244	2,643	15,950
Barrow's Goldeneye	655	64	569	255	32	333	1,908
Hooded Merganser	1,303	1,266	26	118	16	1,561	4,290
Common Merganser	1,298	1,011	145	302	208	2,195	5,159
Red-breasted Merganser	4	3	1	0	0	0	8
<i>Ruddy Duck</i>	1,243	10,331	0	0	0	985	12,559
<i>California Quail</i>	45,818	17,055	15,724	11,207	6,639	27,370	123,813
Northern Bobwhite	0	0	0	40	0	0	40
Chukar	1,632	161	132	65	15	360	2,365
Ring-necked Pheasant	346	278	84	13	5	9	735
Gray Partridge	175	473	195	378	0	9	1,230
Ruffed Grouse	7	2	10	62	16	1	98
Spruce Grouse	0	0	0	0	0	1	1
Dusky Grouse	0	3	1	8	0	0	12
Sharp-tailed Grouse	0	253	0	0	0	0	253
Wild Turkey	8	18	702	2,179	1,214	49	4,170
Red-throated Loon	3	0	0	0	0	0	3
Pacific Loon	2	21	0	0	0	8	31
Common Loon	358	569	0	0	0	520	1,447
Pied-billed Grebe	894	781	3	7	0	381	2,066
Horned Grebe	816	1,163	25	0	0	1,981	3,985
Red-necked Grebe	27	33	0	0	0	81	141

	WE	BR	OK	TW	LV	CH	TOTAL
Eared Grebe	37	57	3	0	0	78	175
Western Grebe	135	58	2	0	0	30	225
Clark's Grebe	0	0	0	0	0	3	3
Western/Clark's Grebe	35	0	0	0	0	0	35
Double-crested Cormorant	440	32	0	0	1	5	478
American White Pelican	0	4	0	0	0	0	4
<i>Great Blue Heron</i>	1,032	312	40	81	67	277	1,809
Great Egret	0	1	0	0	0	0	1
Black-crowned Night Heron	33	0	0	0	0	0	33
Turkey Vulture	0	0	1	0	0	0	1
Osprey	1	0	0	3	0	0	4
<i>Golden Eagle</i>	167	42	80	208	18	102	617
Northern Harrier	152	298	70	43	2	88	653
Sharp-shinned Hawk	457	125	79	58	92	141	952
Cooper's Hawk	322	133	71	96	104	154	880
Northern Goshawk	32	22	14	31	12	63	174
<i>Bald Eagle</i>	705	585	493	1,254	254	365	3,656
Red-shouldered Hawk	0	0	0	1	0	0	1
Swainson's Hawk	3	0	0	0	0	0	3
<i>Red-tailed Hawk</i>	1,433	1,183	769	567	444	925	5,321
Rough-legged Hawk	86	122	40	67	0	36	351
Ferruginous Hawk	3	0	0	0	0	0	3
Virginia Rail	3	19	0	7	1	5	35
Sora	0	1	0	0	0	0	1
American Coot	34,051	225,640	0	3	0	18,706	278,400
Sandhill Crane	0	1	0	0	0	0	1
Killdeer	283	24	2	7	0	41	357
Western Sandpiper	5	0	0	0	0	0	5
Spotted Sandpiper	0	0	0	1	0	0	1
Long-billed Curlew	1	0	0	0	0	0	1
Wilson's Snipe	9	48	3	4	1	5	70
Wilson's/Common Snipe	72	14	0	14	0	15	115
Bonaparte's Gull	2	0	0	0	0	0	2
Mew Gull	0	0	0	0	0	9	9
<i>Ring-billed Gull</i>	1,483	573	63	0	0	768	2,887
Western Gull	0	1	0	0	0	0	1
California Gull	42	12	0	0	0	23	77
Herring Gull	278	157	0	0	0	34	469
Thayer's Gull	1	1	0	0	0	1	3
Glaucous-winged Gull	13	6	0	0	1	6	26
WesternxGlaucous-winged Gull	1		0	0	0	0	1
Glaucous Gull	0	1	0	0	0	0	1
Rock Pigeon	30,402	5,264	7,918	1,267	5,407	2,823	53,081
Band-tailed Pigeon	0	1	0	7	0	0	8
<i>Eurasian Collared-Dove</i>	2,756	1,758	1,898	825	941	967	9,145
<i>Mourning Dove</i>	2,979	1,730	664	1,592	251	887	8,103
Barn Owl	3	12	1	0	0	0	16
Western Screech-Owl	3	1	0	2	1	0	7
<i>Great Horned Owl</i>	128	136	23	53	13	71	424

	WE	BR	OK	TW	LV	CH	TOTAL
Snowy Owl	2	1	0	1	0	0	4
Northern Hawk Owl	0	0	0	2		1	3
Northern Pygmy Owl	37	3	4	71	11	54	180
Barred Owl	2	2	0	1	0	1	6
Great Gray Owl	0	0	0	0	0	1	1
Long-eared Owl	10	8	0	0	0	0	18
Short-eared Owl	13	4	0	0	0	1	18
Northern Saw-whet Owl	17	10	2	6	0	0	35
Anna's Hummingbird	68	0	4		34	4	110
<i>Belted Kingfisher</i>	511	151	57	148	90	156	1,113
Acorn Woodpecker	0	0	0	0	1	0	1
Williamson Sapsucker	0	0	0	0	1	0	1
Lewis's Woodpecker	67	2	0	1	0	3	73
Yellow-bellied Sapsucker	0	0	0	1	0	1	2
Red-naped Sapsucker	0	0	0	1	0	1	2
Red-breasted Sapsucker	7	0	0	3	5	1	16
<i>Downy Woodpecker</i>	309	110	111	474	179	73	1,256
Hairy Woodpecker	45	77	32	288	104	52	598
Black-backed Woodpecker	0	1	0	0	8	0	9
White-headed Woodpecker	0	0	20	22	116	21	179
Northern Flicker	2,324	0	875	474	0	0	3,673
Norther Flicker (Yellow-shafted)	3	0	0	0	0	0	3
<i>Northern Flicker (red-shafted)</i>	2,728	2,577	0	1,041	1,152	2,837	10,335
Pileated Woodpecker	0	0	1	68	10	0	79
<i>American Kestrel</i>	1,104	358	147	99	150	342	2,200
Merlin	246	57	28	19	31	60	441
Gyrfalcon	4	3	0	1	0	0	8
Peregrine Falcon	9	1	5	1	2	4	22
Prairie Falcon	34	17	20	9	3	14	97
Say's Phoebe	11	1	2	0	6	2	22
Northern Shrike	391	221	78	163	19	153	1,025
Loggerhead Shrike	0	0	0	0	0	0	0
Gray Jay	0	0	0	0	9	2	11
<i>Steller's Jay</i>	2,408	396	114	603	2,259	1,455	7,235
Blue Jay	3	0	0	1	0	0	4
Western Scrub-Jay	2	0	0	0	1	0	3
<i>Black-billed Magpie</i>	4,454	1,843	1,119	3,275	135	3,498	14,324
Clark's Nutcracker	81	32	49	648	132	188	1,130
American Crow	4,920	163	439	1,188	2,394	570	9,674
<i>Common Raven</i>	1,543	1,012	1,172	5,355	1,364	779	11,225
Horned Lark	14,628	12,410	1,988	4	0	326	29,356
<i>Black-capped Chickadee</i>	3,216	993	826	4,595	3,260	416	13,306
Mountain Chickadee	460	267	178	1,560	744	918	4,127
Chestnut-backed Chickadee	25	2	0	9	127	49	212
<i>Red-breasted Nuthatch</i>	358	351	210	1,467	1,574	652	4,612
White-breasted Nuthatch	15	22	41	324	84	68	554
Pygmy Nuthatch	21	725	124	305	493	216	1,884
Brown Creeper	31	32	8	72	61	35	239
Rock Wren	5	3	0	0	0	7	15
Canyon Wren	13	32	17	3	7	20	92
House Wren	1	0	0	0	0	0	1
Pacific Wren	11	19	9	11	59	9	118

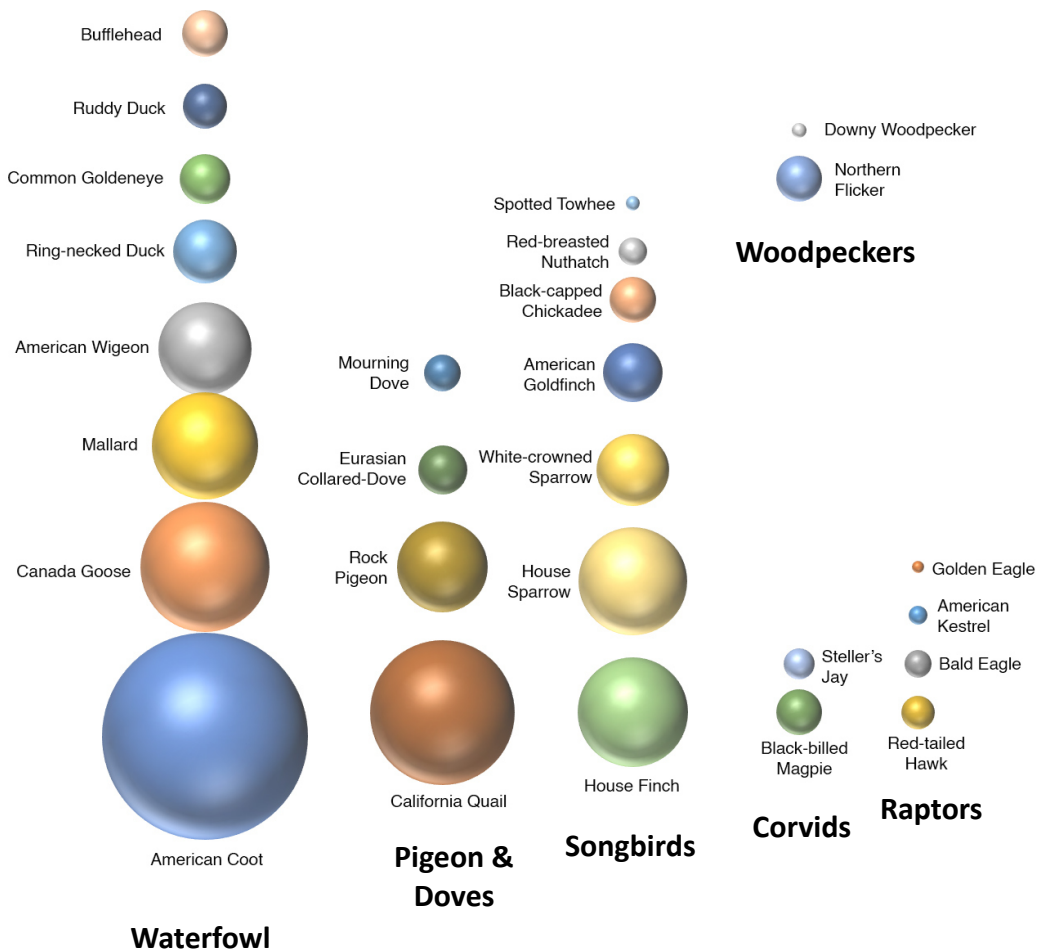
	WF	BR	OK	TW	IV	CH	TOTAL
Pacific/Winter Wren	74	22	3	23	44	33	199
Marsh Wren	12	40	0	2	0	11	65
Bewick's Wren	14	28	5	1	0	2	50
American Dipper	197	55	7	346	445	58	1,108
Golden-crowned Kinglet	490	239	50	486	1,390	722	3,377
Ruby-crowned Kinglet	466	129	7	19	372	65	1,058
Western Bluebird	15	69	2	22	2	1	111
Mountain Bluebird	2	2	0	2	0	1	7
Townsend's Solitaire	171	61	14	39	28	77	390
Hermit Thrush	129	4	0	0	12	10	155
American Robin	11,702	6,316	635	379	1,019	5,963	26,014
Varied Thrush	2,105	145	84	605	744	367	4,050
Sage Thrasher	0	1	0	0	0	0	1
Northern Mockingbird	1	0	0	0	0	0	1
European Starling	74,313	20,732	11,847	3,081	5,016	31,599	146,588
American Pipit	2	13	0	0	1	0	16
Bohemian Waxwing	19,698	8,186	3,997	3,584	316	5,279	41,060
Cedar Waxwing	6,669	1,988	474	426	572	1,289	11,418
Bohemian/Cedar Waxwing	100	0	0	15	0	25	140
Snow Bunting	167	873	75	523	0	24	1,662
Yellow-throated Warbler	0	0	0	1	0	0	1
Orange-crowned Warbler	4	0	0	0	0	0	4
Yellow-rumped Warbler	125	1	0	0	98	0	224
Yellow-rumped Warbler (Audubon's)	185	188	0	0	0	18	391
American Tree Sparrow	50	243	32	9	0	28	362
Fox Sparrow	118	10	1	13	77	18	237
Dark-eyed Junco	11,463	6,359	4,574	4,311	0	3,068	29,775
Dark-eyed Junco (Slate colored)	59	13	9	82	3	0	166
Dark-eyed Junco (Oregon)	47,610	8,798	0	2,850	16,857	22,121	98,236
White-crowned Sparrow	22,307	13,446	809	152	1,078	5,789	43,581
Golden-crowned Sparrow	649	7	1	9	667	34	1,367
Harris's Sparrow	7	1	0	1	0	0	9
White-throated Sparrow	7	2	0	1	6	1	17
Savannah Sparrow	0	1	0	2	0	0	3
Song Sparrow	4,405	2,532	215	485	1,186	1,308	10,131
Lincoln's Sparrow	1	1	0	2	0	1	5
Swamp Sparrow	0	1	0	0	1	0	2
Spotted Towhee	669	106	16	92	201	146	1,230
Spotted/Eastern Towhee	40	0	0	0	0	0	40
Western Tanager	0	1	1	0	0	0	2
Red-winged Blackbird	2,346	6,574	452	431	511	1,111	11,425
Western Meadowlark	191	244	4	1	0	4	444
Yellow-headed Blackbird	1	0	0	0	0	0	1
Brewer's Blackbird	175	158	27	162	11	374	907
Brown-headed Cowbird	11	0	0	1	0	0	12
Gray-crowned Rosy-Finch	4,756	707	0	1,938	0	265	7,666
rosy-finch	120	0	0	0	0	0	120
Pine Grosbeak	384	29	18	353	88	242	1,114
House Finch	40,695	13,850	6,289	4,575	7,223	19,360	91,992
Purple Finch	156	5	0	152	46	14	373
Cassin's Finch	177	8	16	480	243	93	1,017
Red Crossbill	166	473	210	906	207	278	2,240
White-winged Crossbill	20	0	135	7	0	9	171
Common Redpoll	615	798	0	1,551	193	421	3,578
Pine Siskin	599	37	131	1,858	915	683	4,223
Lesser Goldfinch	6	0	0	0	21	0	27
American Goldfinch	7,380	1,596	1,748	7,179	2,561	2,138	22,602
Evening Grosbeak	315	16	14	1,685	83	13	2,126
House Sparrow	72,291	9,355	8,542	2,374	4,994	9,250	106,806

It can be challenging to try to compare the numbers on the previous four pages. While it is easy to find the largest and smallest numbers, it is difficult to discern the relative abundance of each of the species using the numbers alone. The chart below is a visual representation of twenty-seven species. The species were chosen to include those with the highest overall abundance. Choosing species with fewer counts yields spheres that are too small to clearly see on the chart.

People who are familiar with winter birds in north central Washington will not be surprised to see large spheres (= many birds) for Canada Goose and California Quail. What may be of interest in the chart is that there are about the same number of Northern Flickers as there are American Goldfinch. There are about the same number of House Sparrows as Mallards. Likewise, Black-capped Chickadees show up in numbers that are roughly equal to the number of Eurasian Collared-Doves. The American Coot is the most abundant species counted during Christmas Bird Counts even though they are only seen in the Wenatchee, Bridgeport, and Chelan count circles. This points to the value of the habitat provided by the mainstem of the Columbia River for winter waterfowl.

Relative Abundance of Common Winter Birds in North Central Washington

Data is based on time-normalized counts during Christmas Bird Counts in North Central Washington 2002-2020



Understanding the Box-and-Whisker and Bubble Charts

Box-and-Whisker Plots

The box-and-whisker plot, or box plot, is an efficient way to show a summary of primary statistical characteristics of a set of data. Microsoft Excel provides a Box-and-Whisker chart that does all the behind-the-scenes math involved to calculate the statistics shown: median, average, 1st quartile value, 3rd quartile value, “upper whisker”, “lower whisker” and outlier data points. A generalized plot is shown in Figure 1.

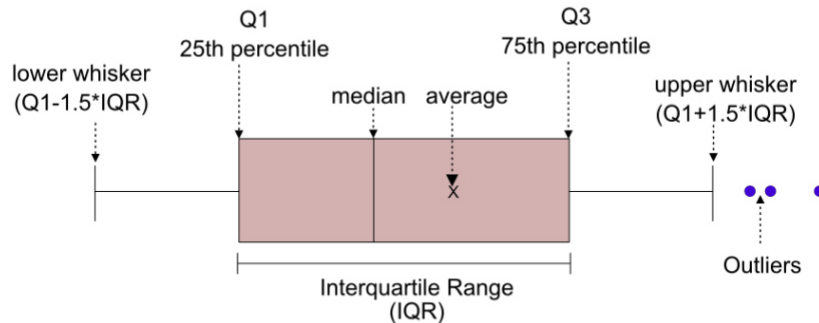


Figure 1. Typical Box-and-Whisker Plot

It is important to note that the “upper whisker” and “lower whisker” values are calculated and do not represent the actual maximum and minimum data values. Calculating the “upper whisker” and “lower whisker” allow the graph to show any data points that are well beyond the majority of the data – these are referred to as “outliers”.

The size of the box is an indicator of the amount of variability in the data. When several box-and-whisker plots are presented side-by-side, as in this paper, one can easily see the relative variability of the data sets.

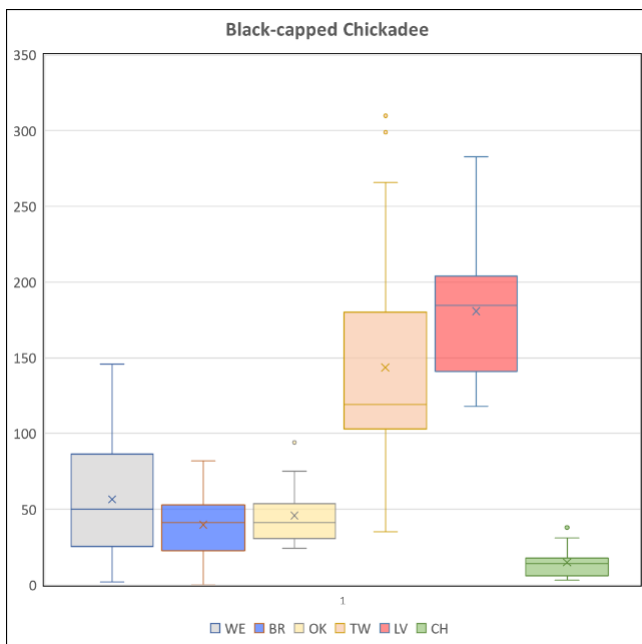


Figure 2. Example of Box-and-Whisker Plot

Figure 2 shows a representative plot used in this paper. One can see that the data for Chelan is much less variable (smaller box) than the data for Twisp (larger box). The boxes for Twisp and Leavenworth sit higher than the other boxes indicating that there are, on average, more Black-capped Chickadees in these circles than the others. The solid lines across each box represent the median value of each circles data. The “X” in the box is the average value. Clearly, the median value of the Leavenworth data is higher than any other data sets. The “whiskers” extend to “upper whisker” and “lower whisker” values as shown in Figure 1. Any outliers are shown beyond the whiskers. In some plots I chose to remove the outliers of a data set so that the boxes would be expanded to make the boxes and whiskers easier to see.

Bubble Charts

A Bubble Chart is a graph that shows three dimensions of data. In this paper the three dimensions are: **Time** (1960-2019) on the X-axis, an **index number** to plot data on a line using the Y-axis (1=Wenatchee, 2=Bridgeport, 3=Okanogan, 4=Twisp, 5=Leavenworth, and 6=Chelan), and the third dimension, the **bubble size**, is determined by the number of birds counted in each year of the survey. Large bubbles indicate a lot of birds while smaller bubbles are proportionally sized based on area or diameter. Here's an example:

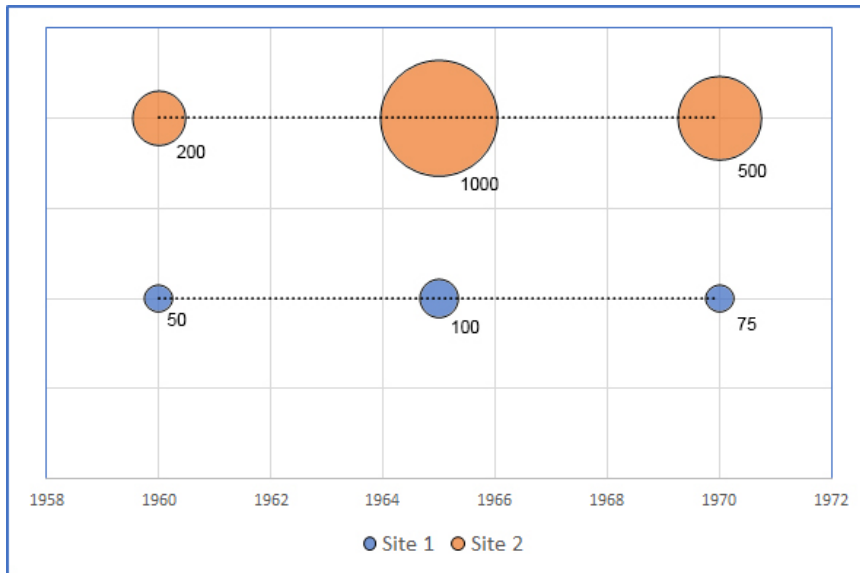


Figure 3. Example bubble chart

The chart shows two series of data, Site 1 and Site 2. Site 1 has three observations (50, 75, 100). Site 2 also has three observations that are much larger than Site 1's. In this case, the diameters of the bubbles are proportional to each yearly bird count value. The largest number (1000) becomes the value to which all the rest of the data are scaled. The bubble labeled "200" is 5x smaller than the "1000" circle. The "50" circle is 20x smaller than the "1000" circle.

This chart quickly shows that Site 2 has many more birds than Site 1. We also see that 1965 had higher values than the other two years.

This model works well as long as the data is collected under similar circumstances. CBC data is gathered under widely different situations each year. Some years may be relatively nice with little wind and warm temperatures and the volunteers may elect to stay out for many hours. Other years may be frigid with gale force winds resulting in a short day to count birds. Some years may have ten people on a team on one route and the next year there may be only three people. The data is very diverse which complicates the goal of directly comparing one year to the next or the counts between CBC circles during any given year.

One way to allow more direct comparison is to normalize the data based on the total hours spent surveying each year. The CBC survey protocol asks each circle leader to tabulate the total number of hours spent during the survey that year. This is known as "party hours". Dividing the number of birds by the "party hours" normalizes the data to account for some years having more or less counts than other years. The CBC spreadsheets that are downloaded contain the number of hours spent in each year. The spreadsheets also contain a normalized value of "birds/party hours" below each raw count of birds in a give year.

This paper presents two versions of bubble charts for each bird species. The first shows bubble sizes that are based entirely on the number of birds in each species counted each year. The chart is most useful to show the variability of the number of birds counted in a CBC circle over time. Presenting all six CBC circles together allows the comparison of gross counts of a species each year, much like the chart in Figure 3. While it is risky to draw conclusions about big years vs. small years, one will get a quick, visual impression of the bird count over time.

The second bubble chart plots normalized counts (birds/survey hour) over time. This presentation allows a more refined comparison of bird populations over time at a given site. It also allows comparison between CBC circles for any given year.

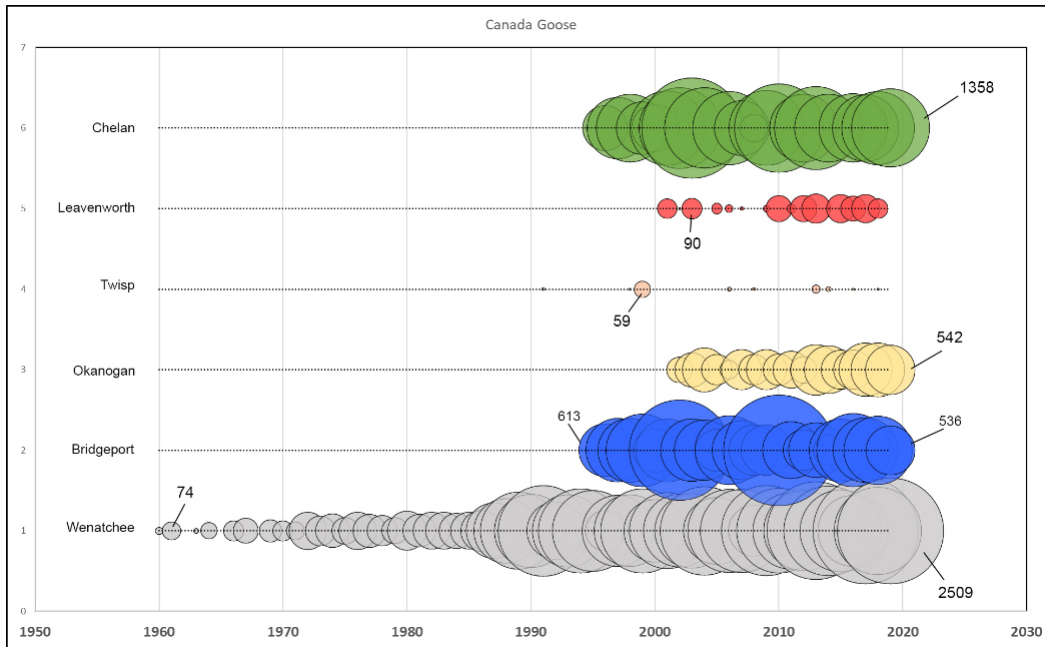


Figure 4. Canada Goose counts

Since Excel does not provide a scale to identify the magnitude of each bird count, annotations showing the absolute bird number counted during several years have been added. All the bubbles in Figure 4 are scaled to the maximum value, 2509.

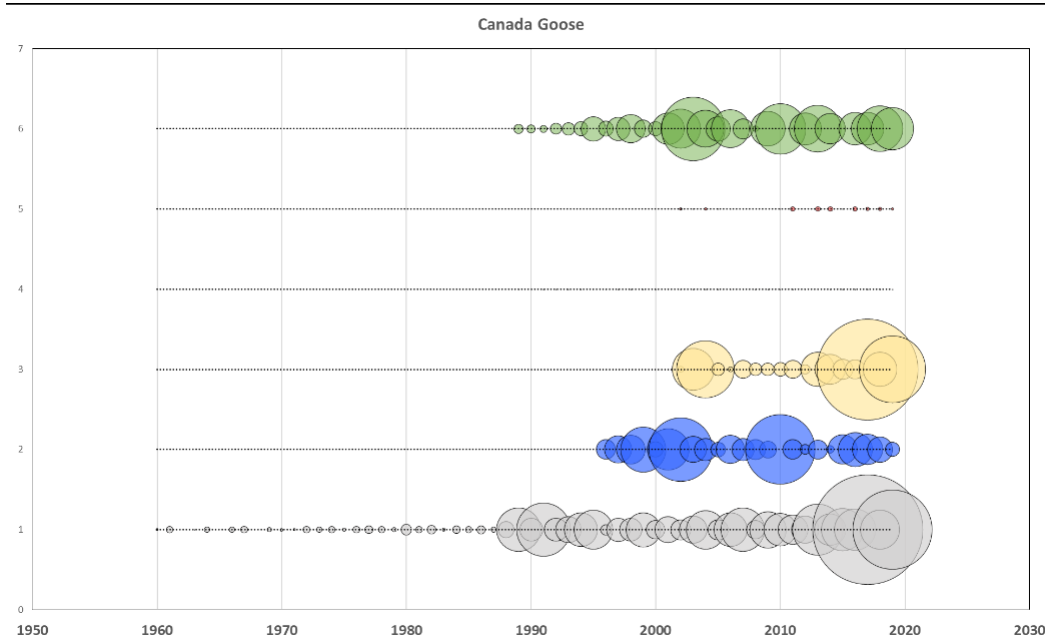
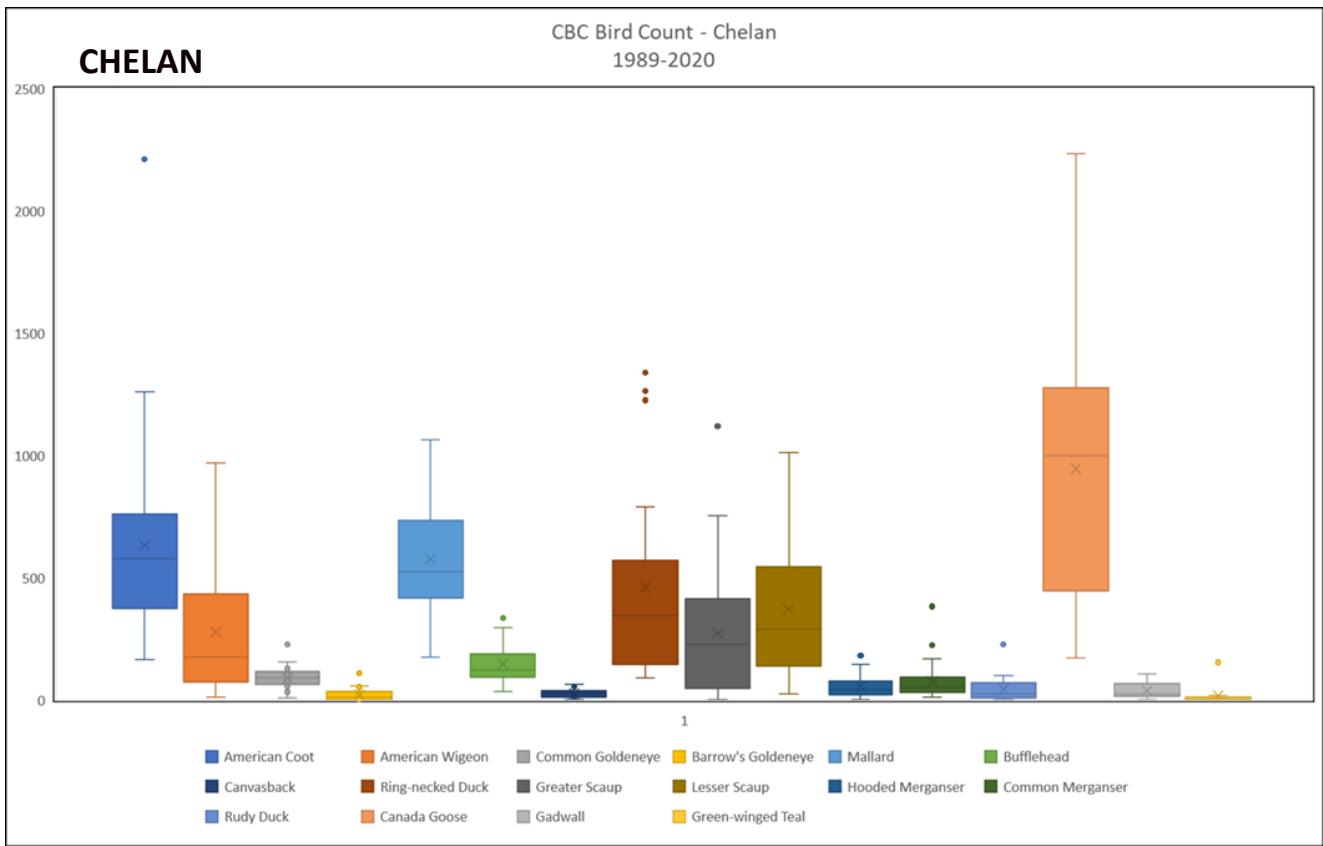
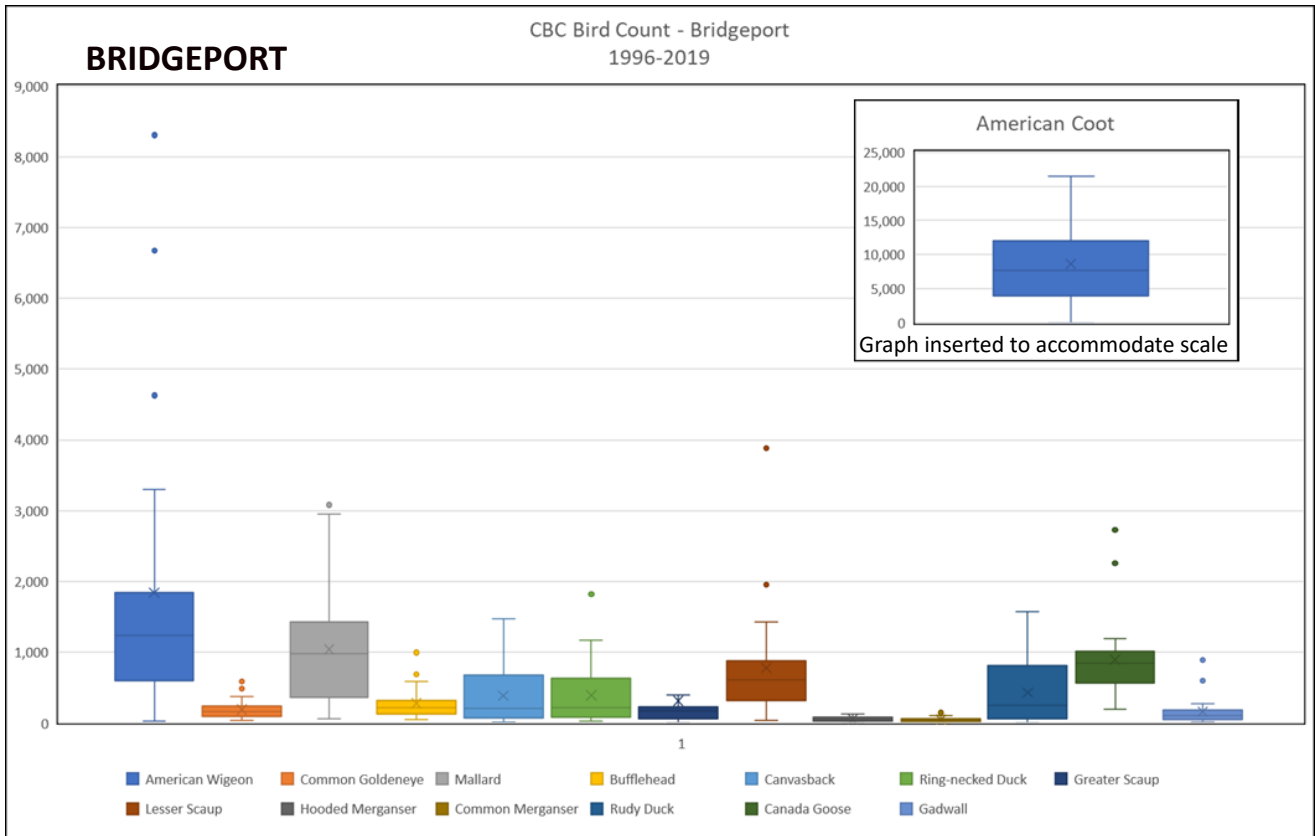


Figure 5. Normalized Canada Goose counts

In Figure 5, a large bubble conveys that many birds were counted in a short time. Small bubbles indicate fewer birds per hour of time invested. Since numbers like 2.4783 birds/survey hour are not commonly used, no annotations have been added to these charts.

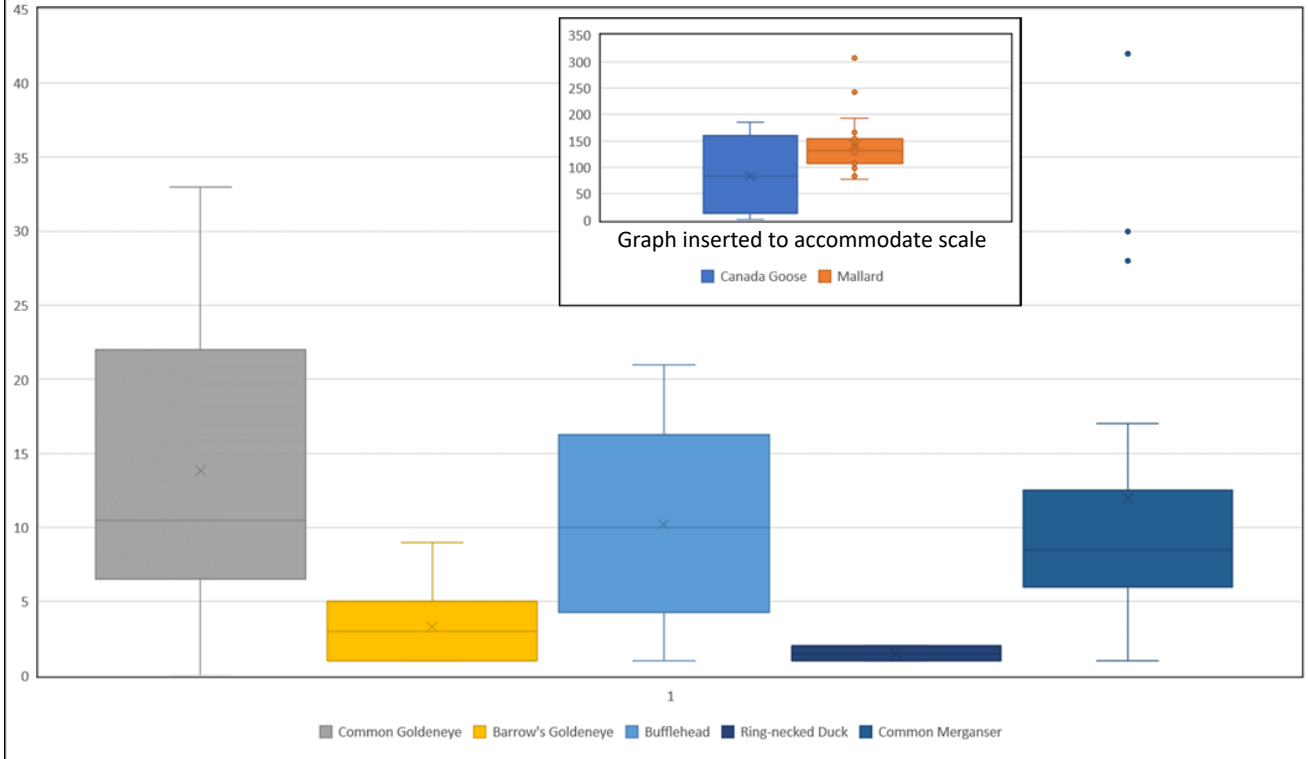
Section 1

Relative abundance of waterfowl species in each of
the six CBC circles in north central Washington



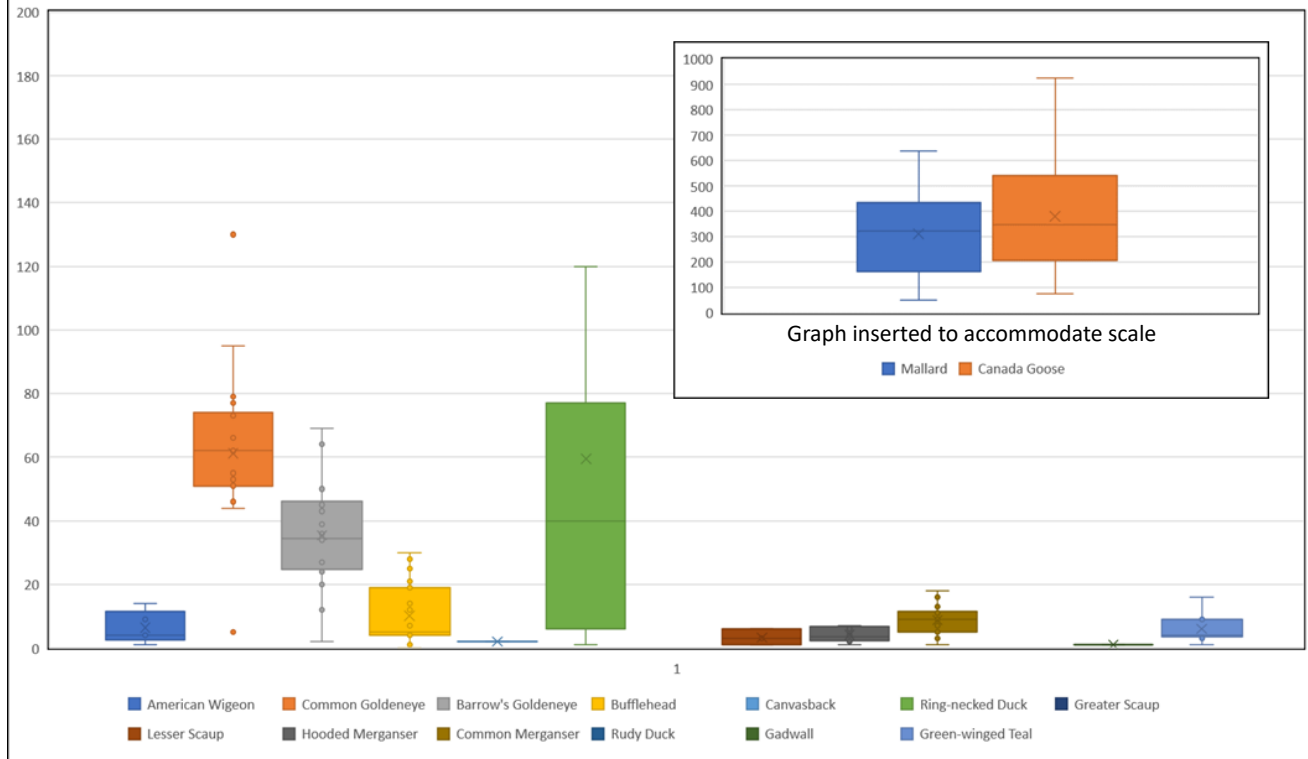
LEAVENWORTH

CBC Bird Count - Leavenworth
2001-2020



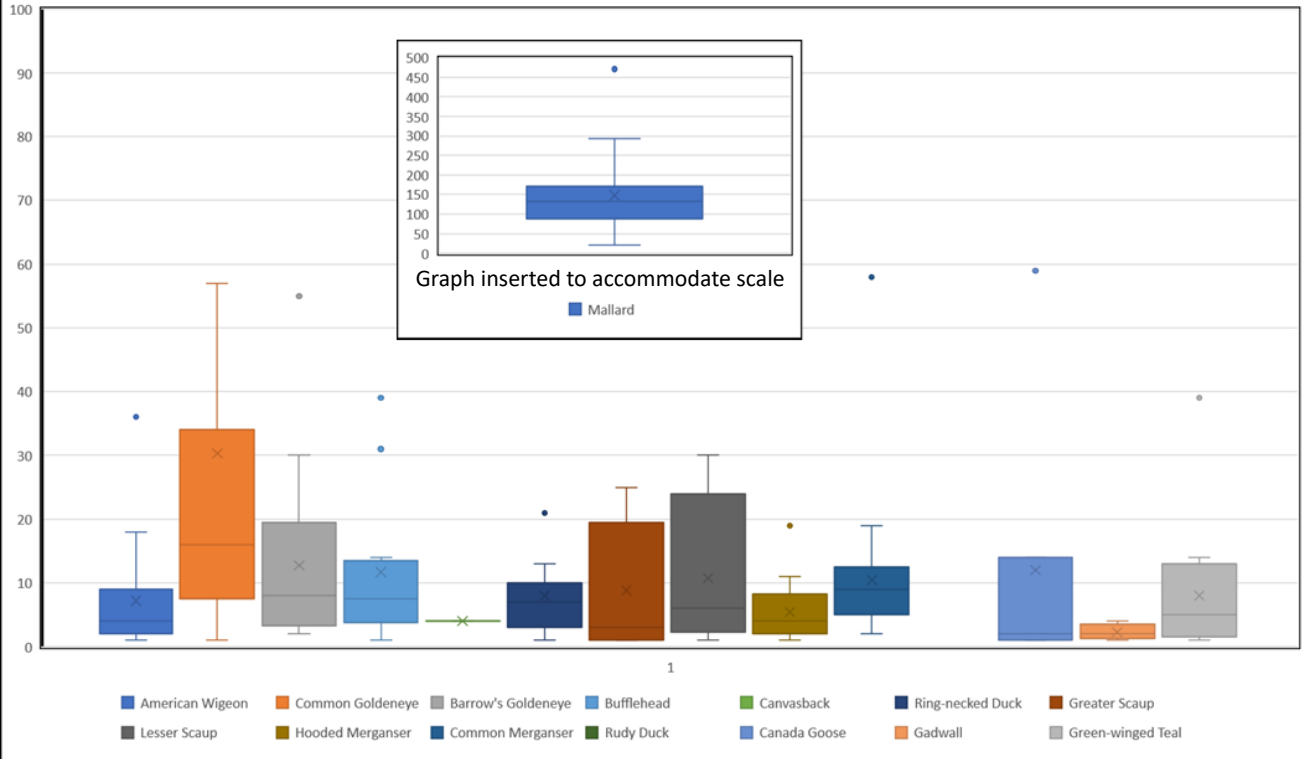
OKANOGAN

CBC Bird Count - Okanogan
2002-2020



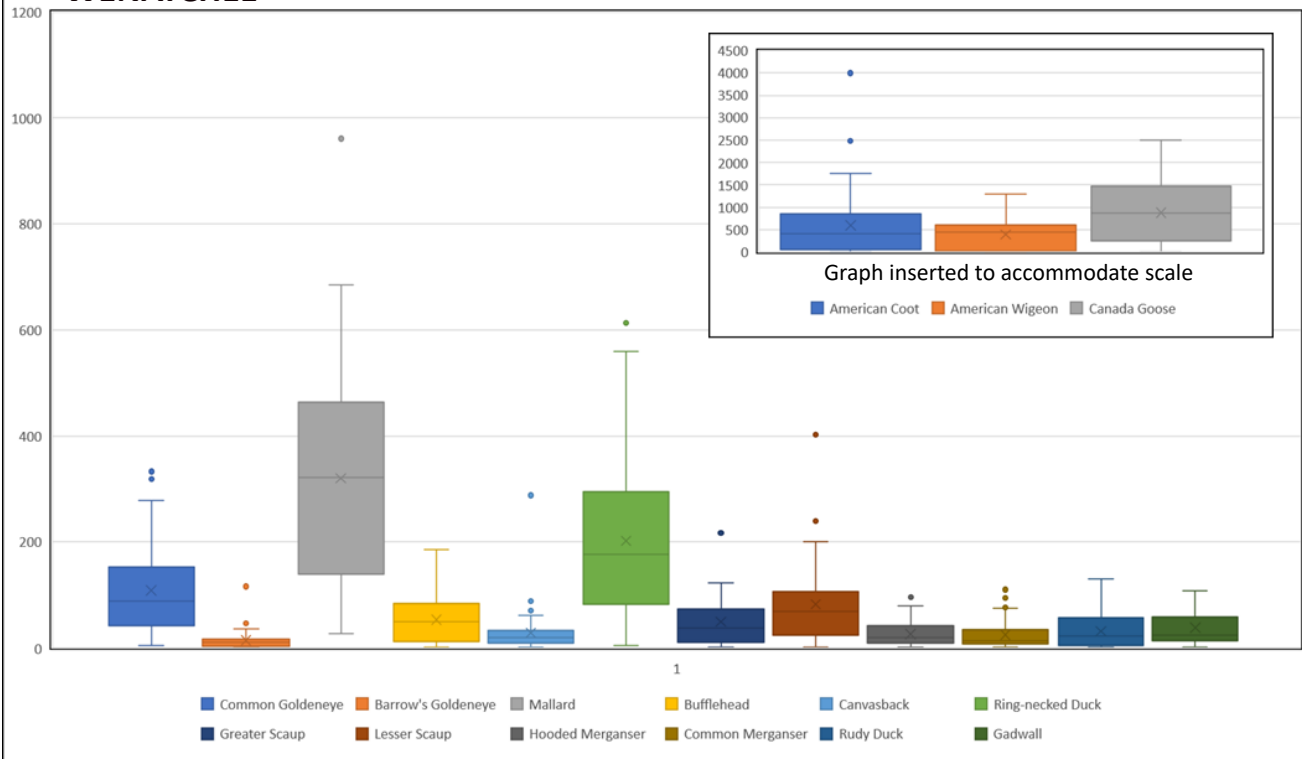
TWISP

CBC Bird Count - Twisp
1988-2019



WENATCHEE

CBC Bird Count - Wenatchee
1960-2019

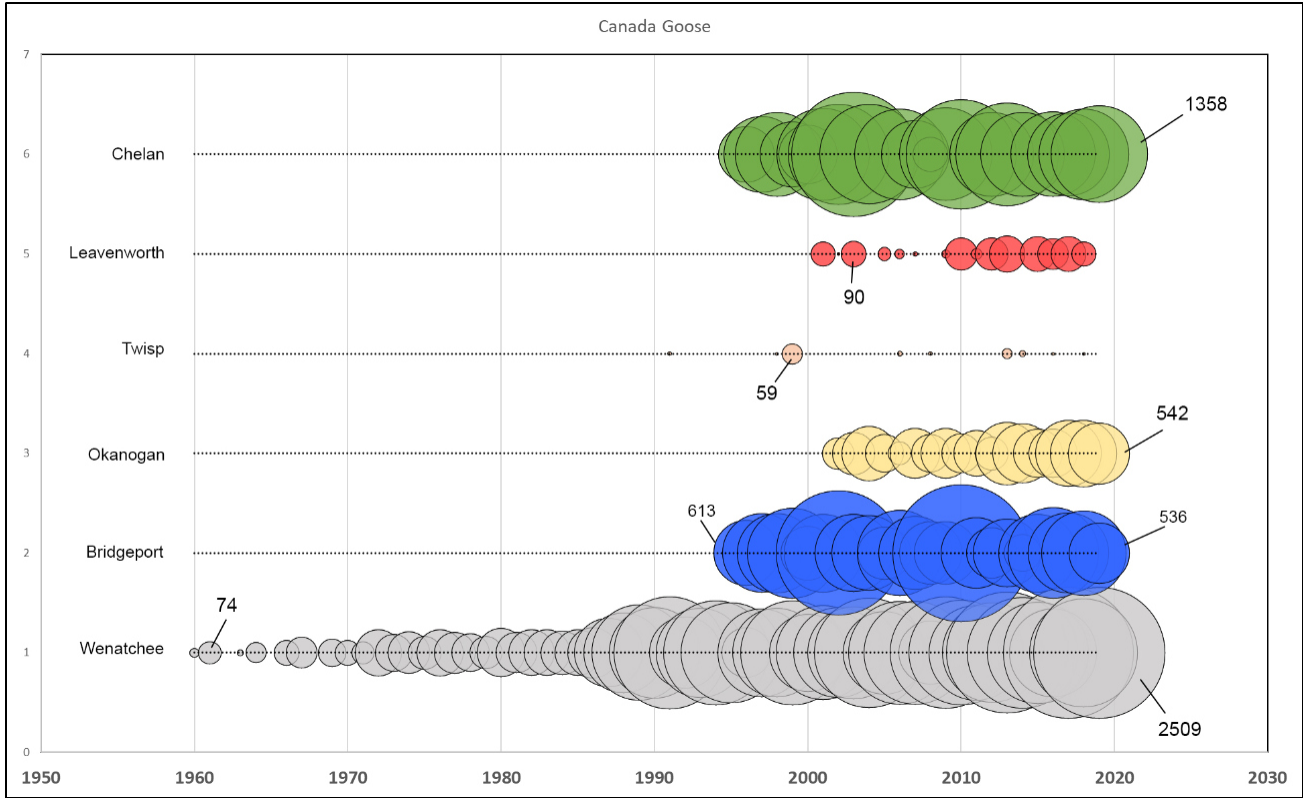


Section 2

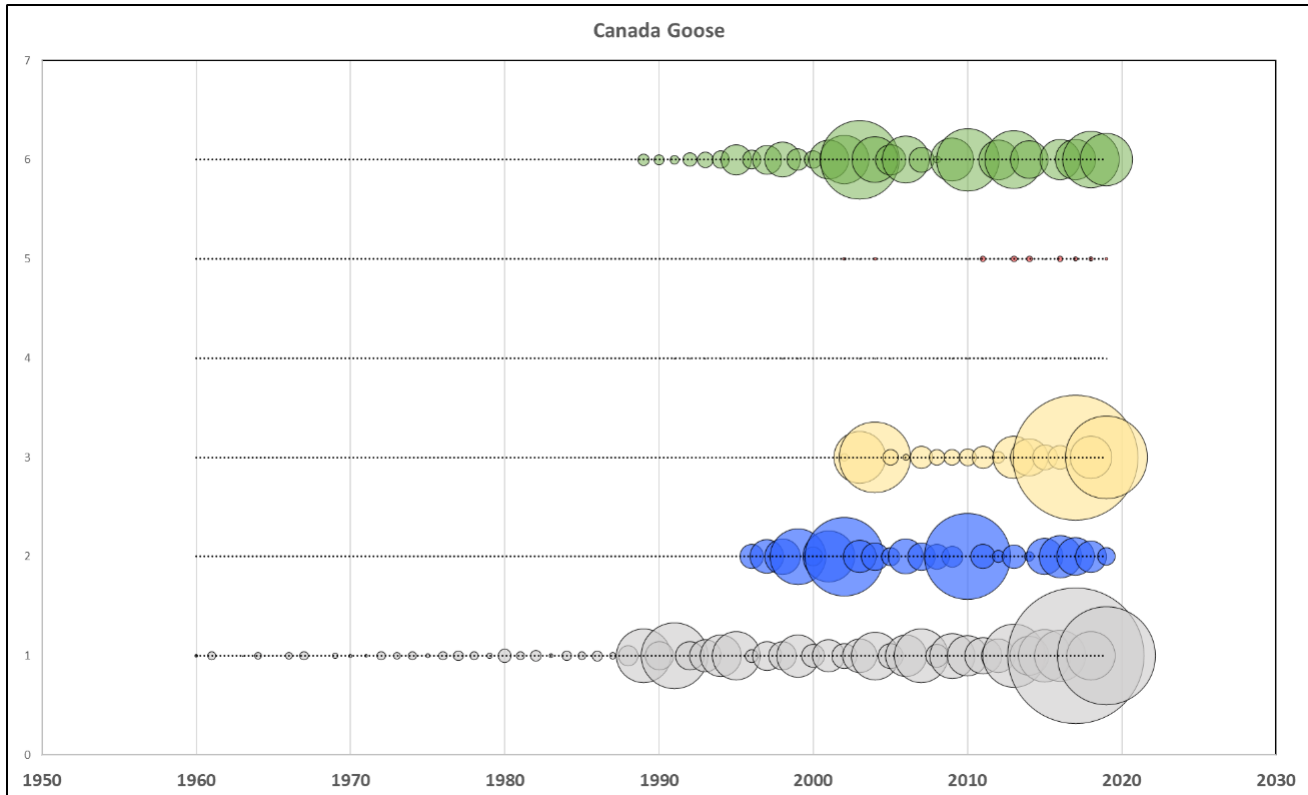
Bubble Chart time series for
32 selected species

Canada Goose

Number of birds counted



Number of birds / survey hour

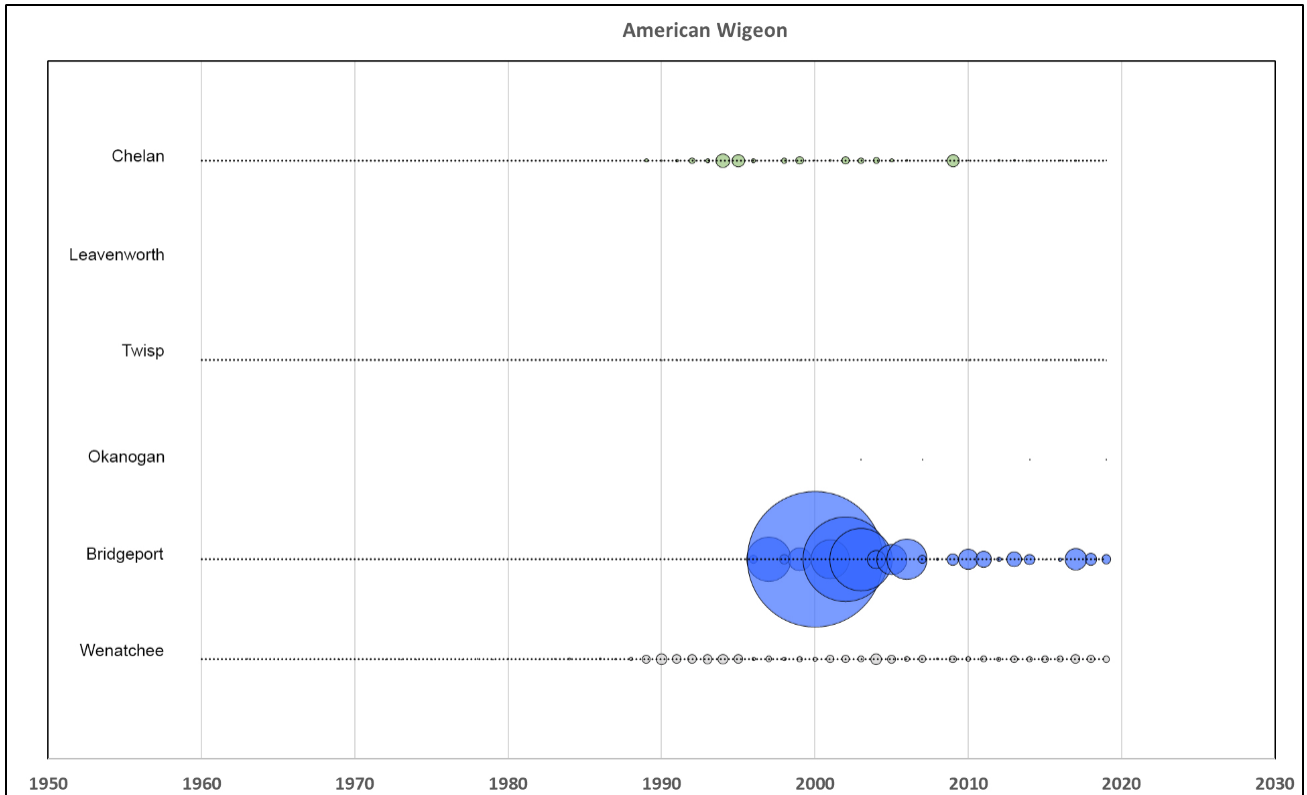


American Wigeon

Number of birds counted

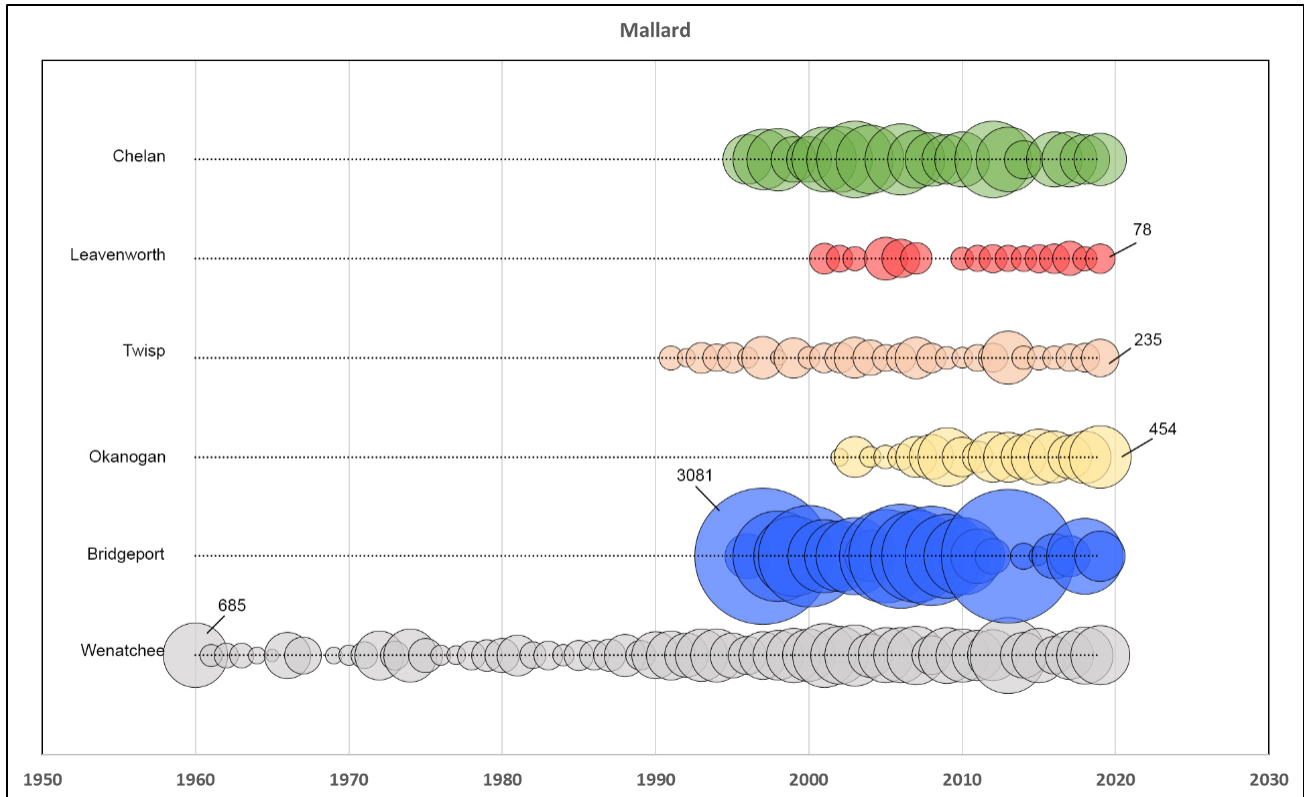


Number of birds / survey hour

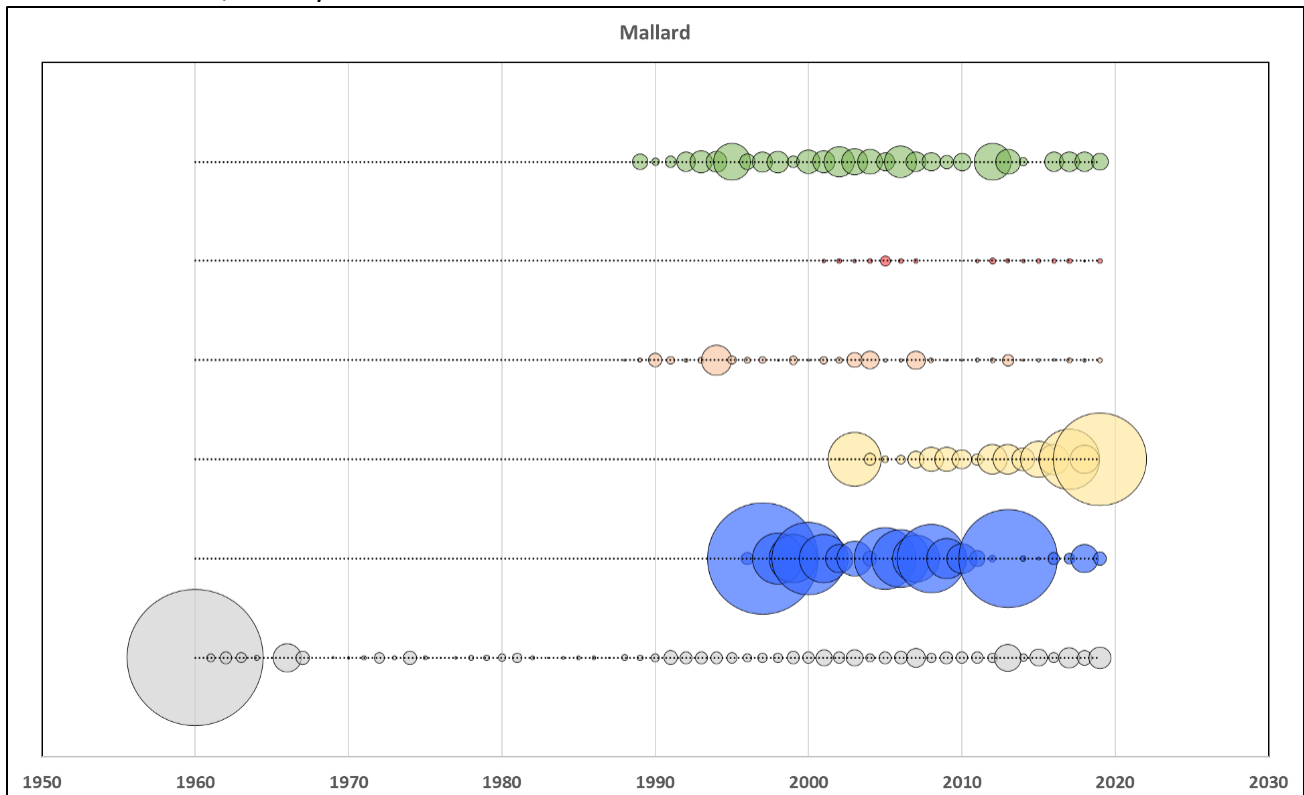


Mallard

Number of birds counted

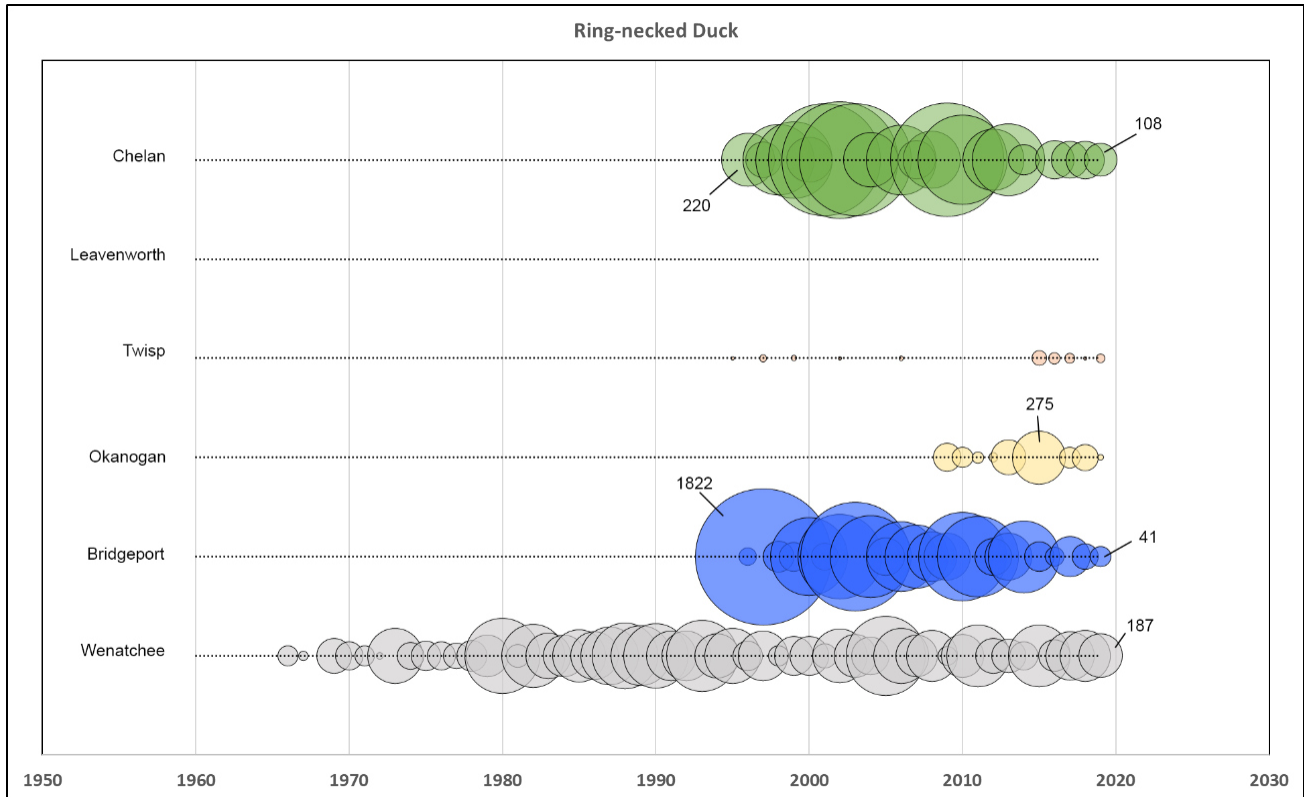


Number of birds / survey hour

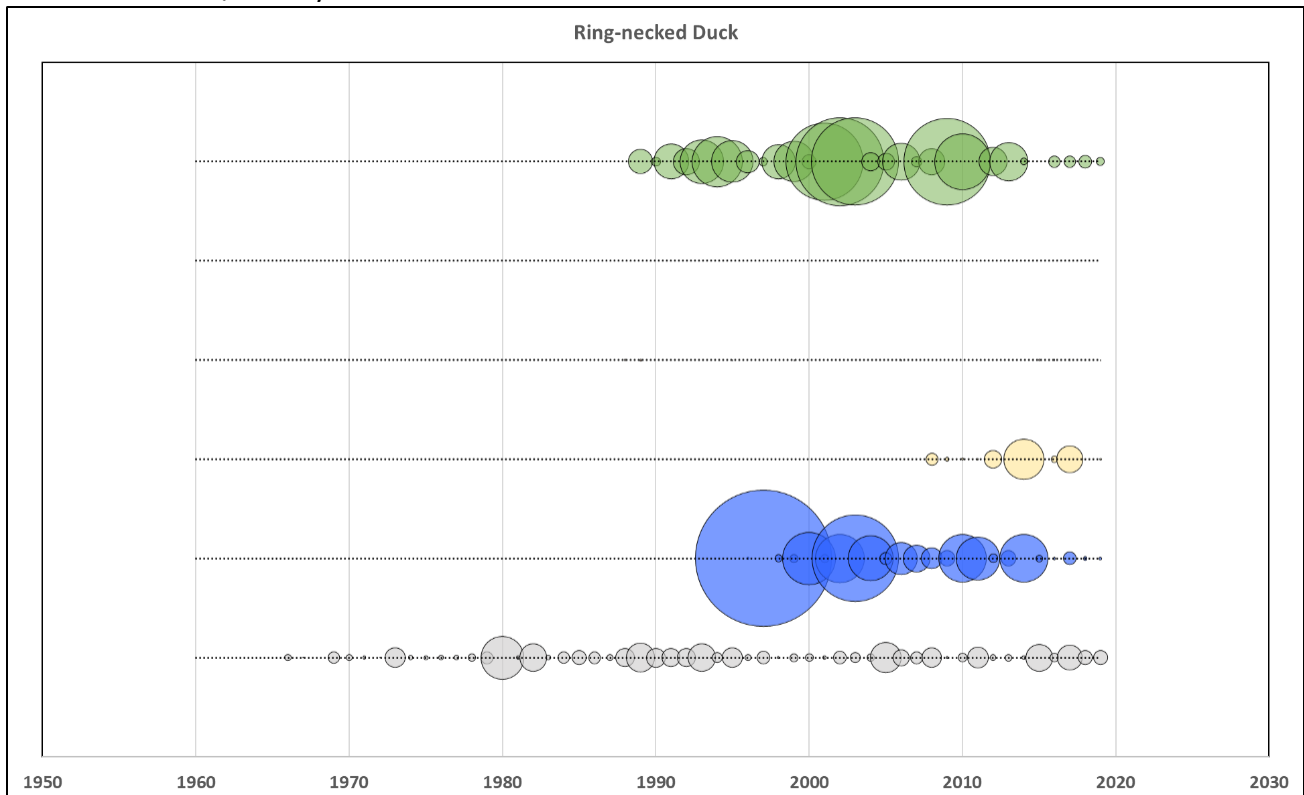


Ring-necked Duck

Number of birds counted

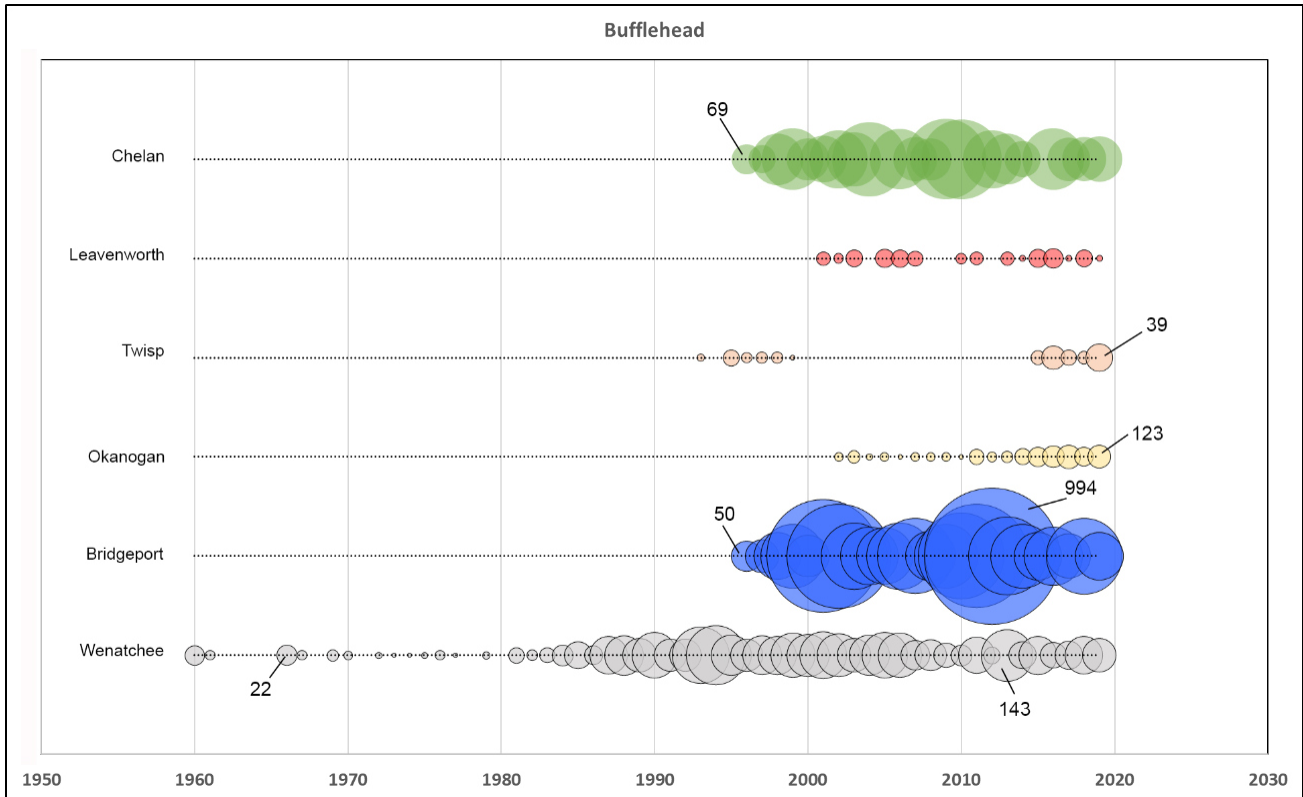


Number of birds / survey hour

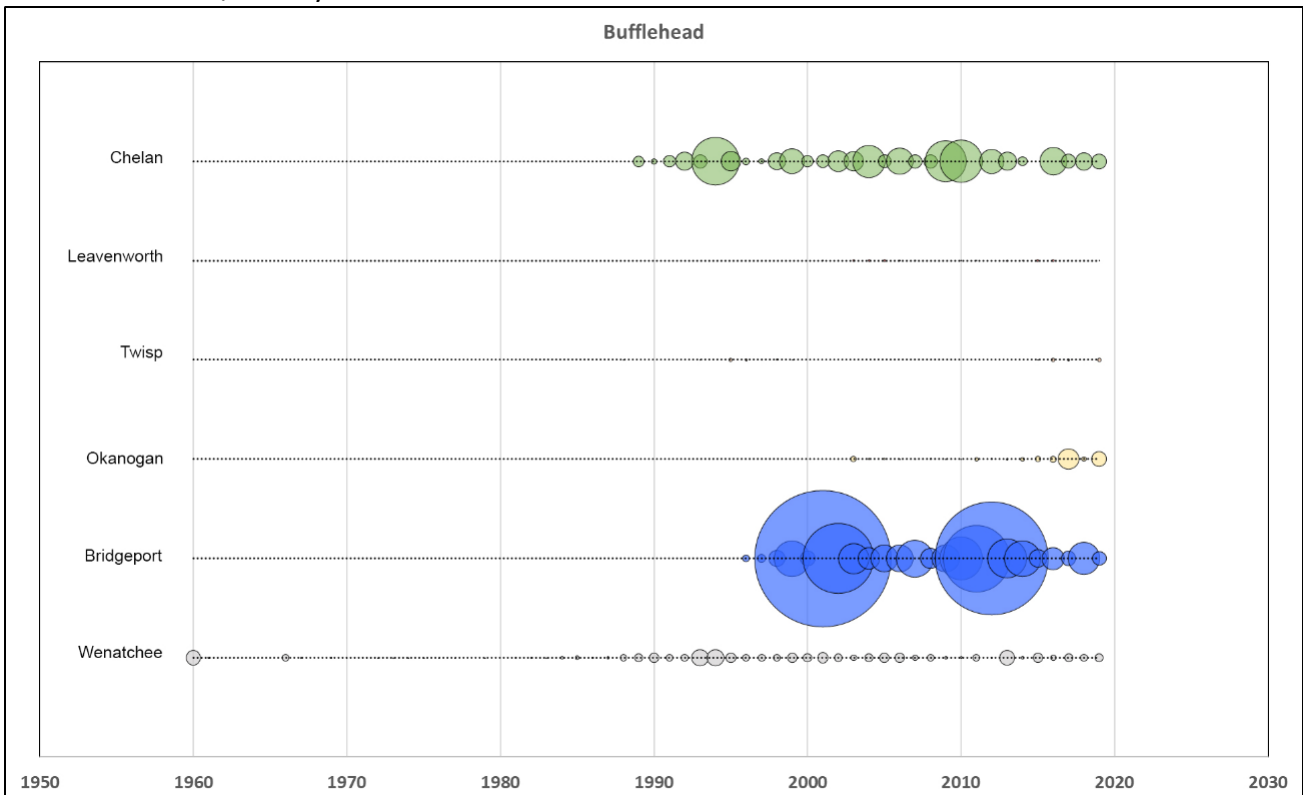


Bufflehead

Number of birds counted

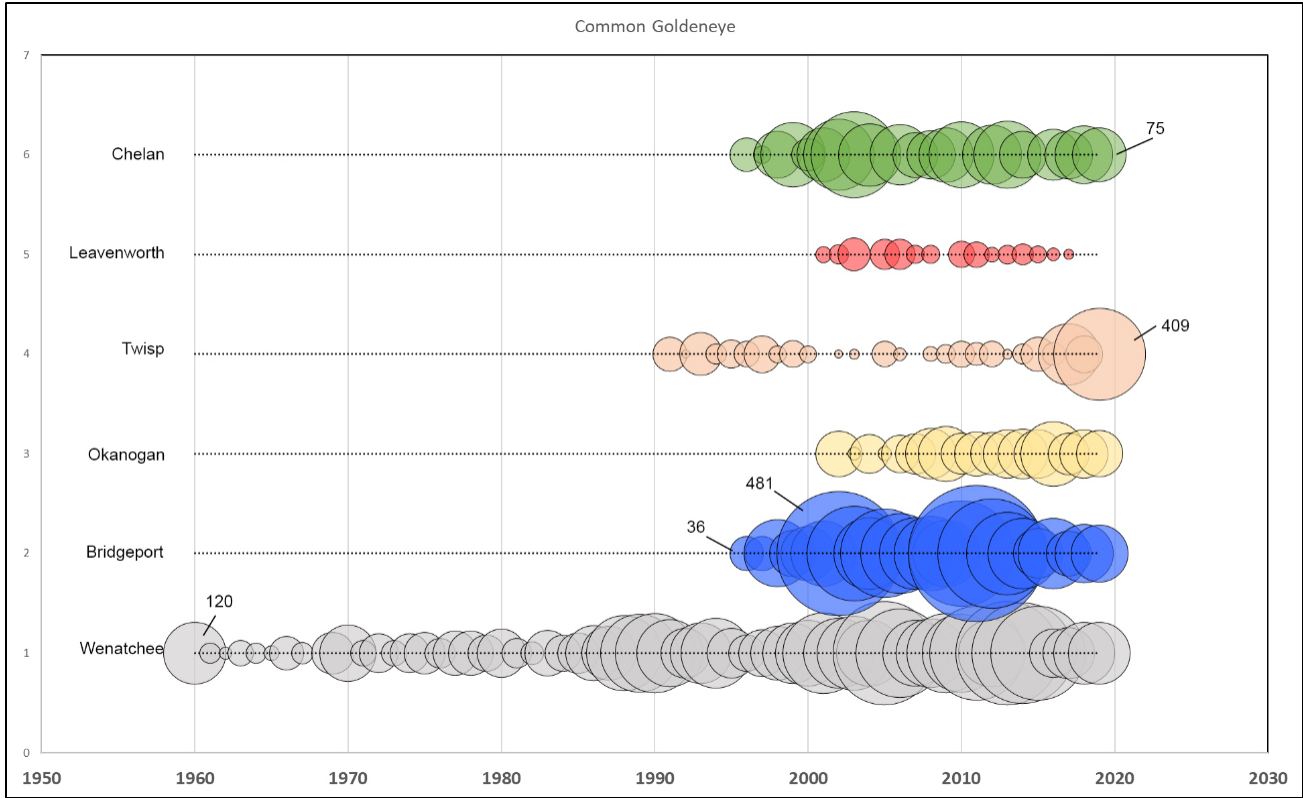


Number of birds / survey hour

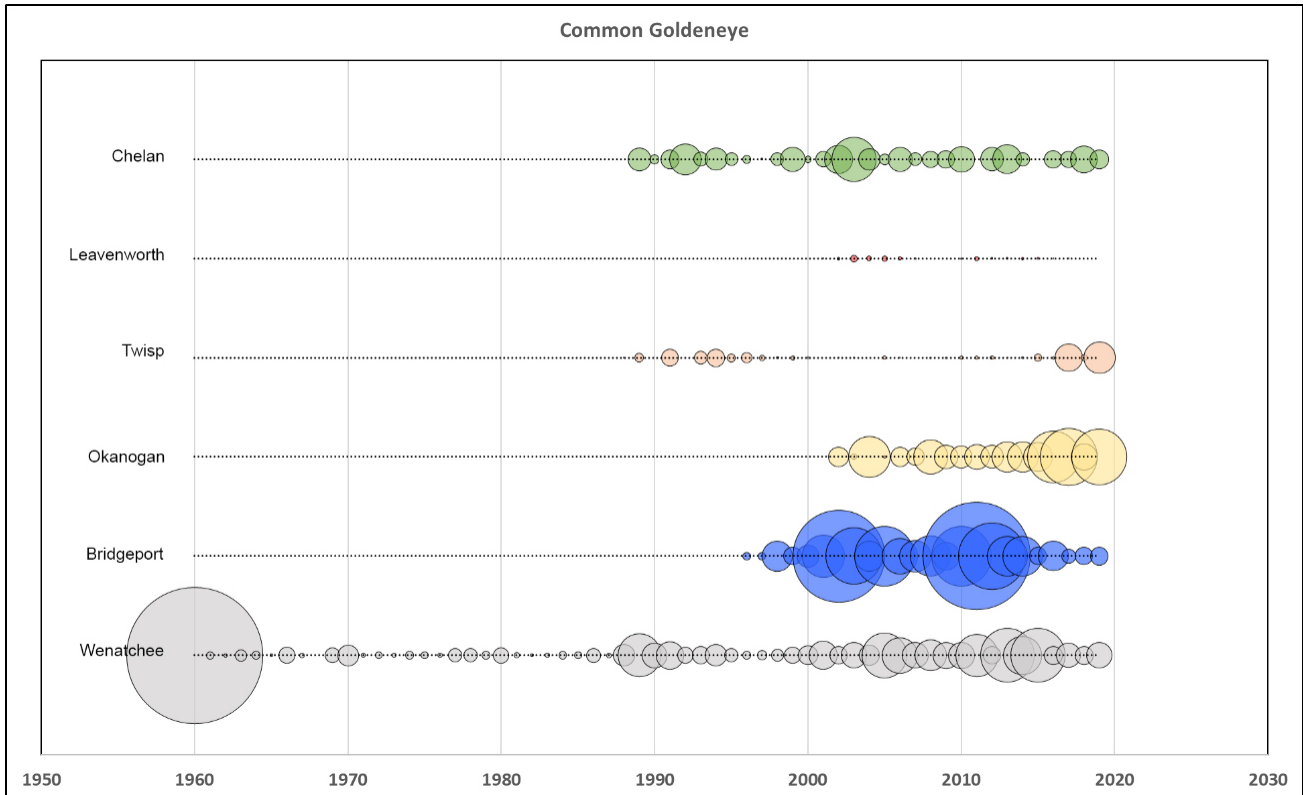


Common Goldeneye

Number of birds counted

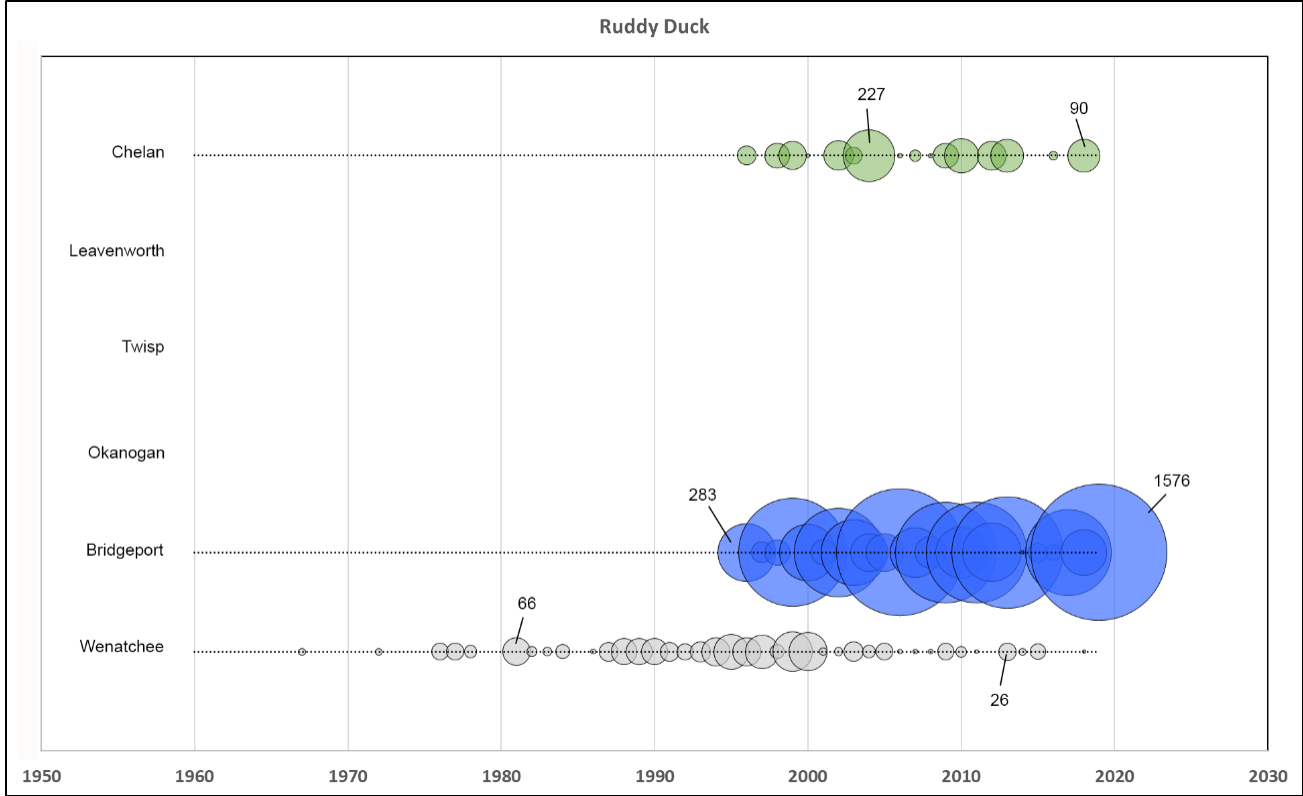


Number of birds / survey hour

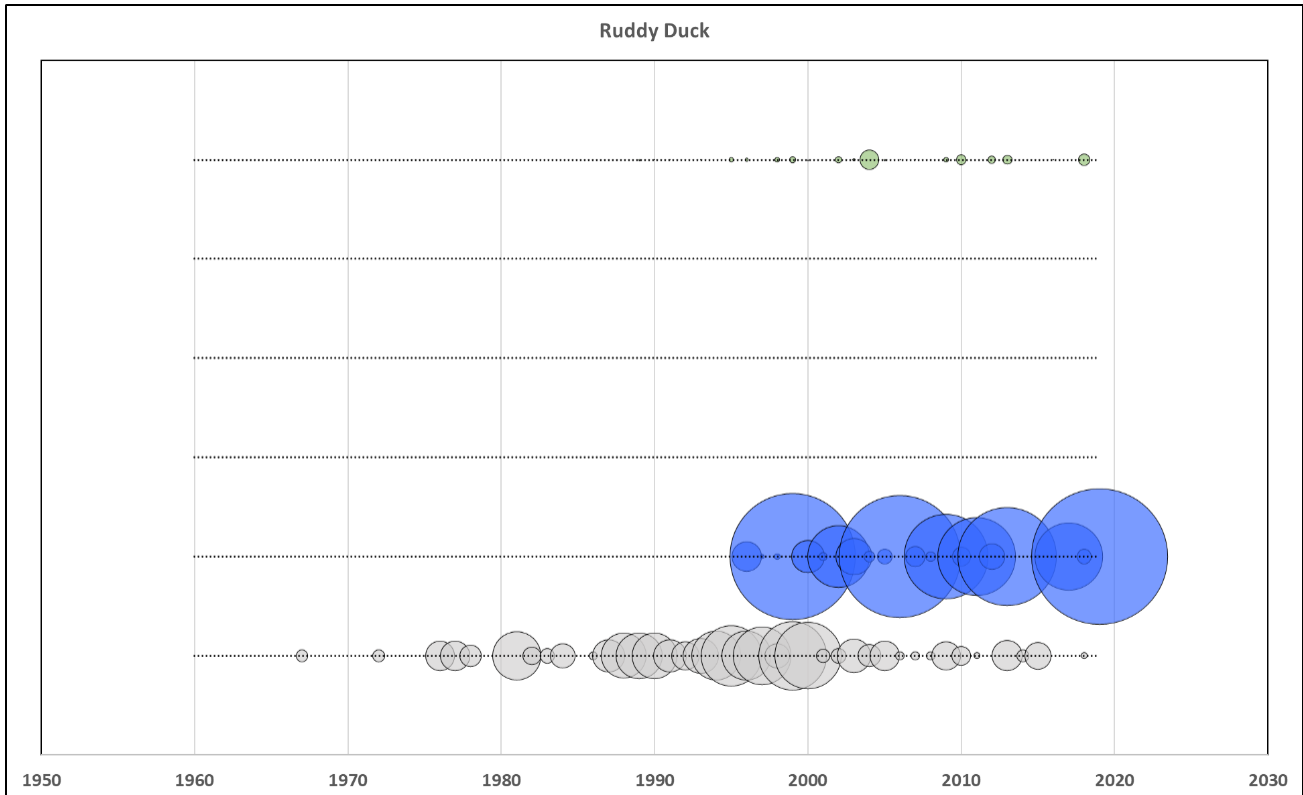


Ruddy Duck

Number of birds counted

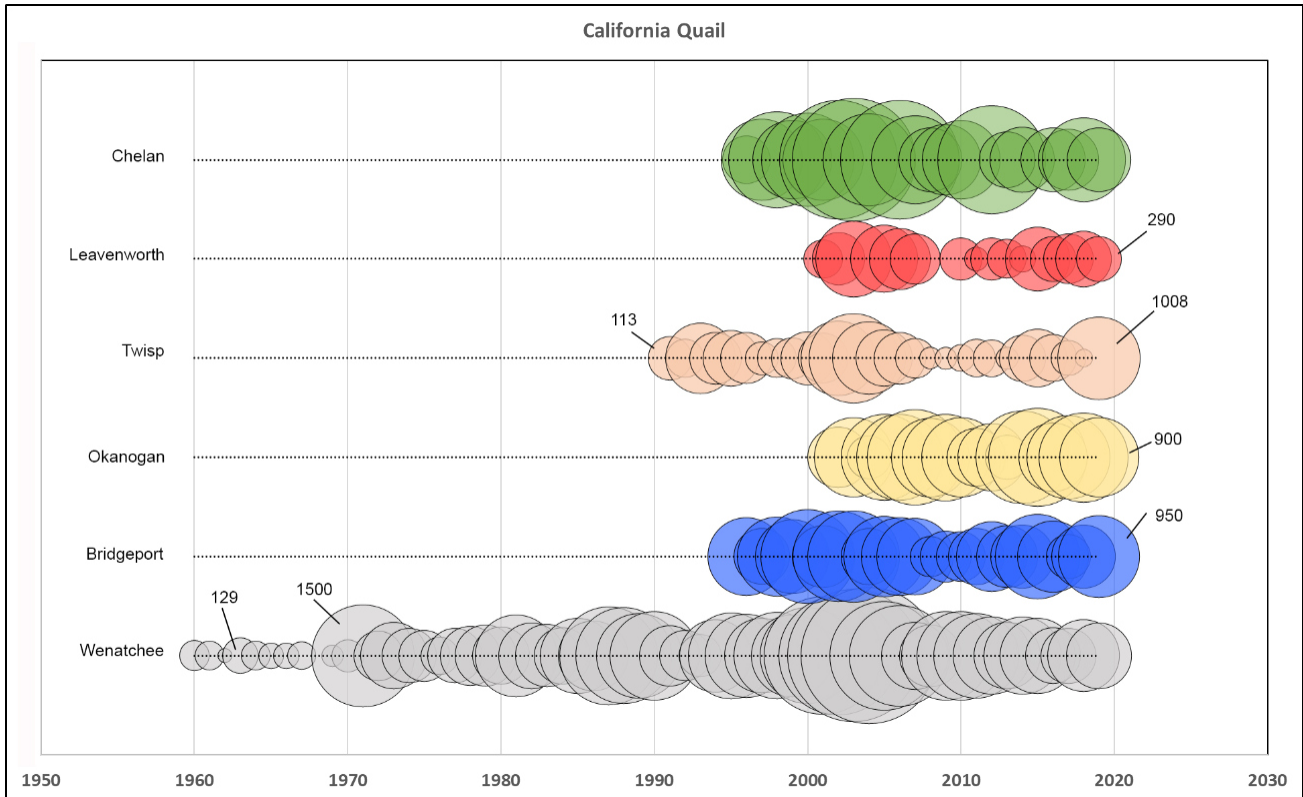


Number of birds / survey hour

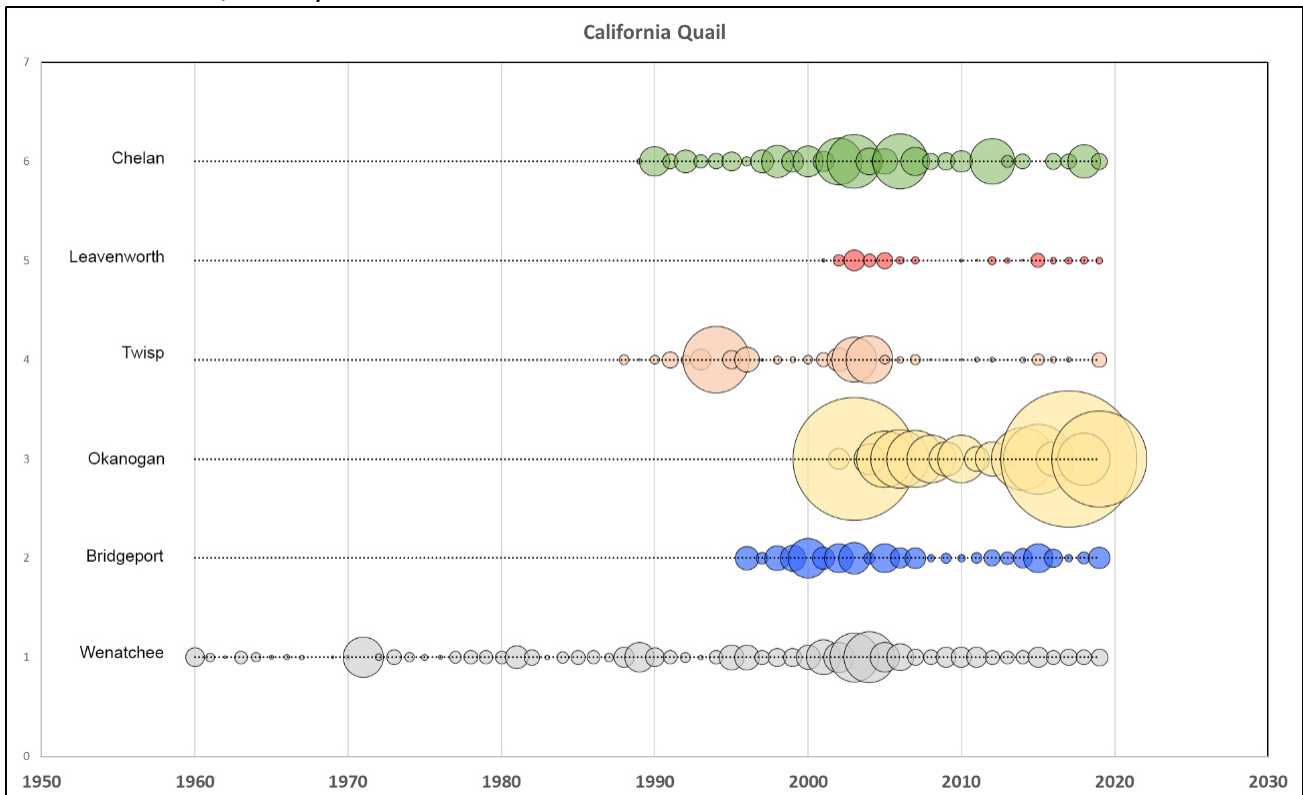


California Quail

Number of birds counted

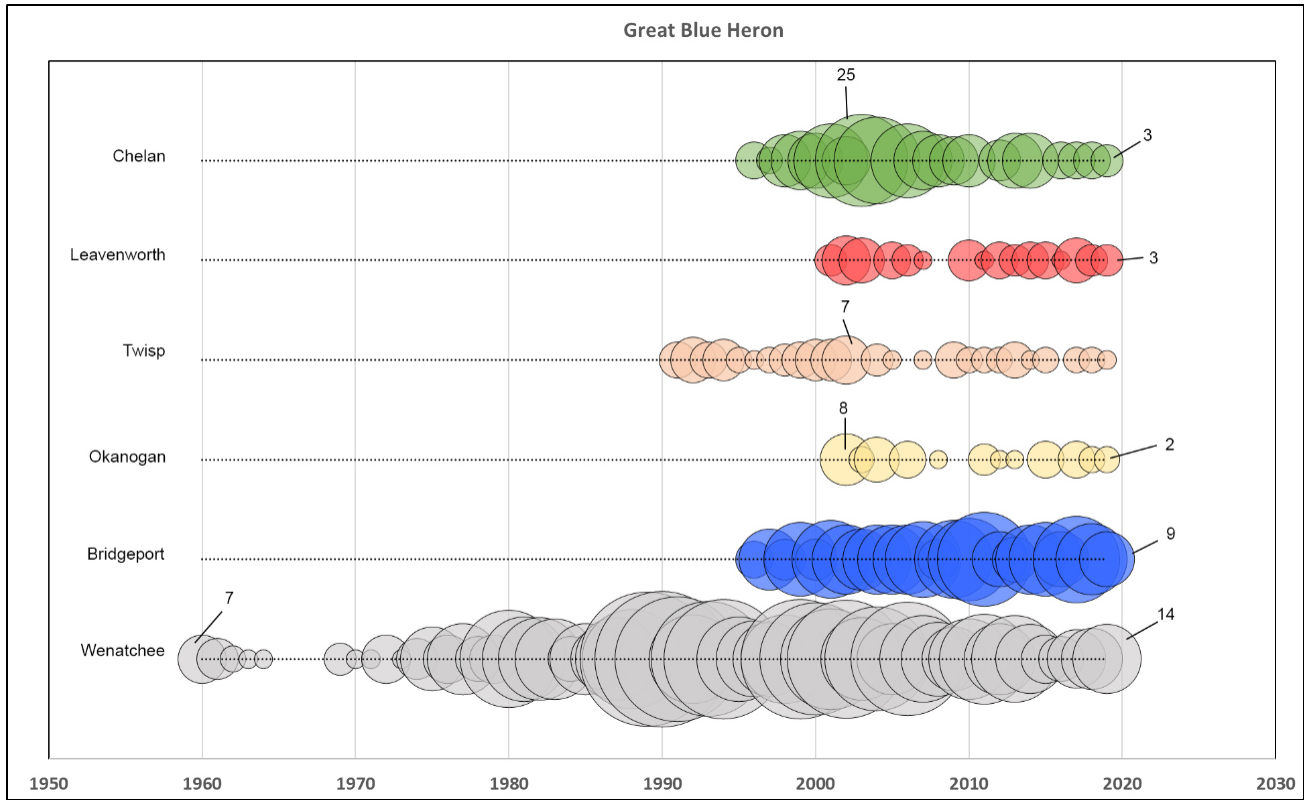


Number of birds / survey hour

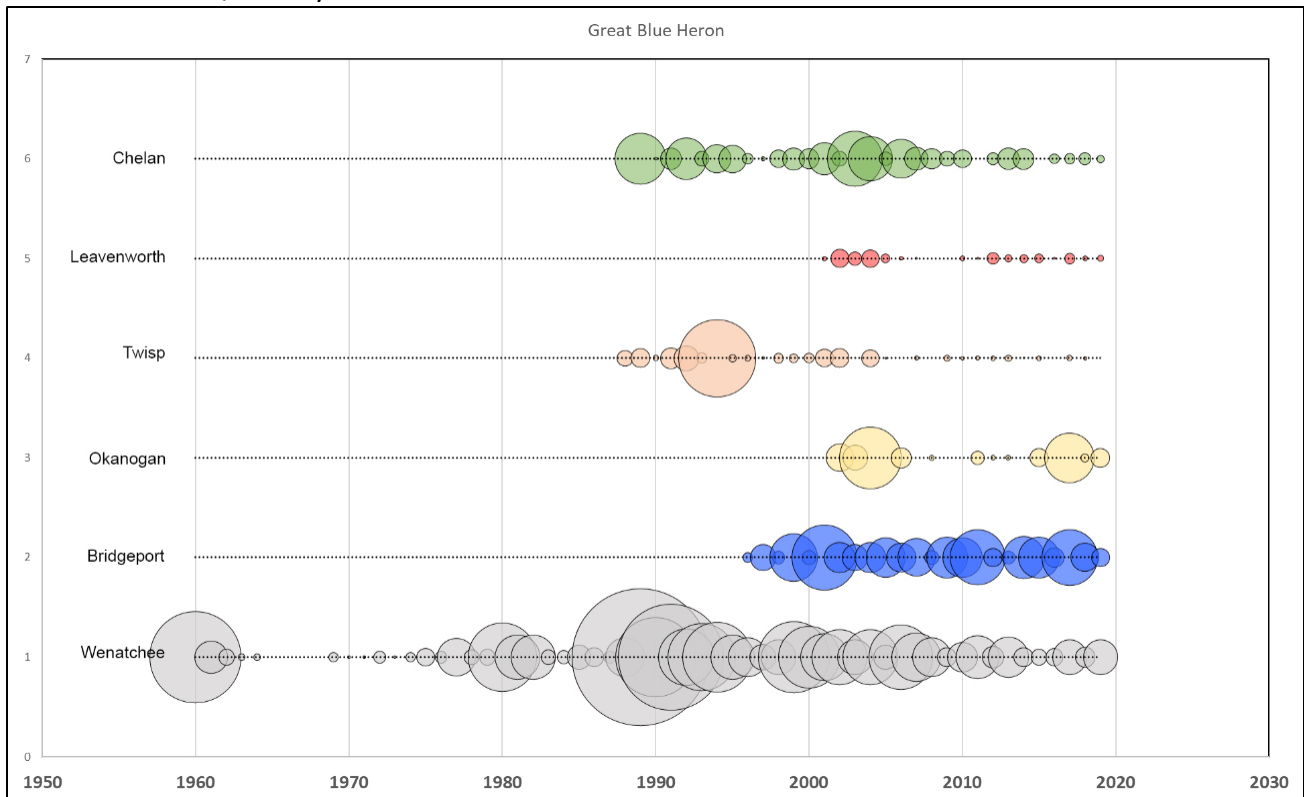


Great Blue Heron

Number of birds counted

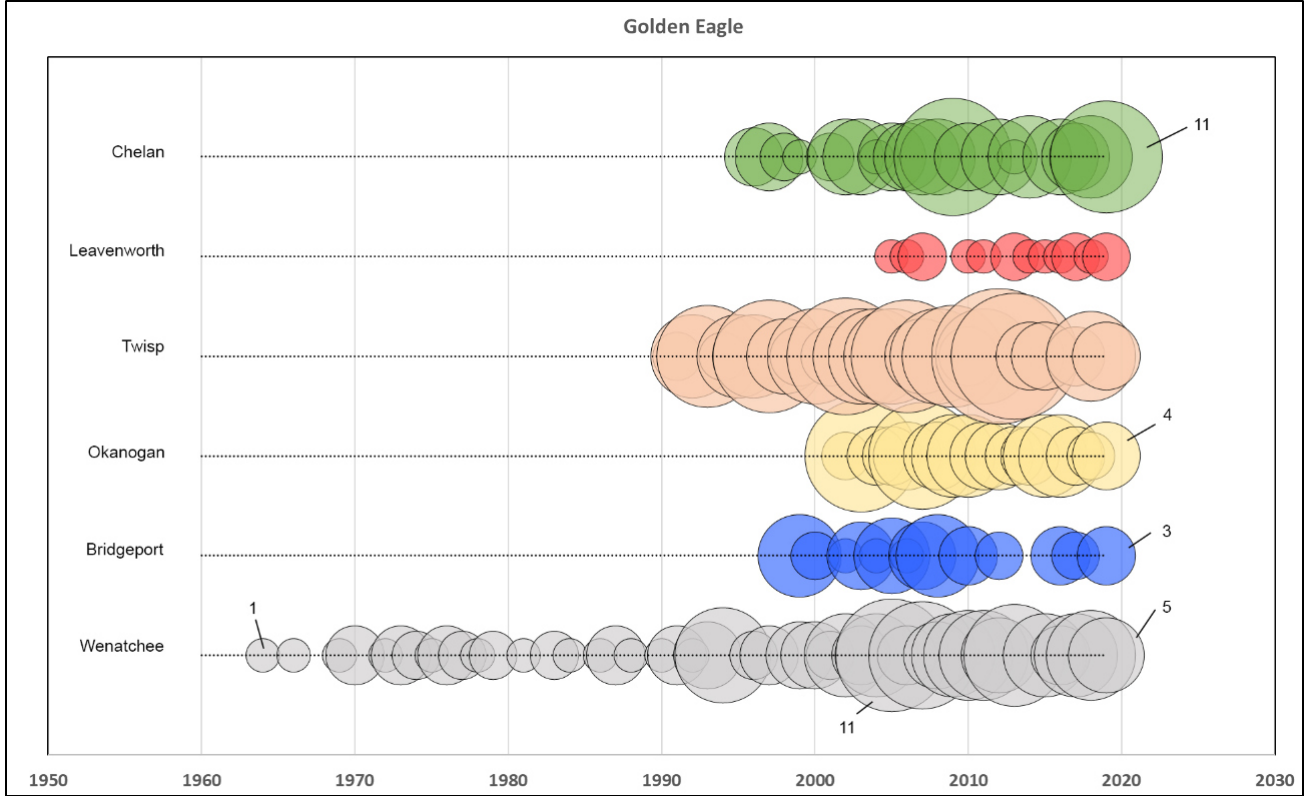


Number of birds / survey hour

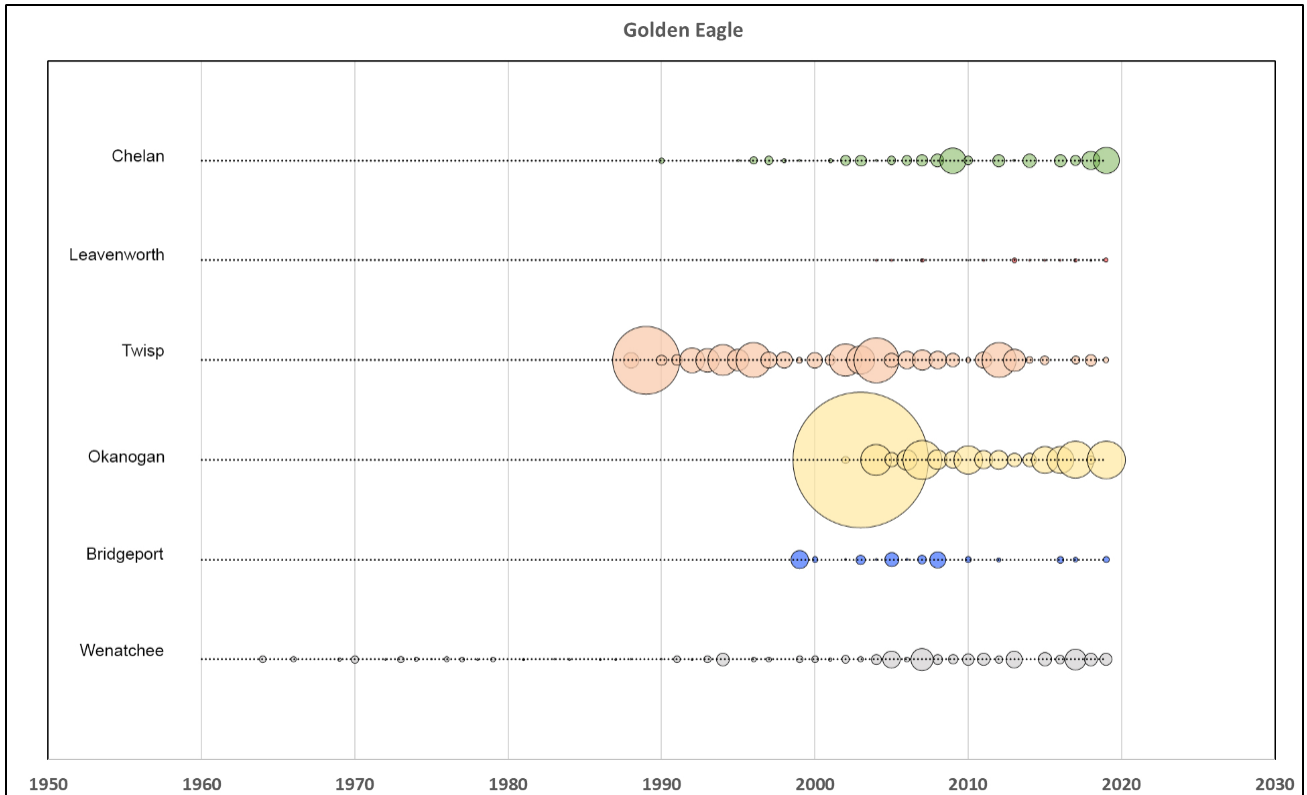


Golden Eagle

Number of birds counted

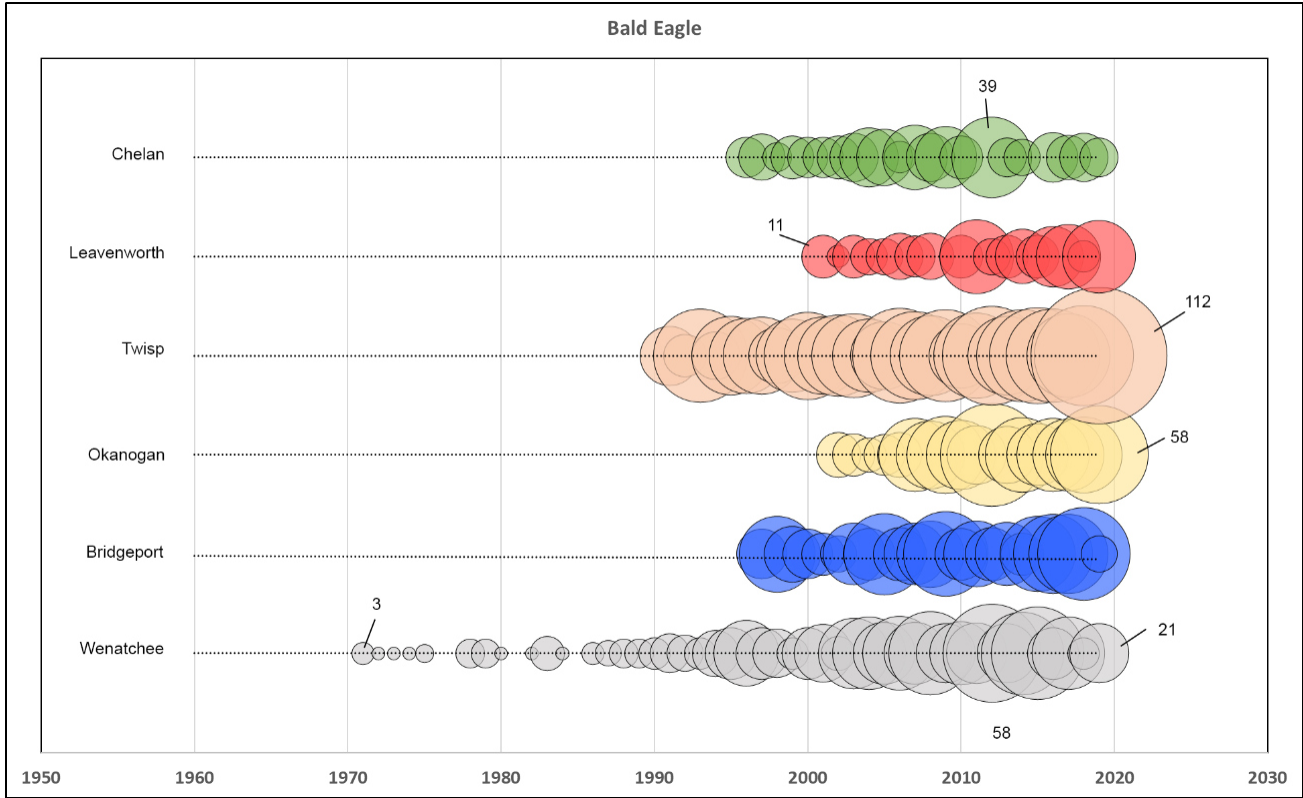


Number of birds / survey hour

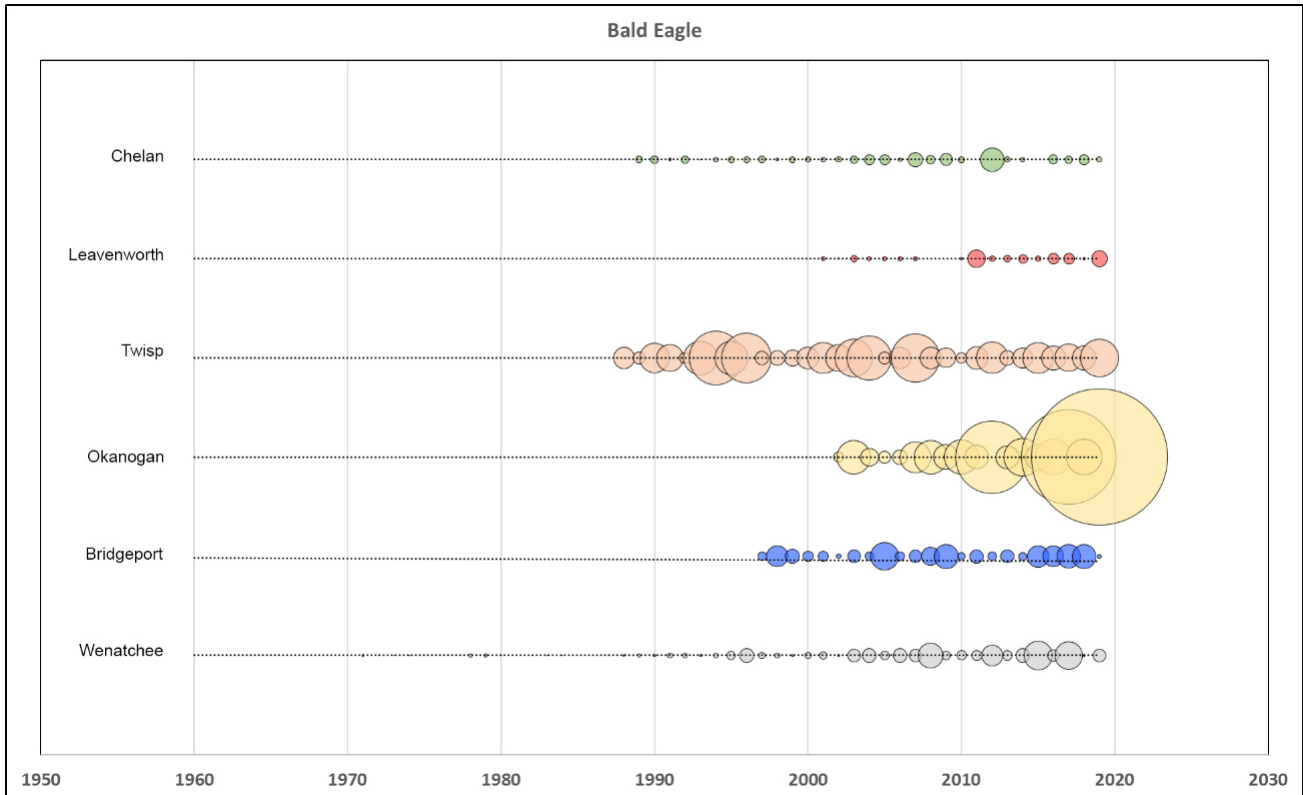


Bald Eagle

Number of birds counted

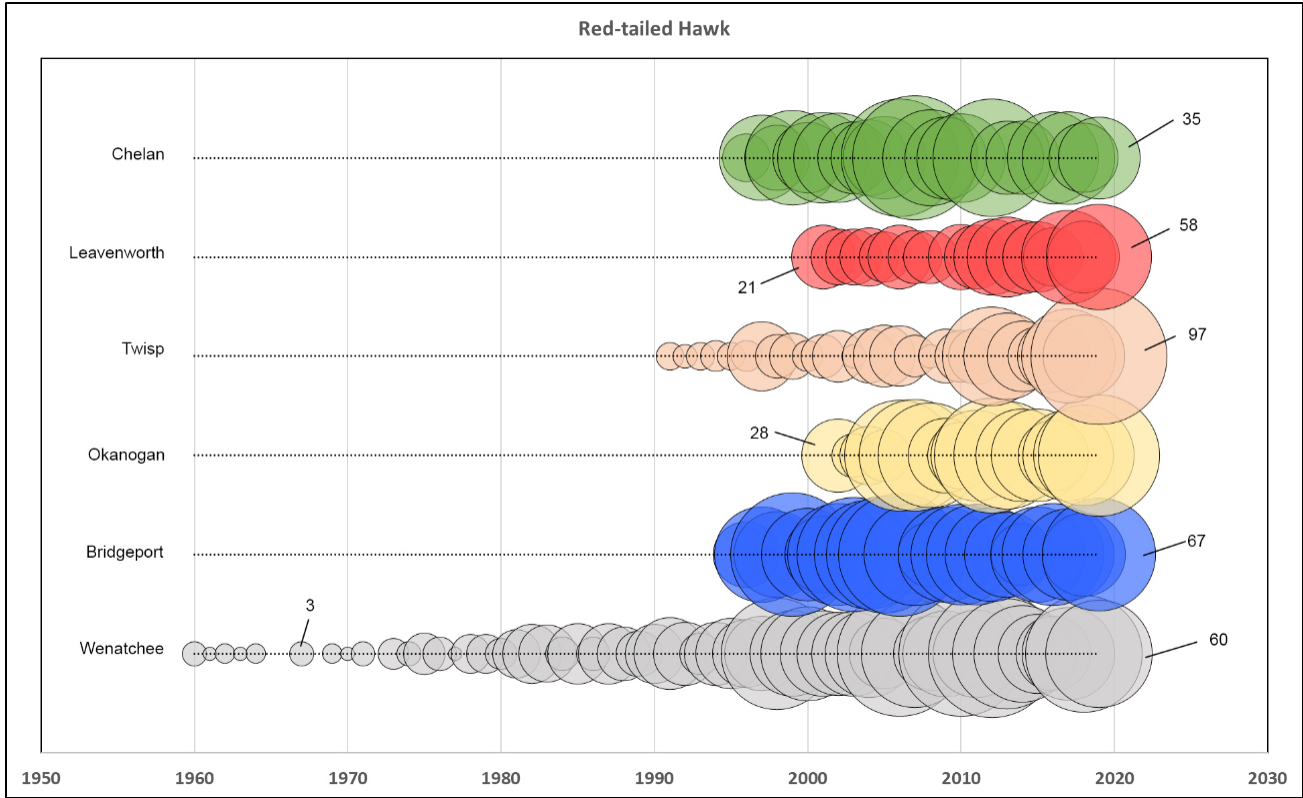


Number of birds / survey hour

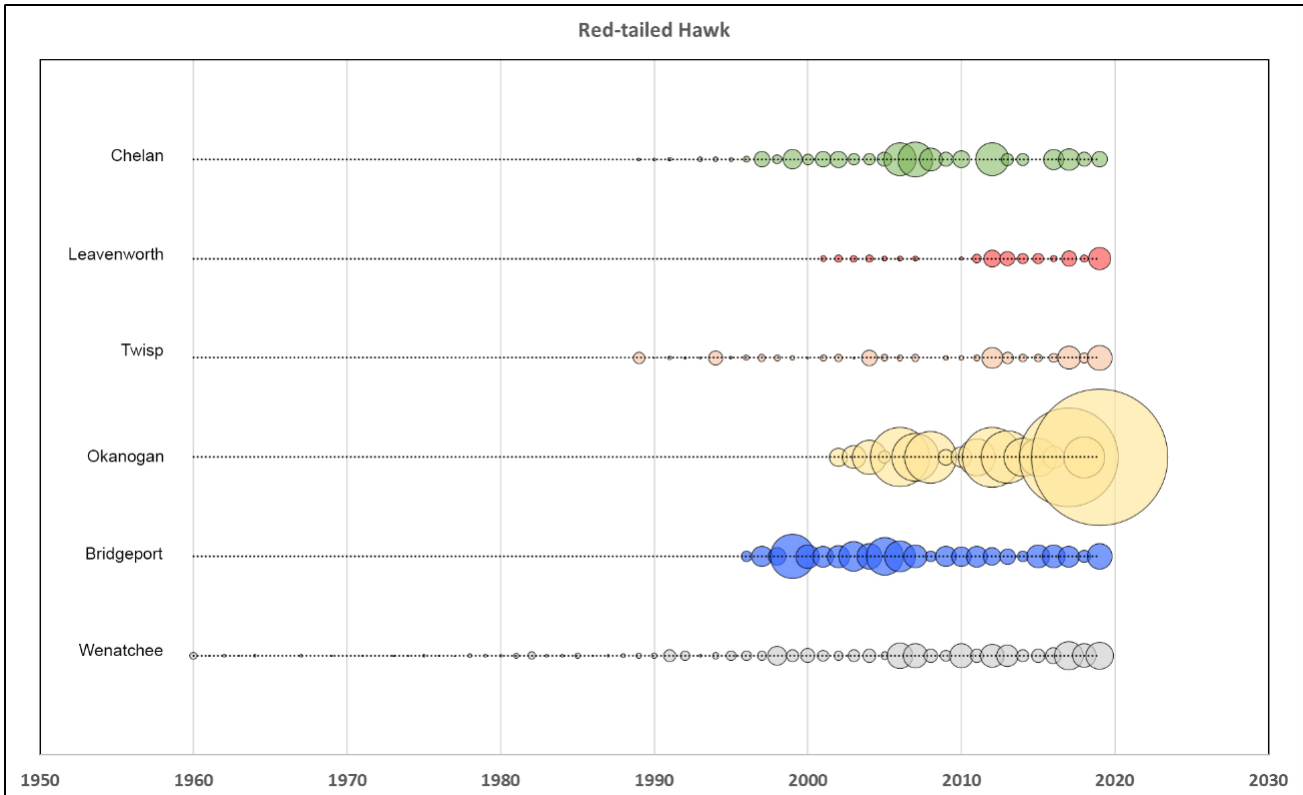


Red-tailed Hawk

Number of birds counted

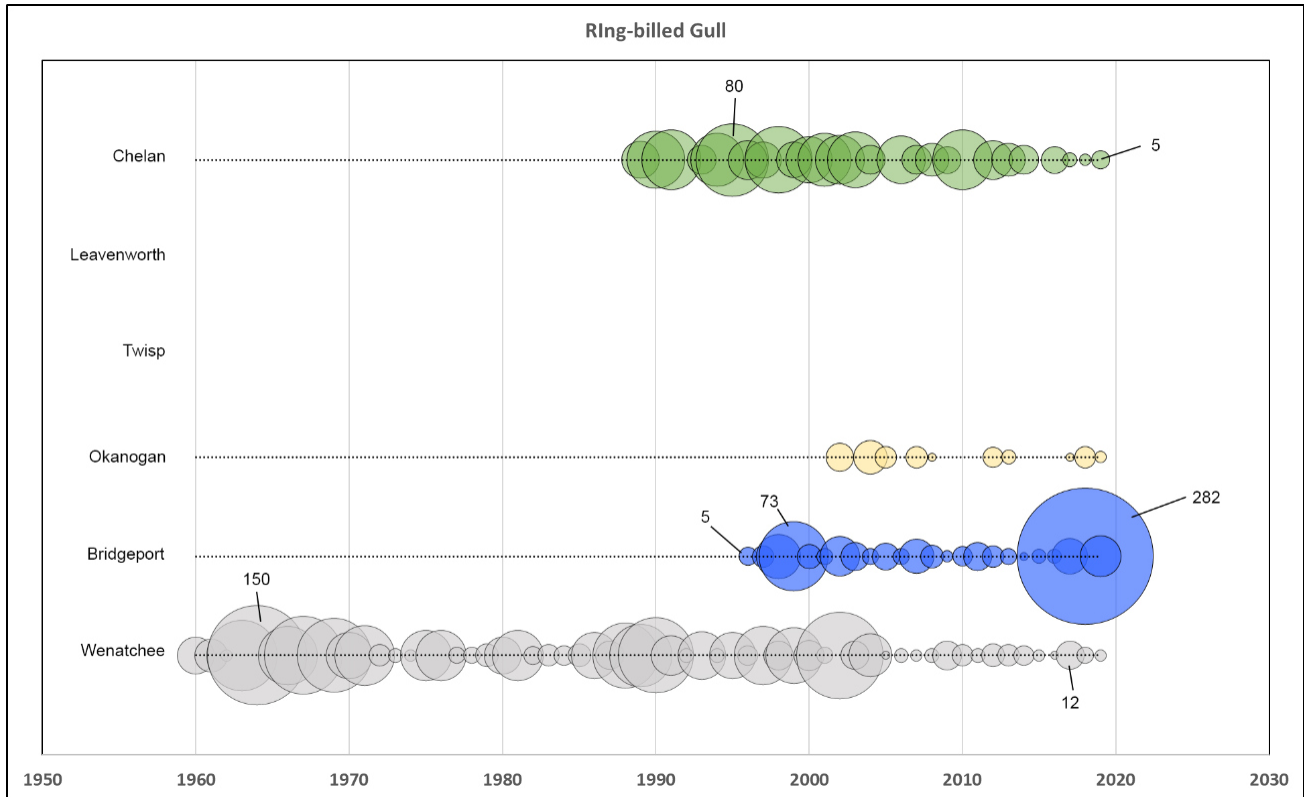


Number of birds / survey hour

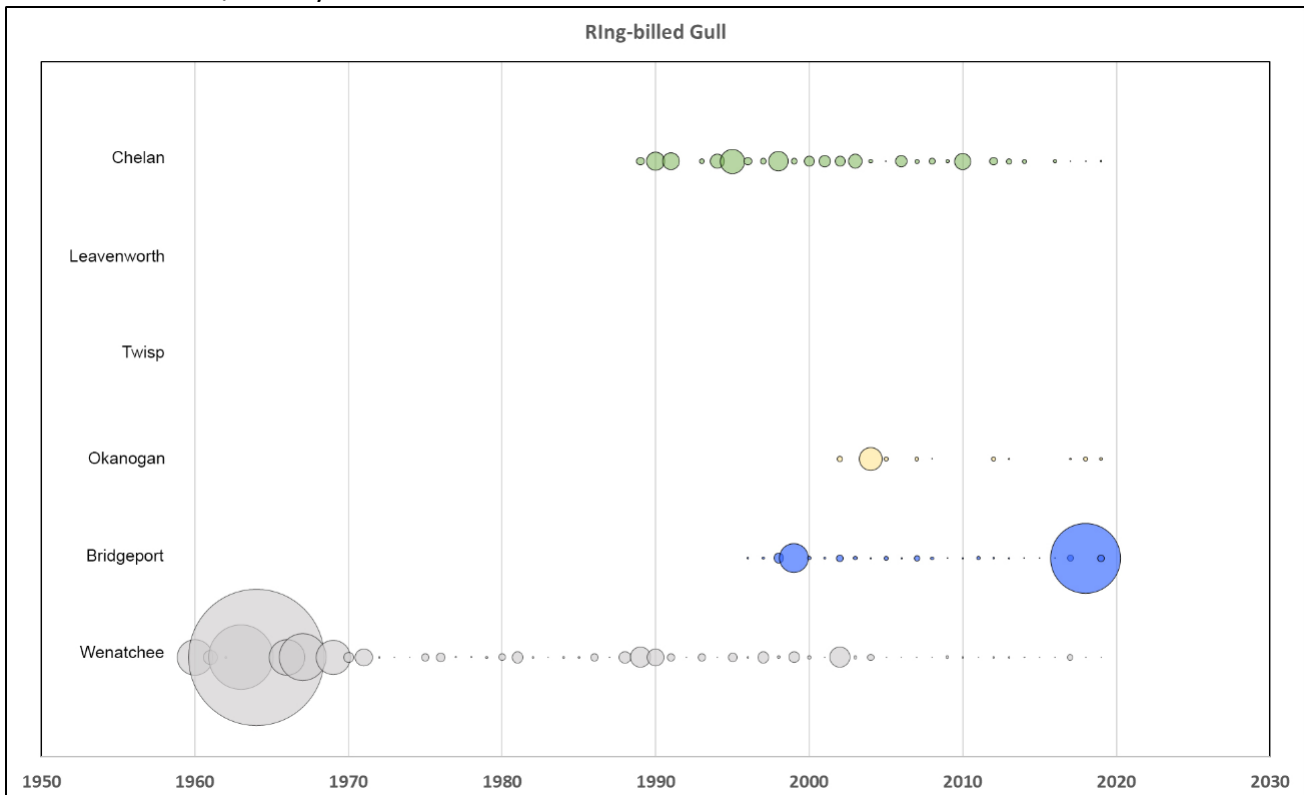


Ring-billed Gull

Number of birds counted

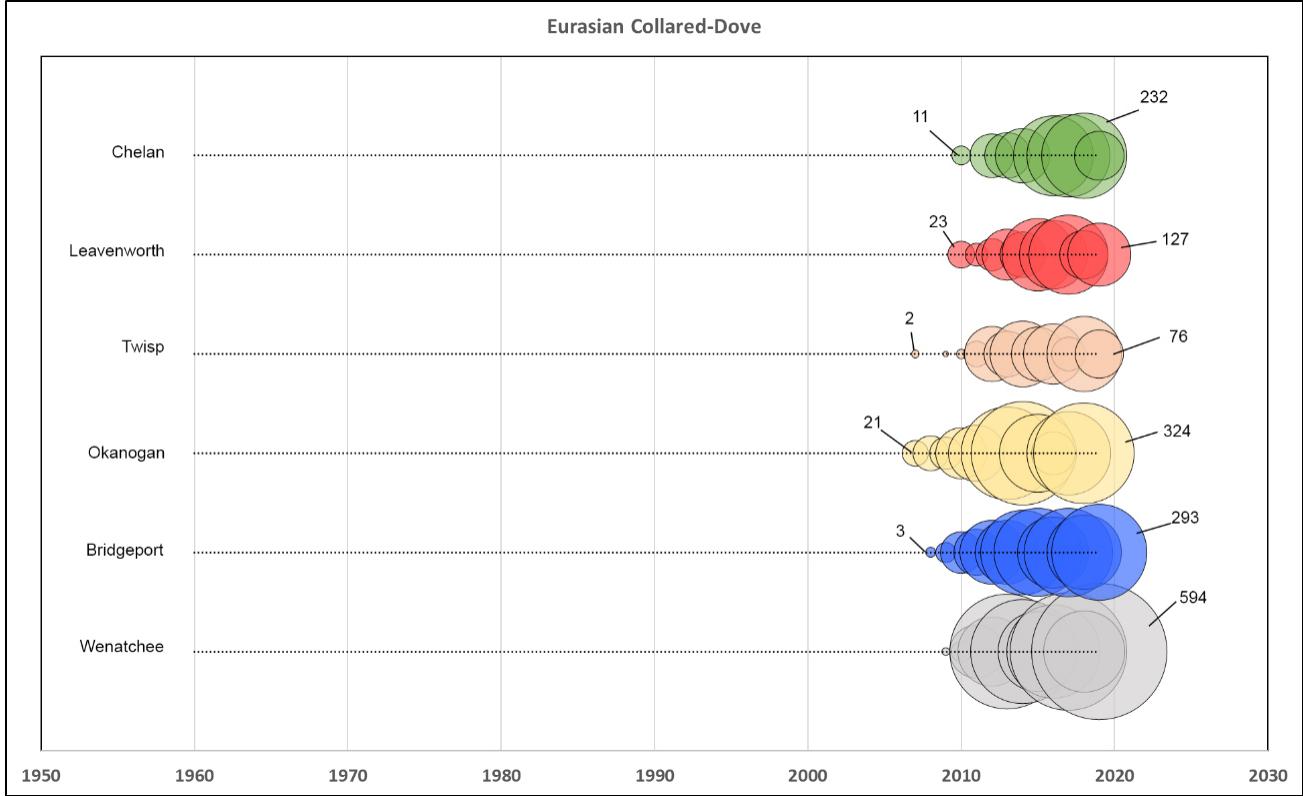


Number of birds / survey hour

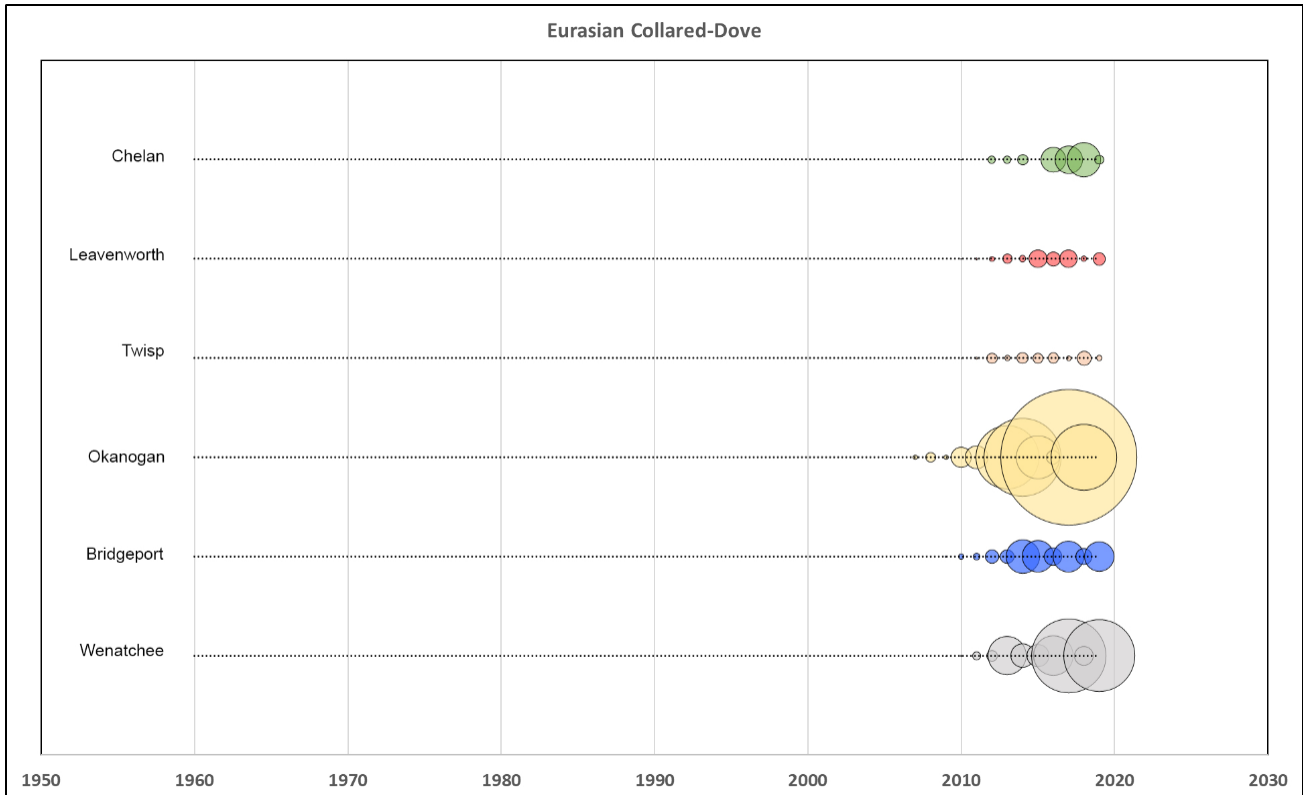


Eurasian Collared-Dove

Number of birds counted

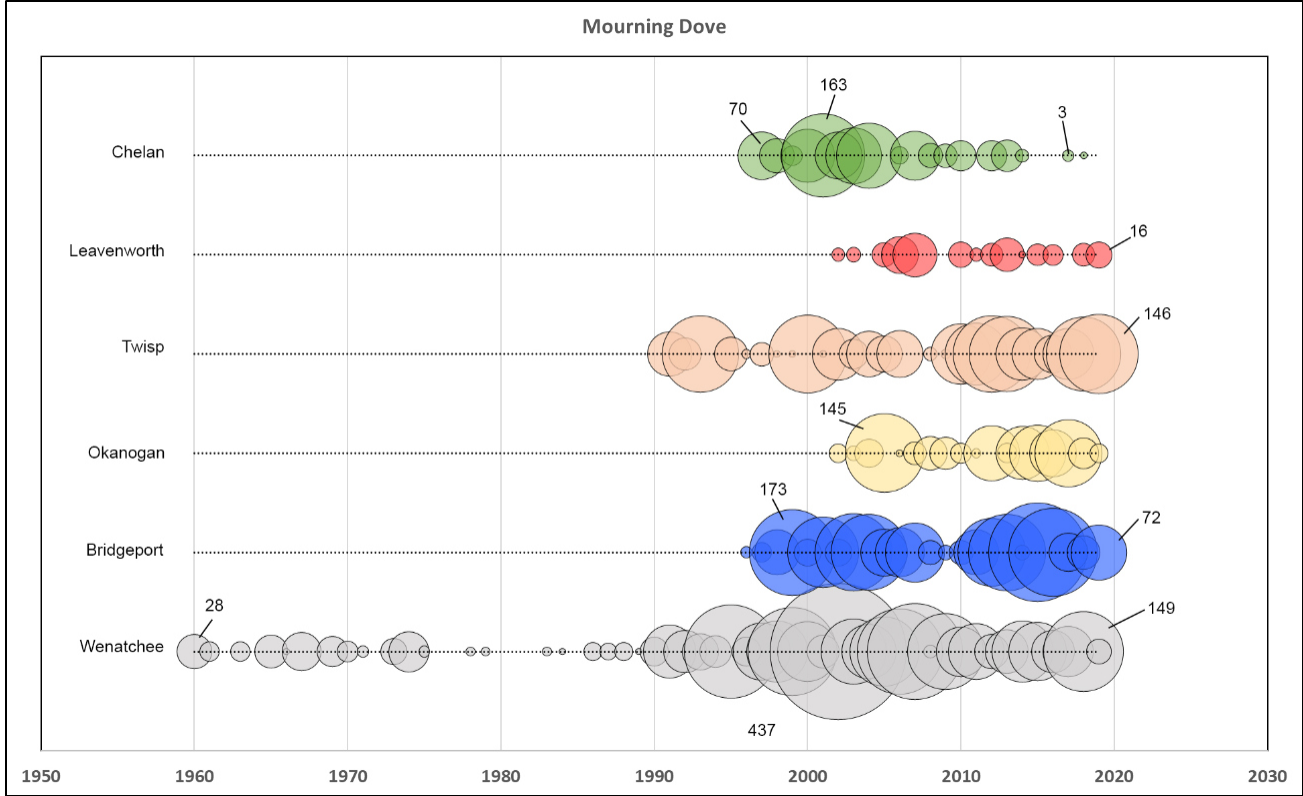


Number of birds / survey hour

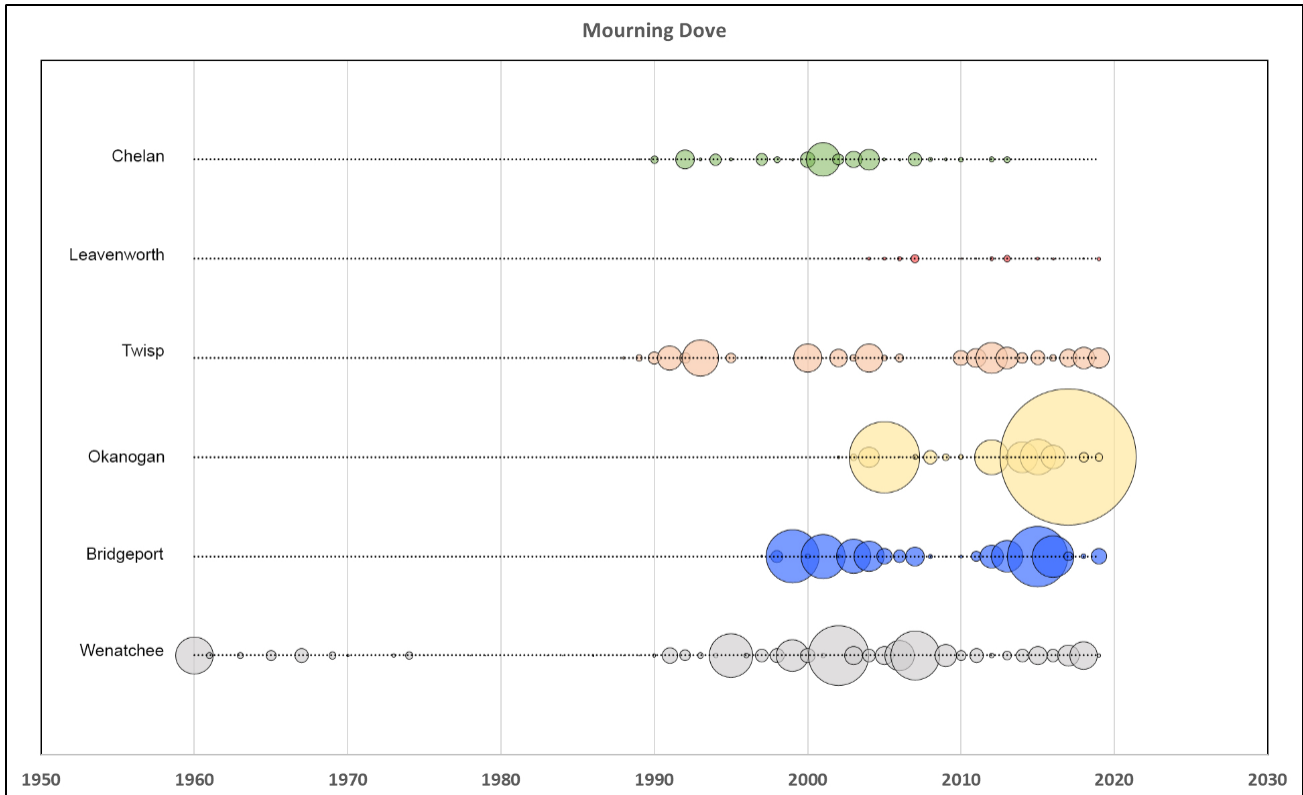


Mourning Dove

Number of birds counted

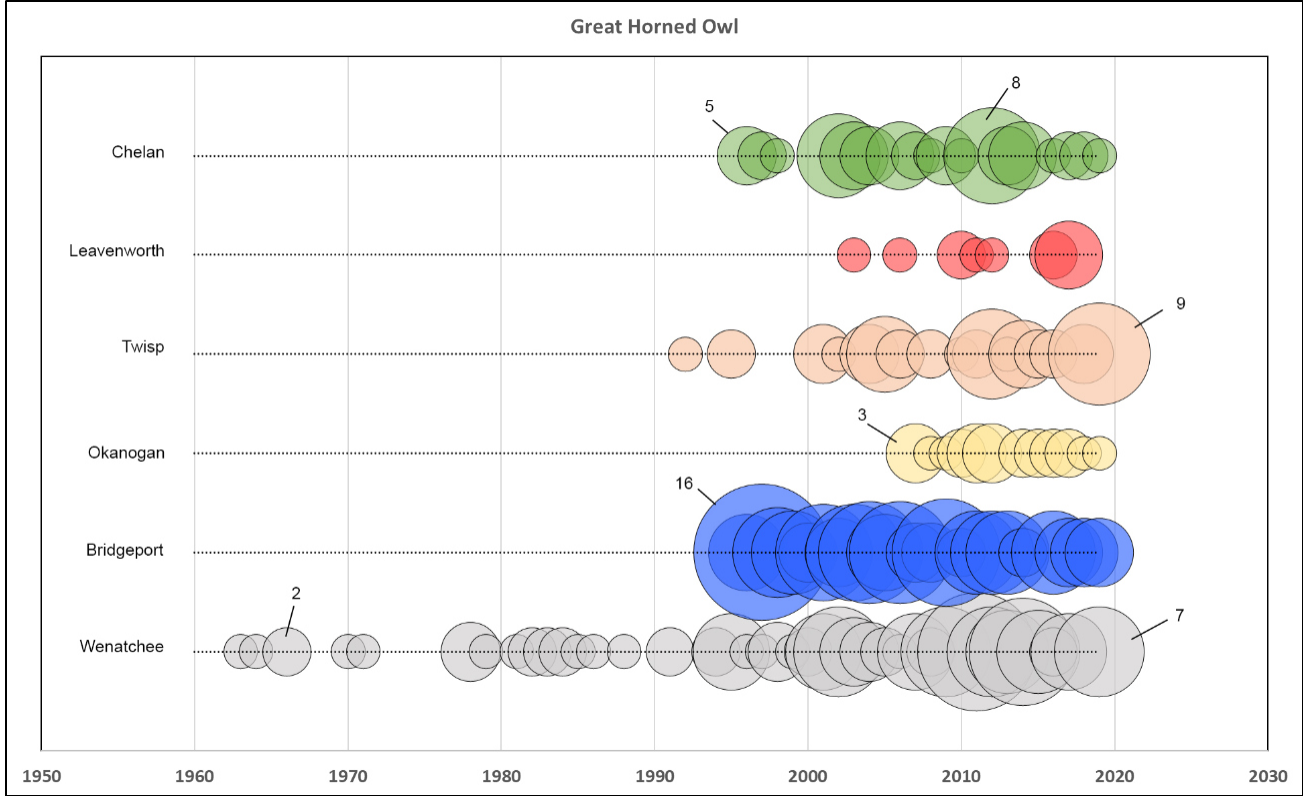


Number of birds / survey hour

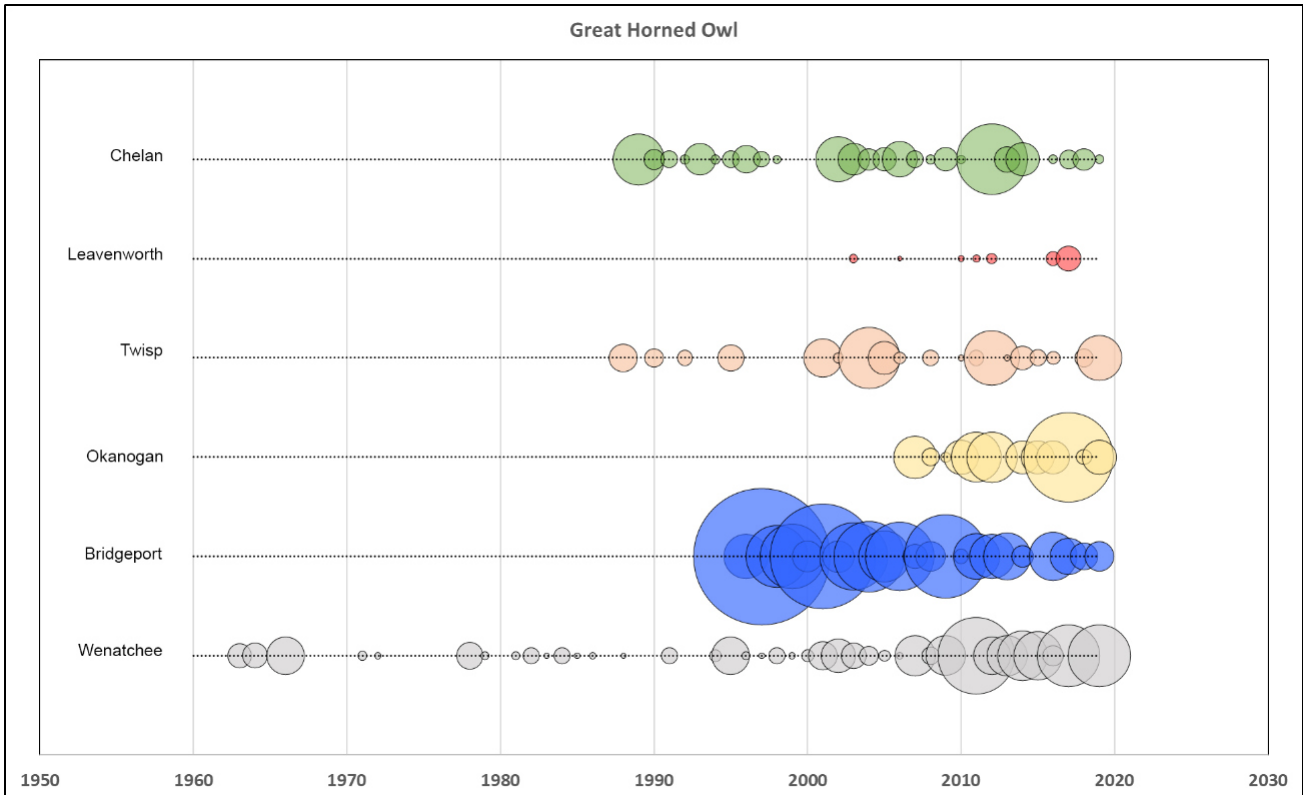


Great Horned Owl

Number of birds counted

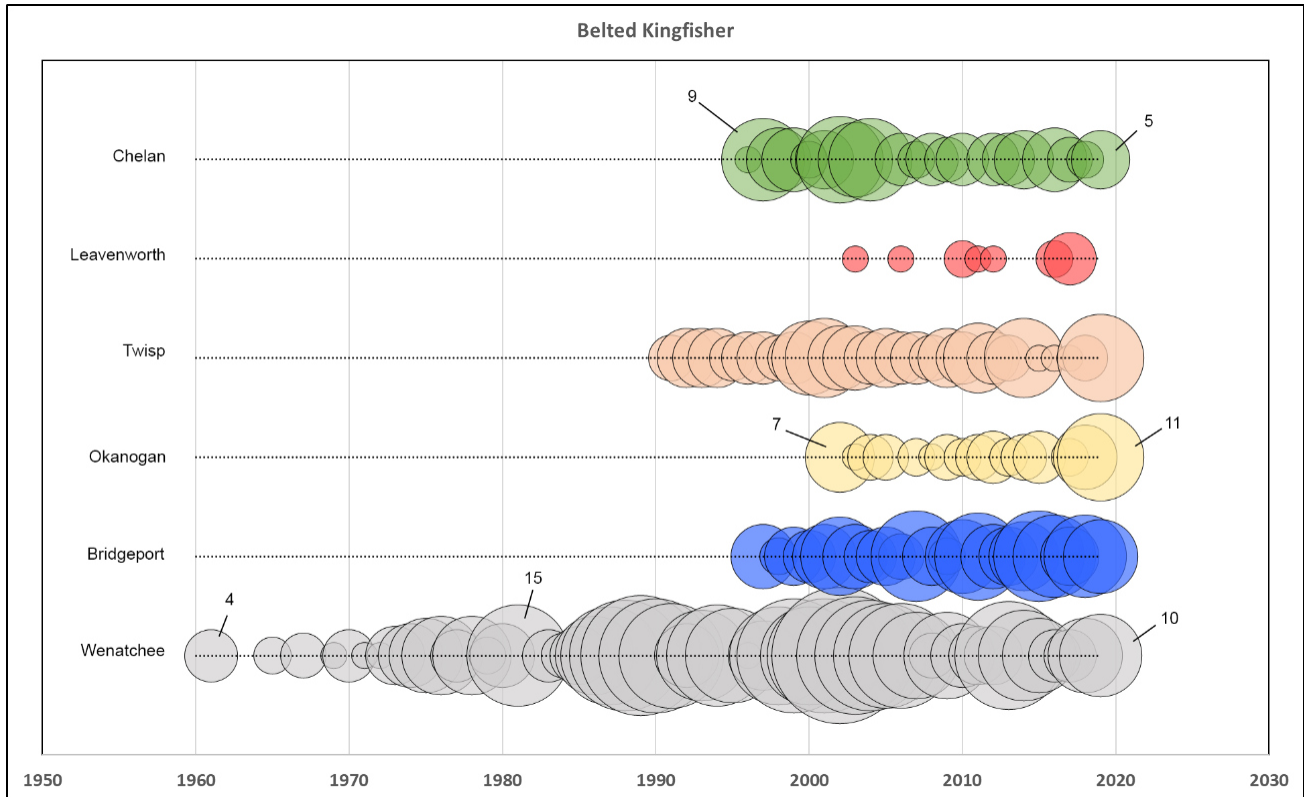


Number of birds / survey hour

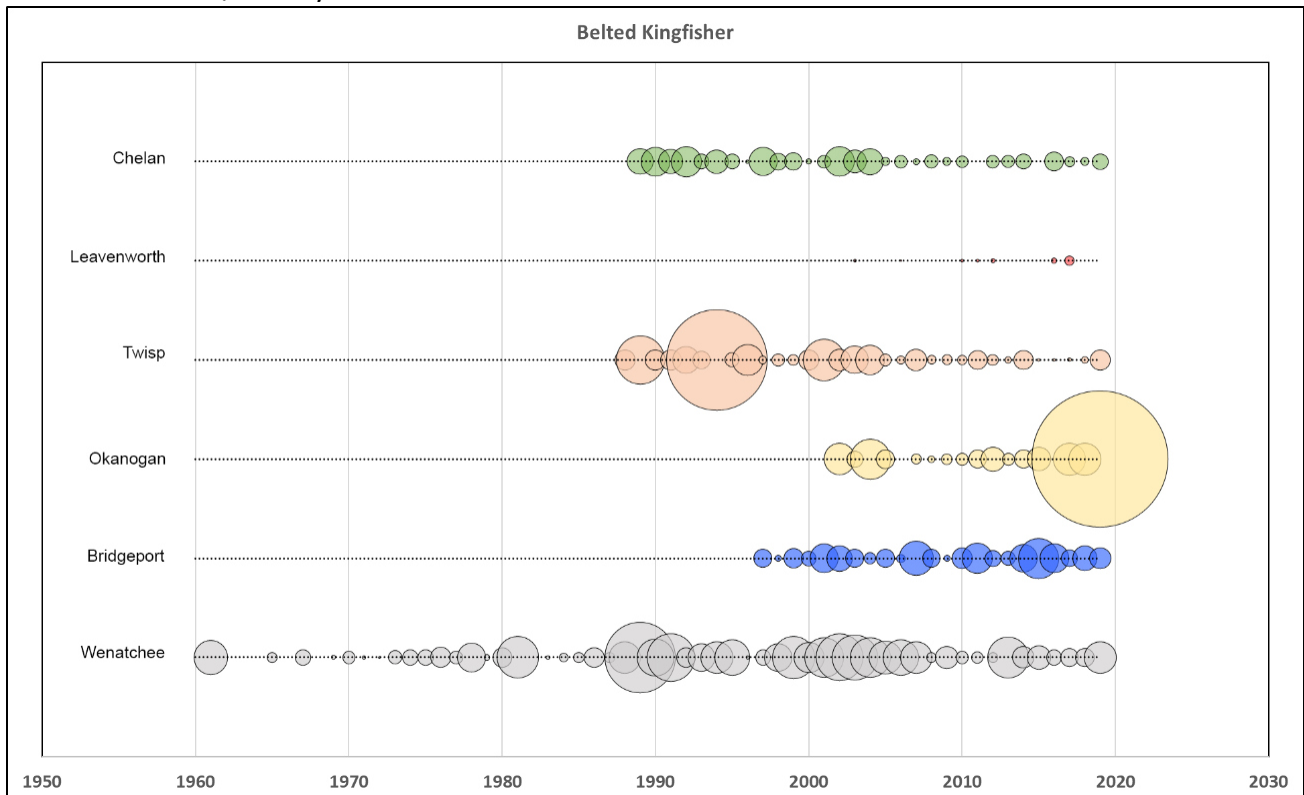


Belted Kingfisher

Number of birds counted

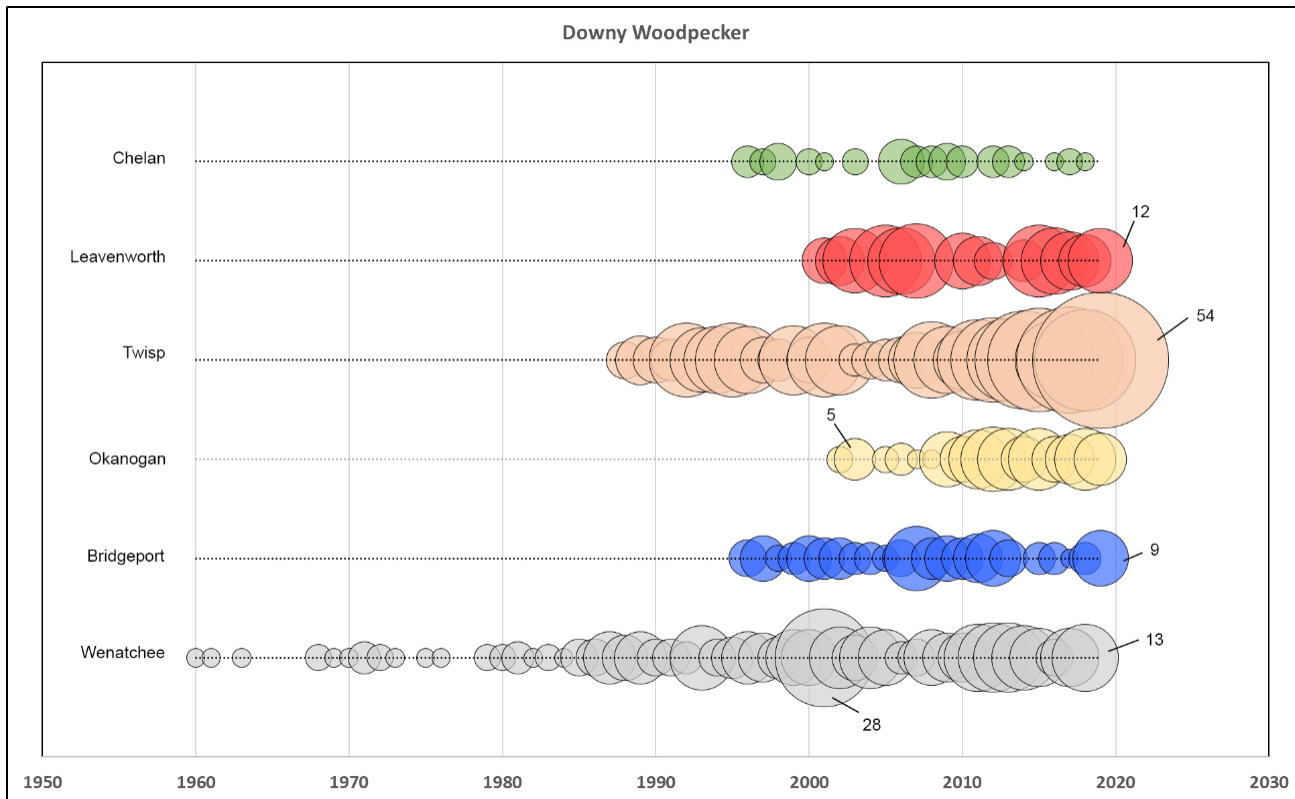


Number of birds / survey hour

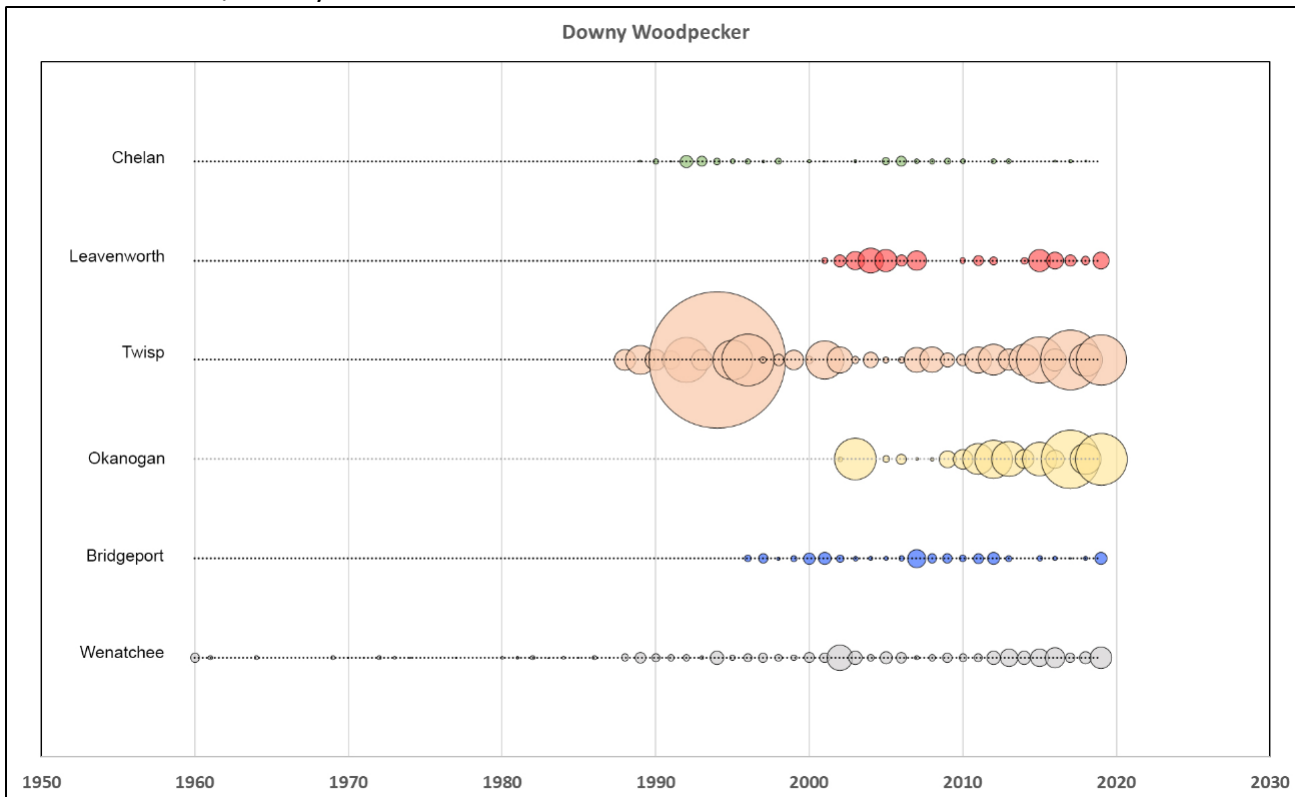


Downy Woodpecker

Number of birds counted

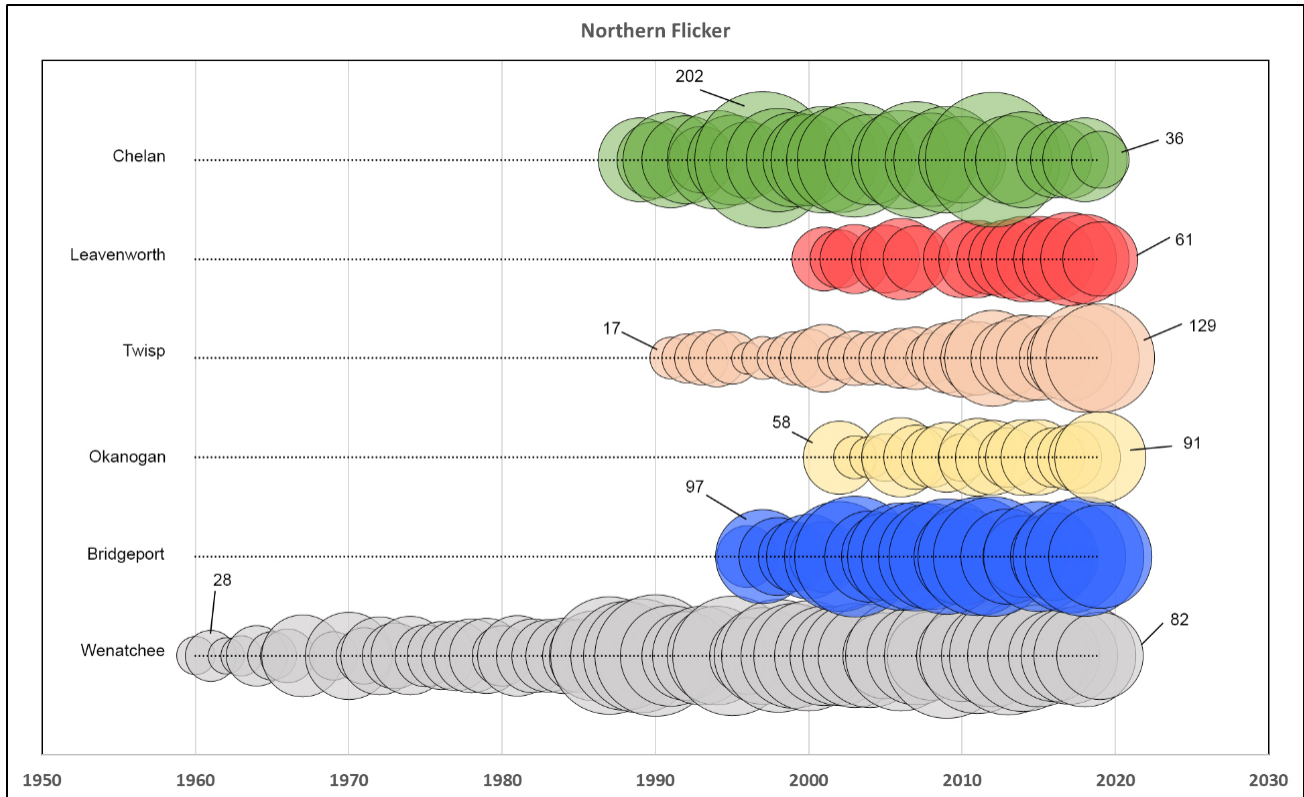


Number of birds / survey hour

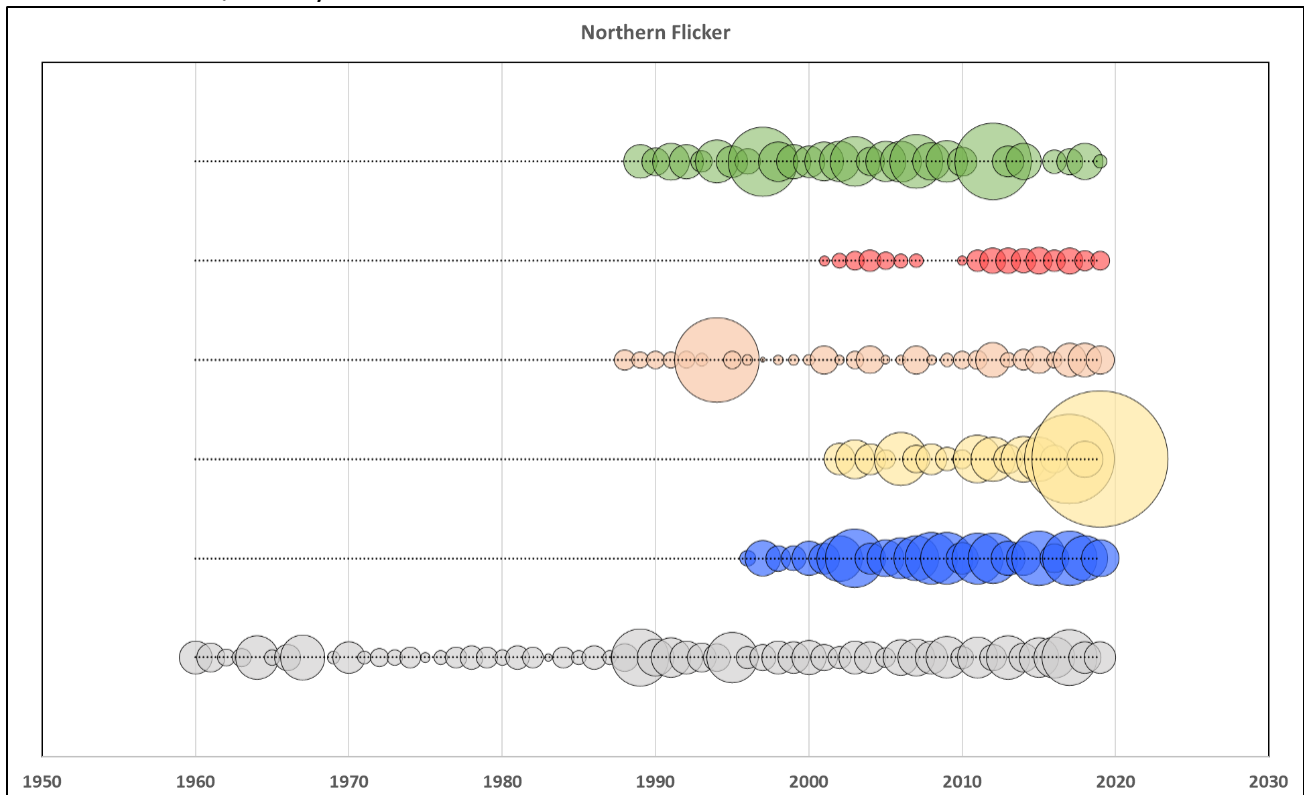


Northern Flicker

Number of birds counted

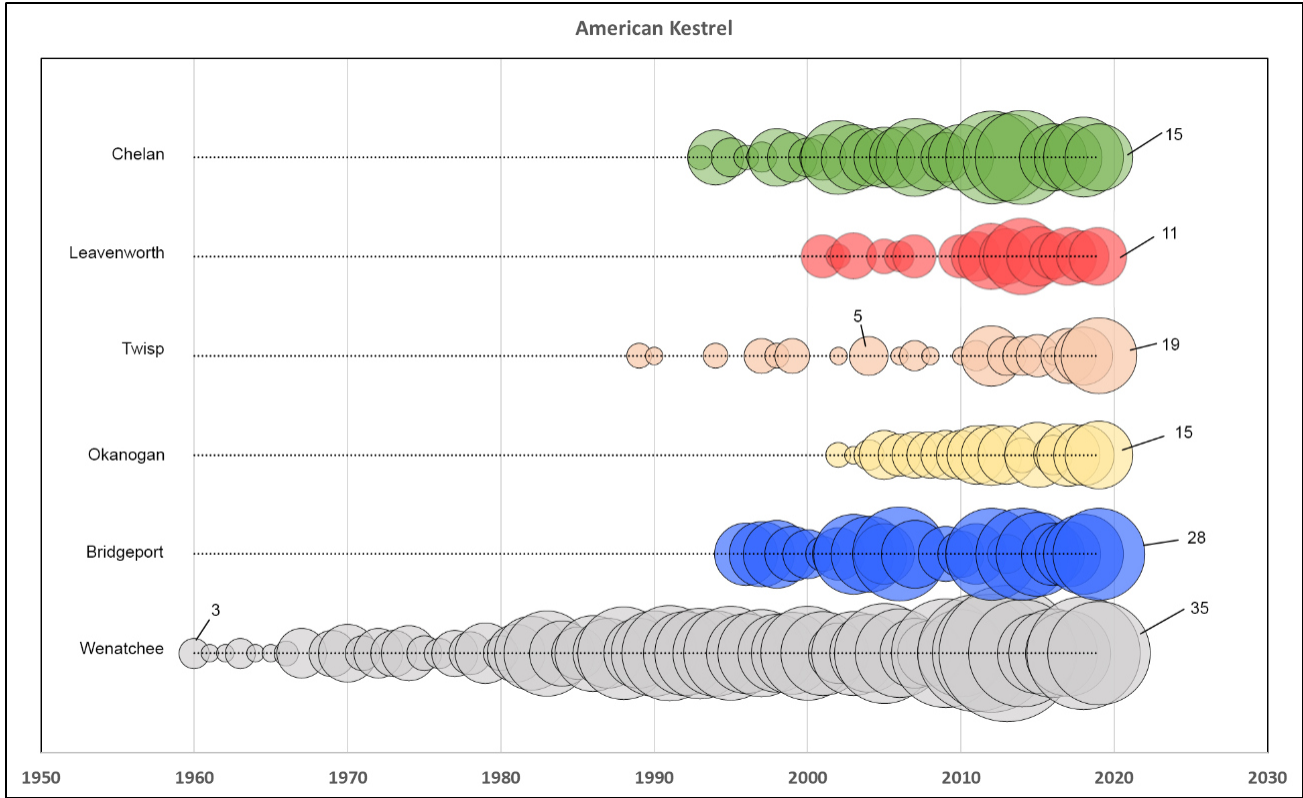


Number of birds / survey hour

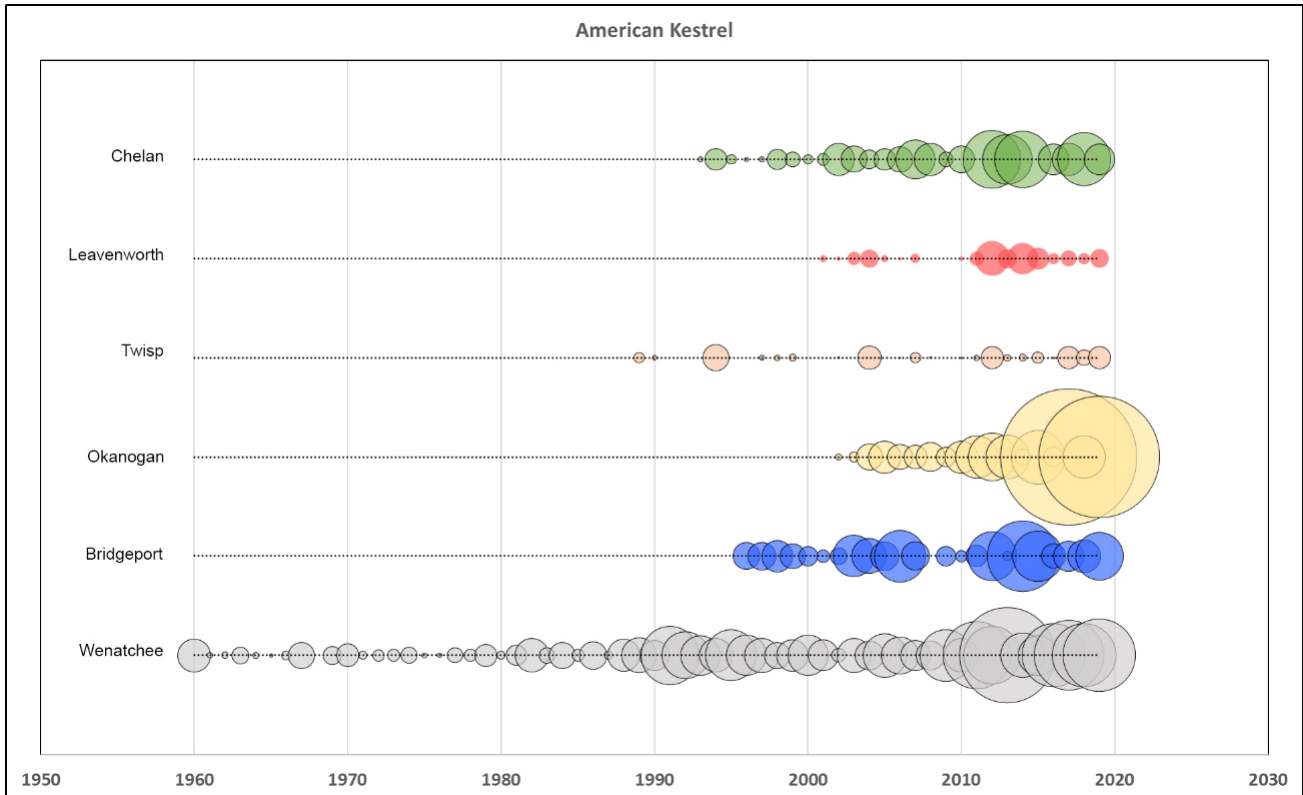


American Kestrel

Number of birds counted

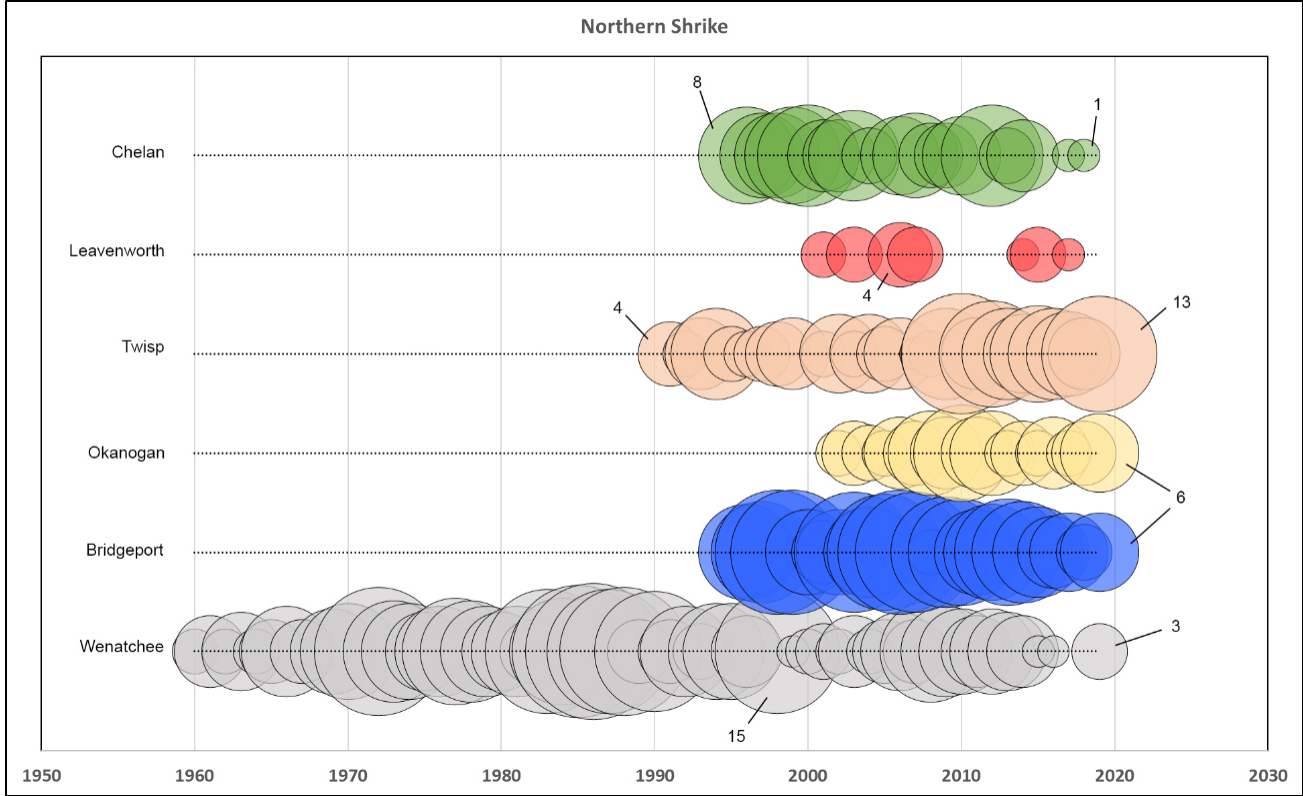


Number of birds / survey hour

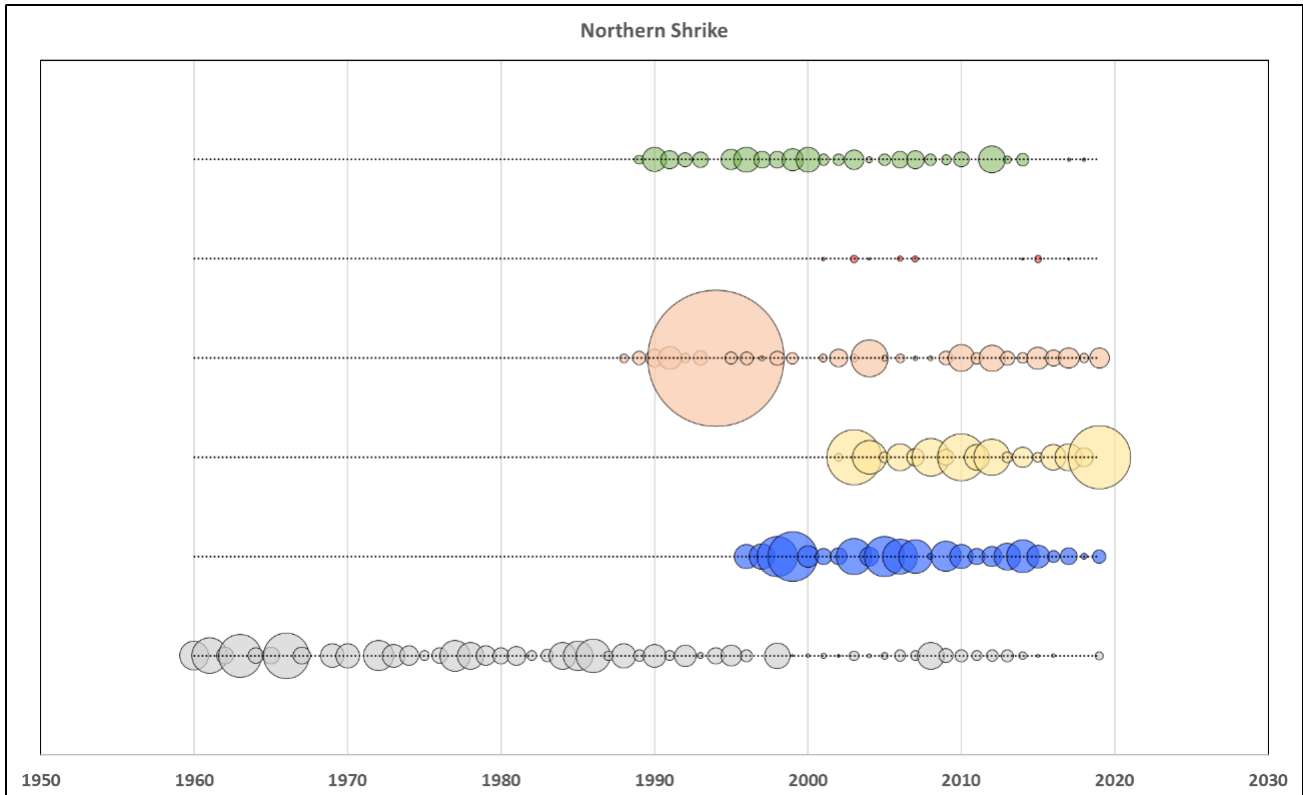


Northern Shrike

Number of birds counted

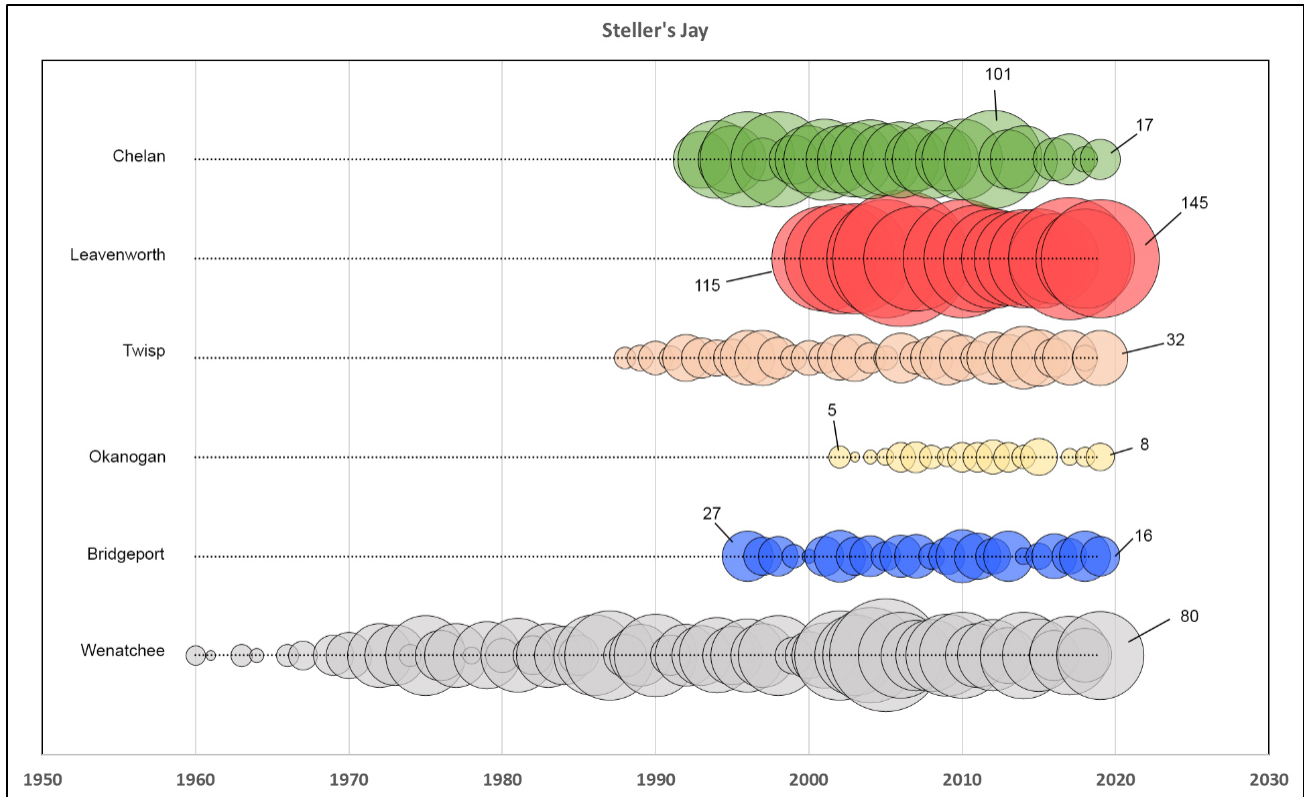


Number of birds / survey hour

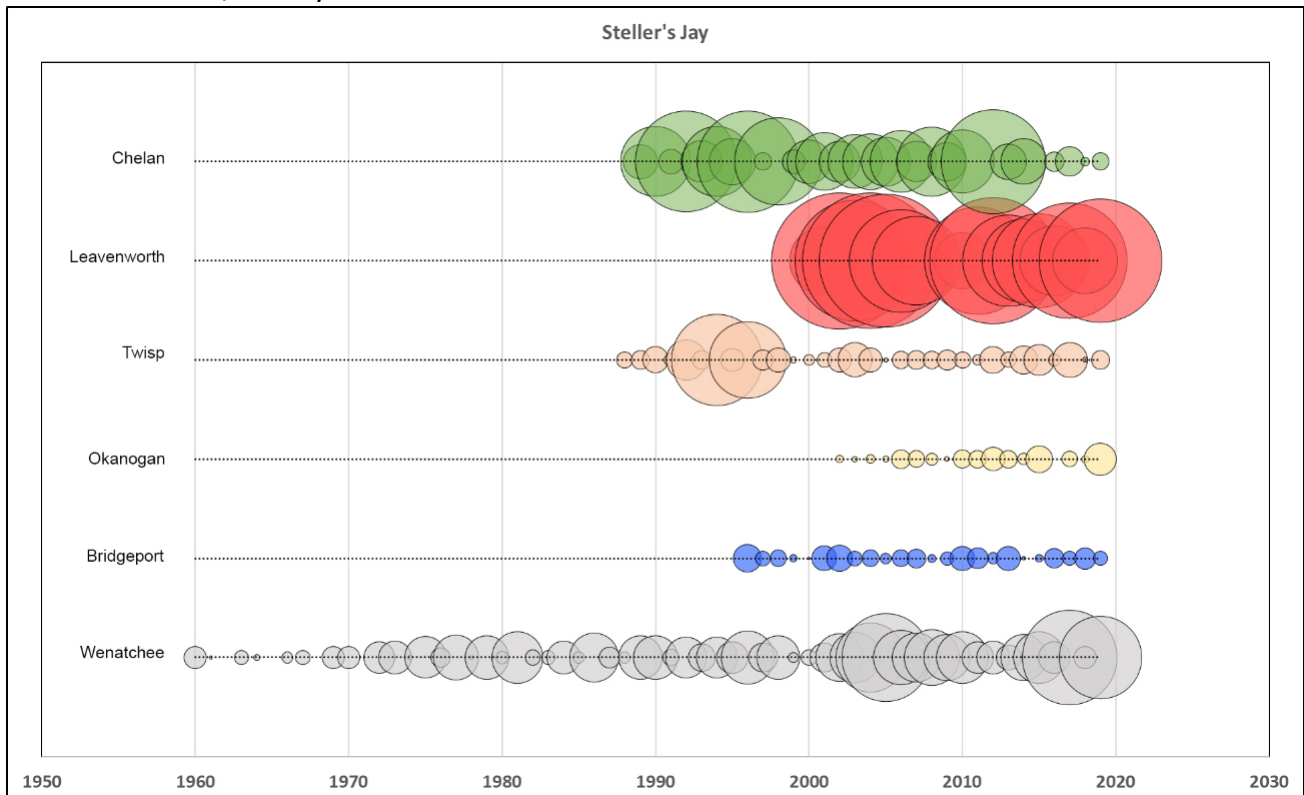


Steller's Jay

Number of birds counted

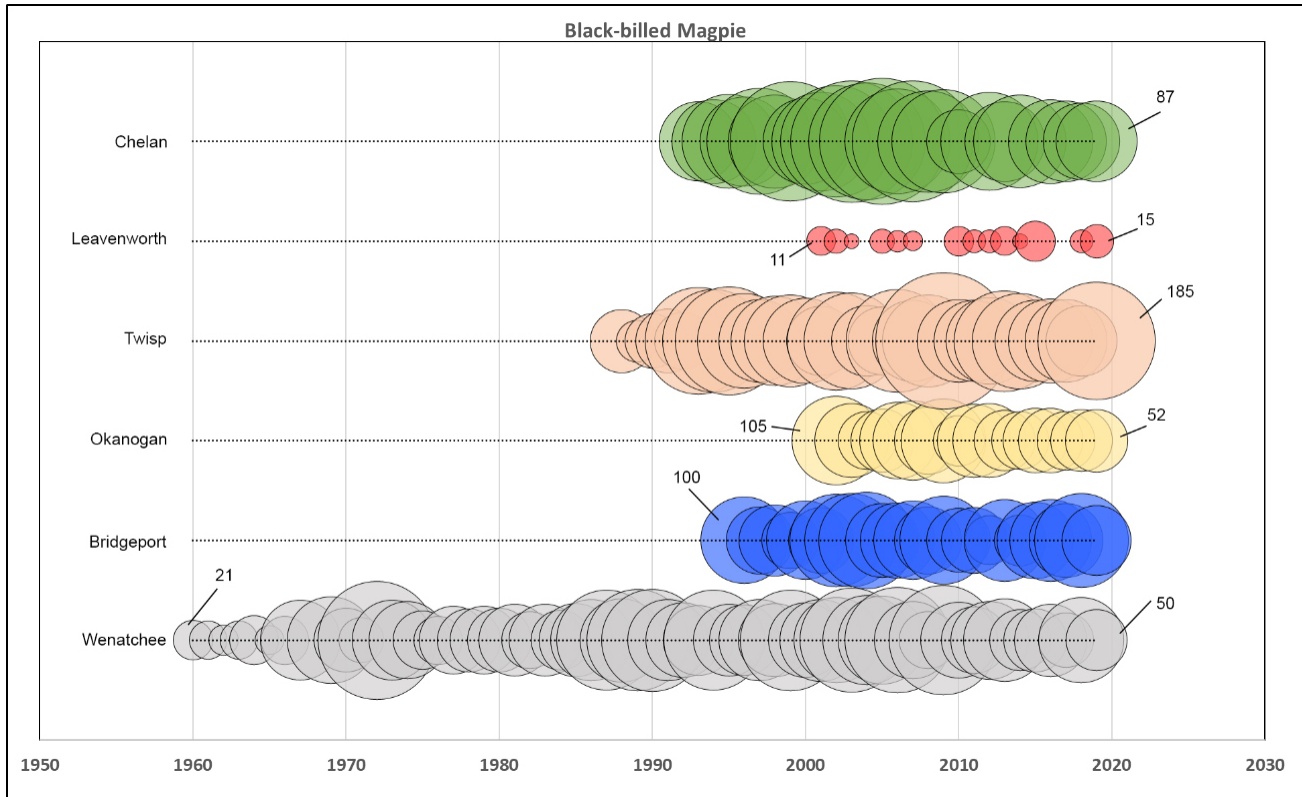


Number of birds / survey hour

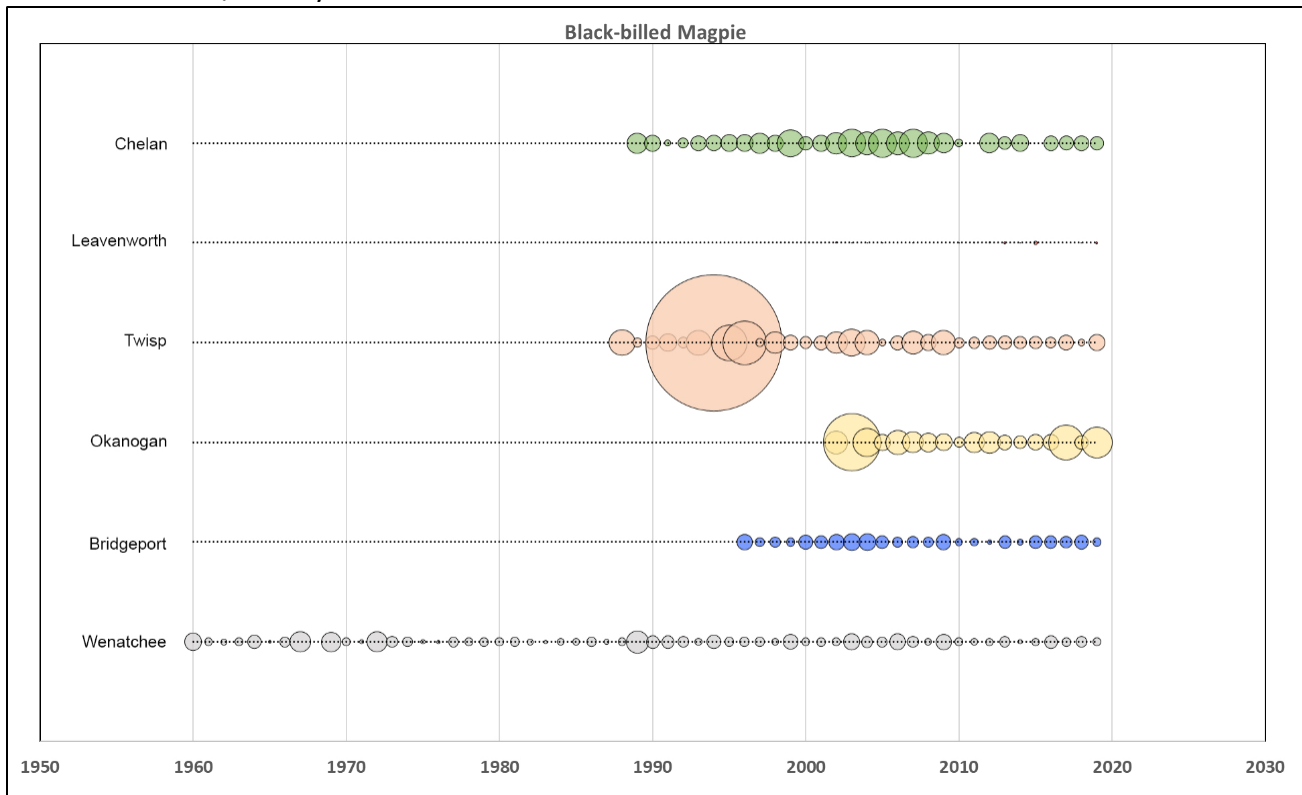


Black-billed Magpie

Number of birds counted

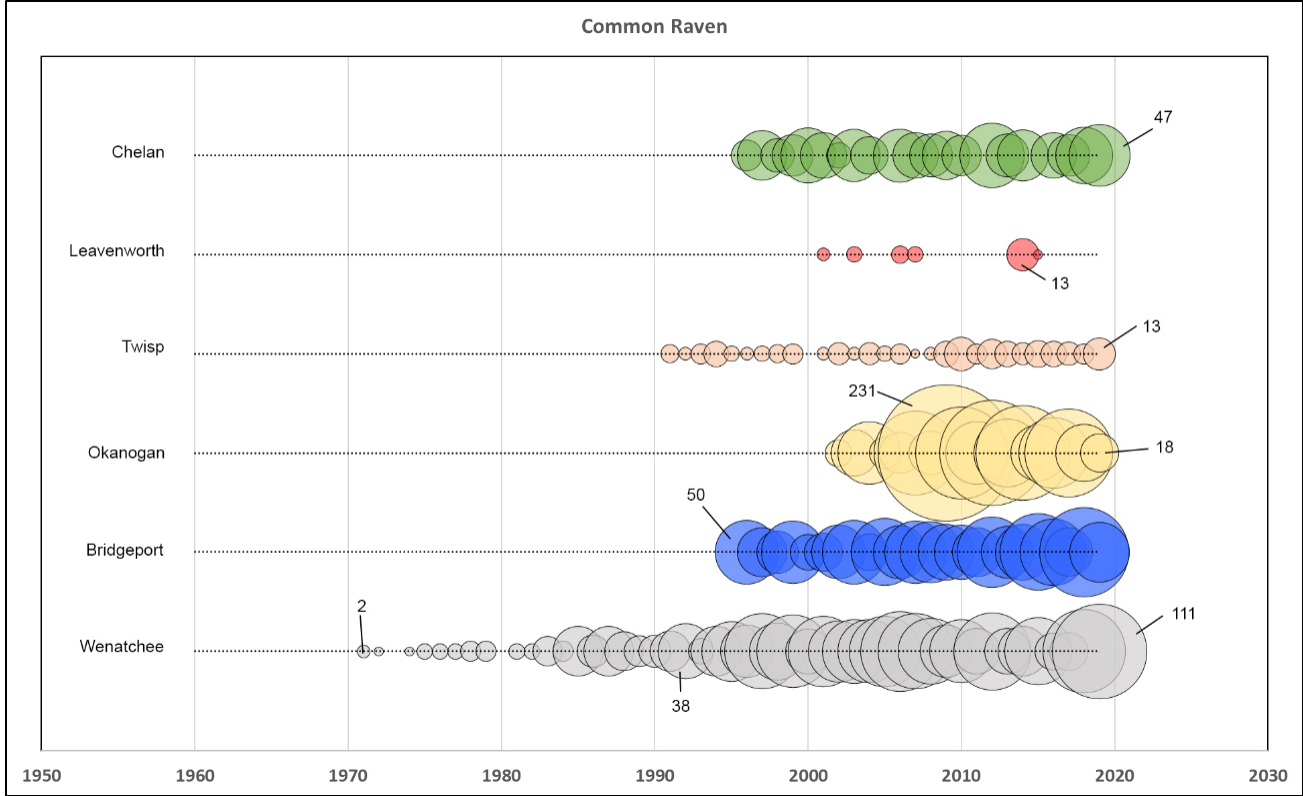


Number of birds / survey hour

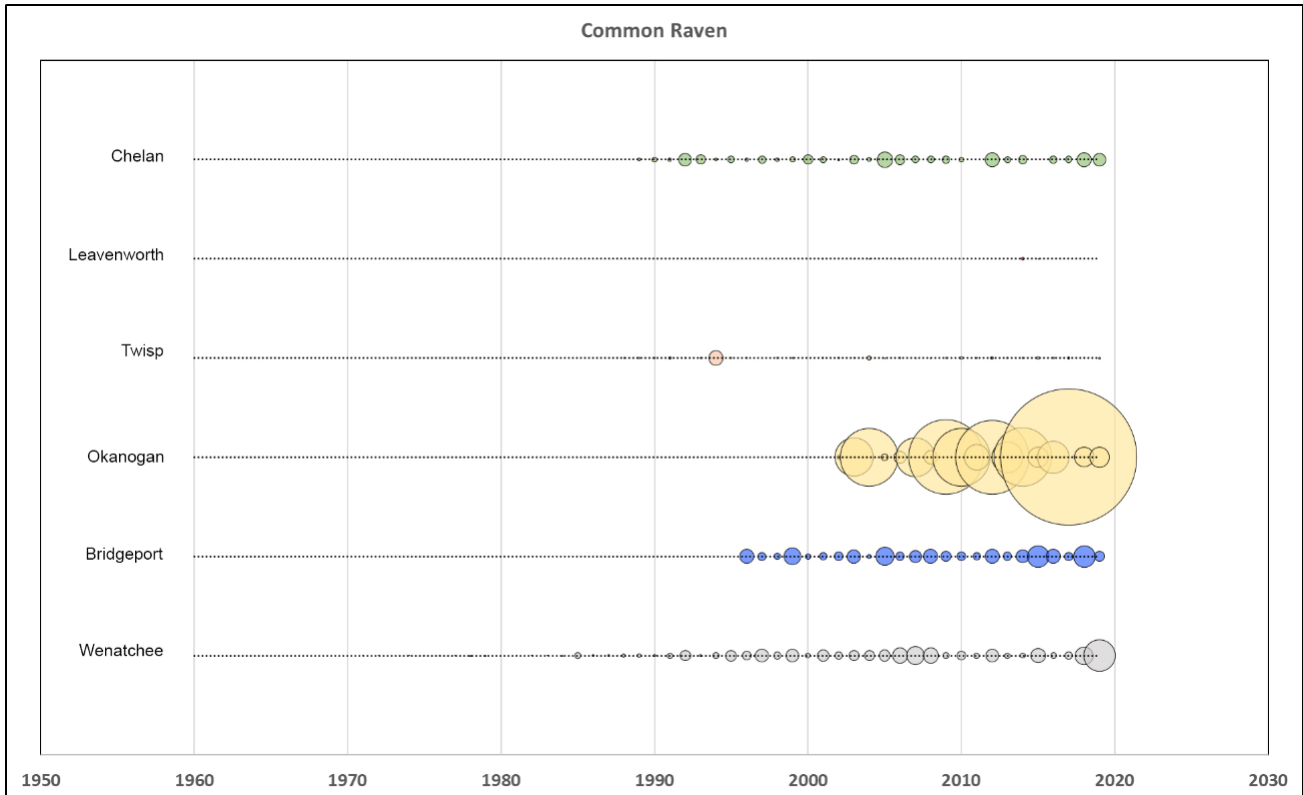


Common Raven

Number of birds counted

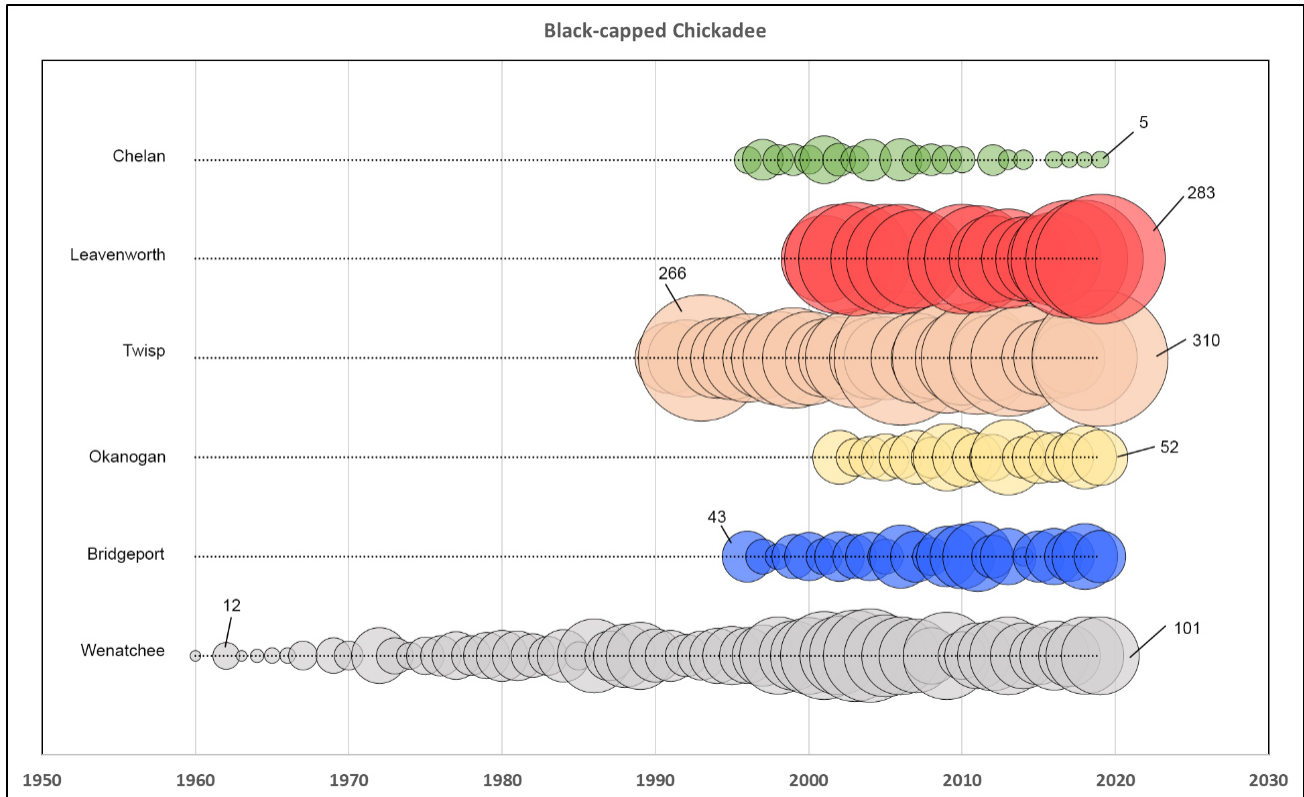


Number of birds / survey hour

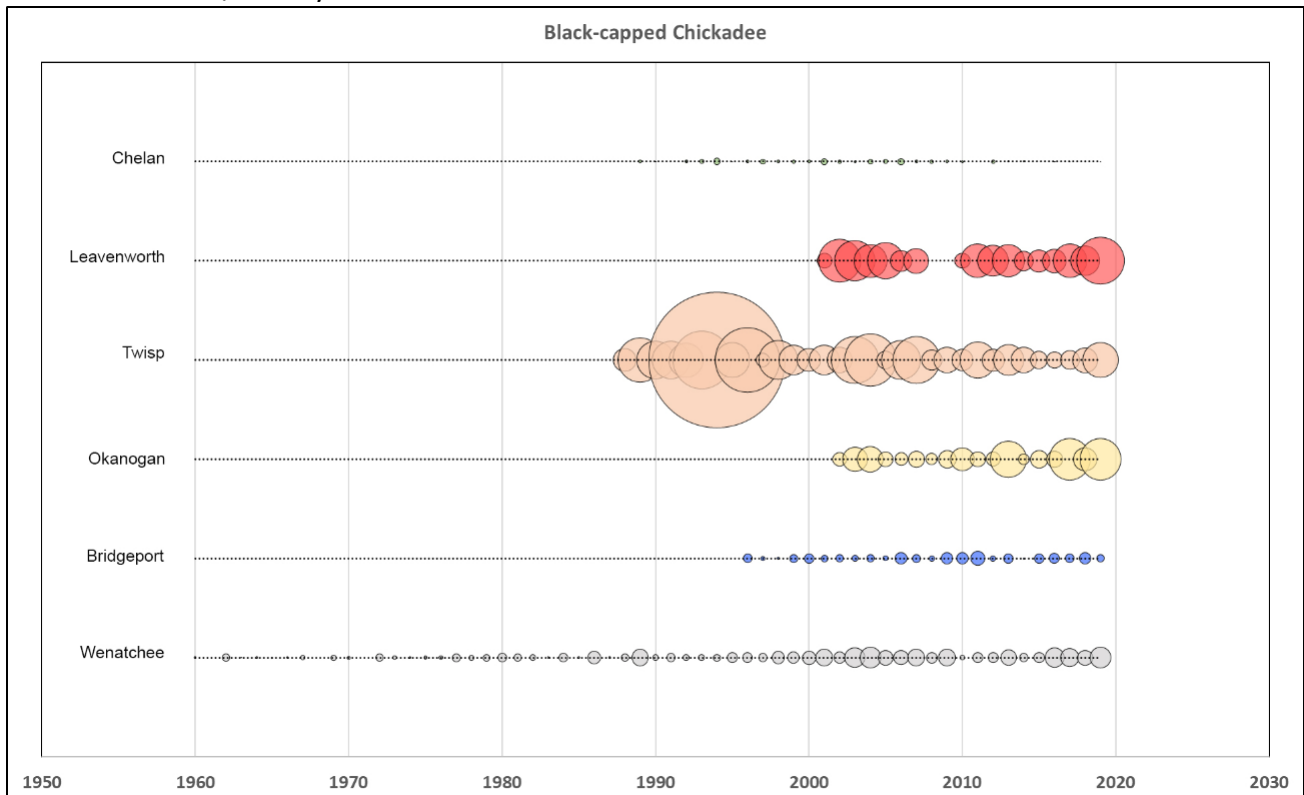


Black-capped Chickadee

Number of birds counted

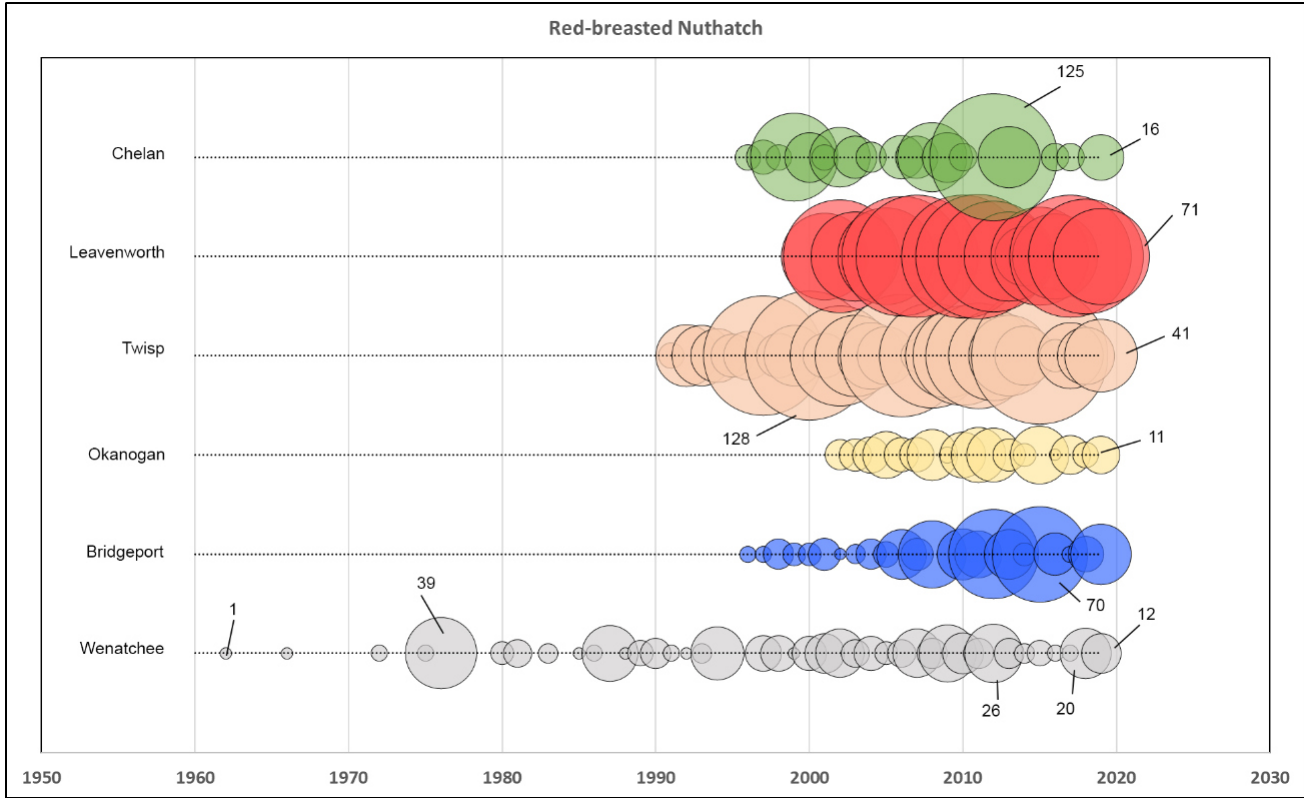


Number of birds / survey hour

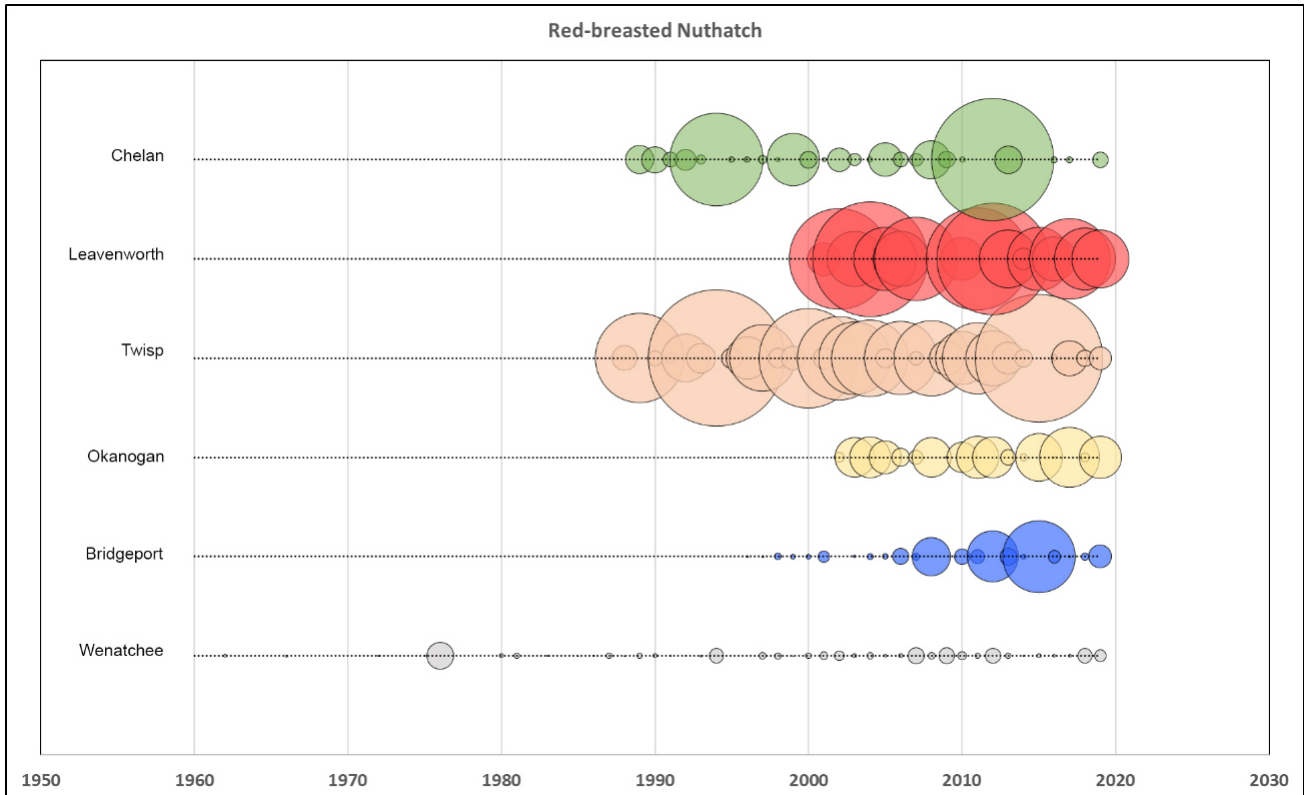


Red-breasted Nuthatch

Number of birds counted

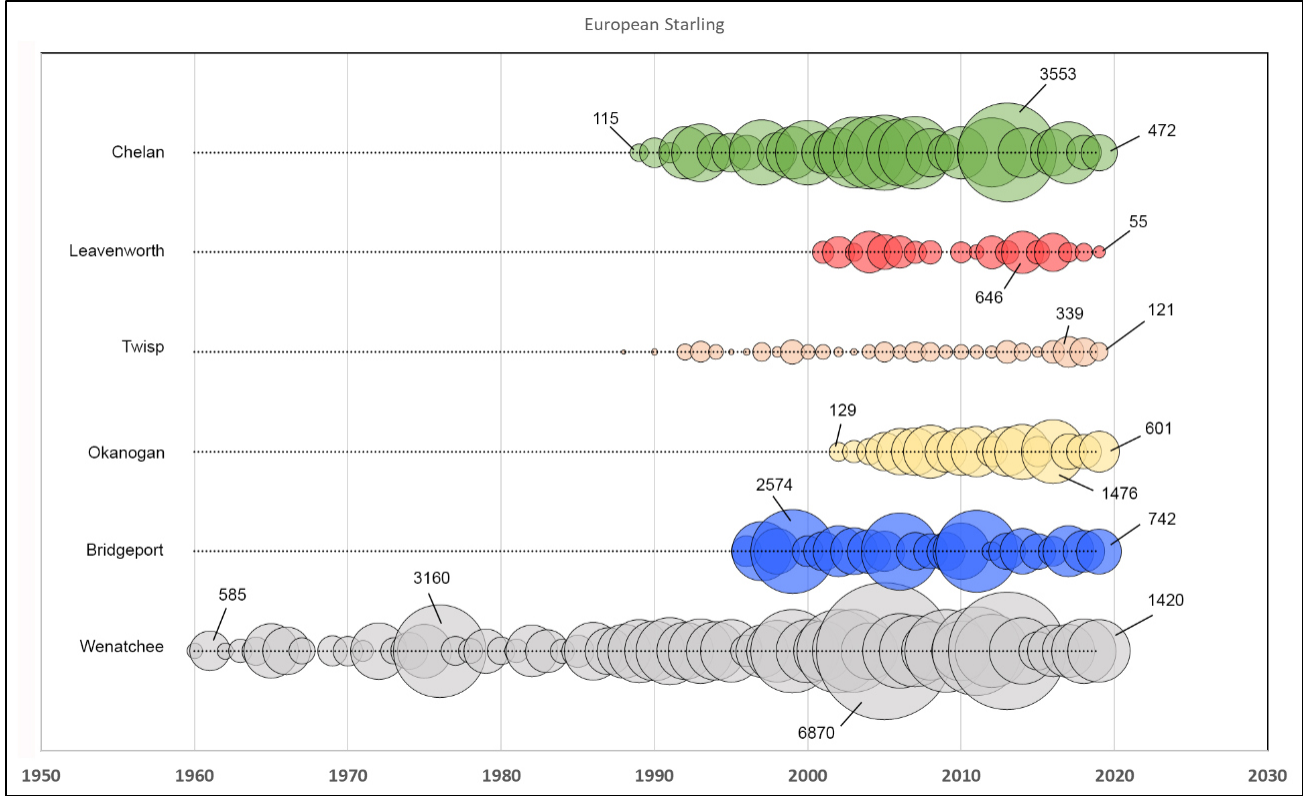


Number of birds / survey hour

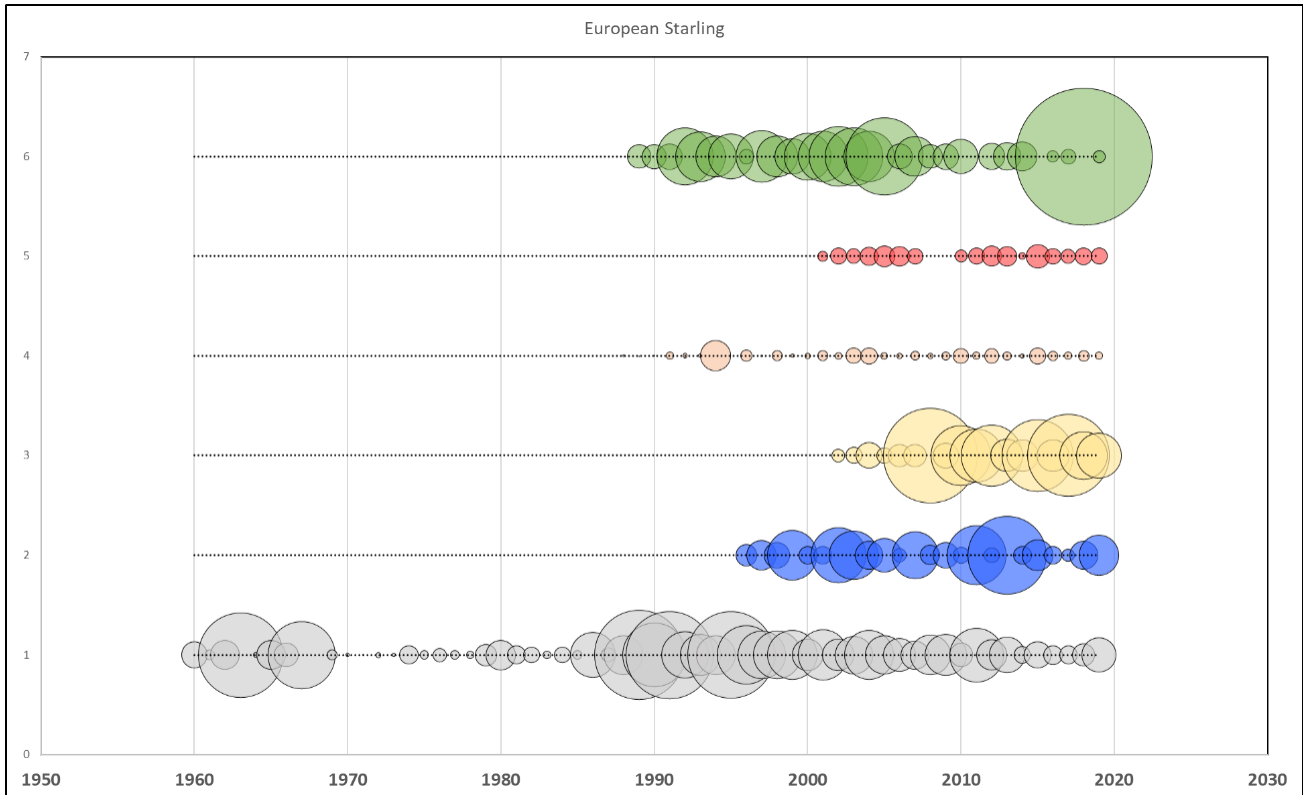


European Starling

Number of birds counted

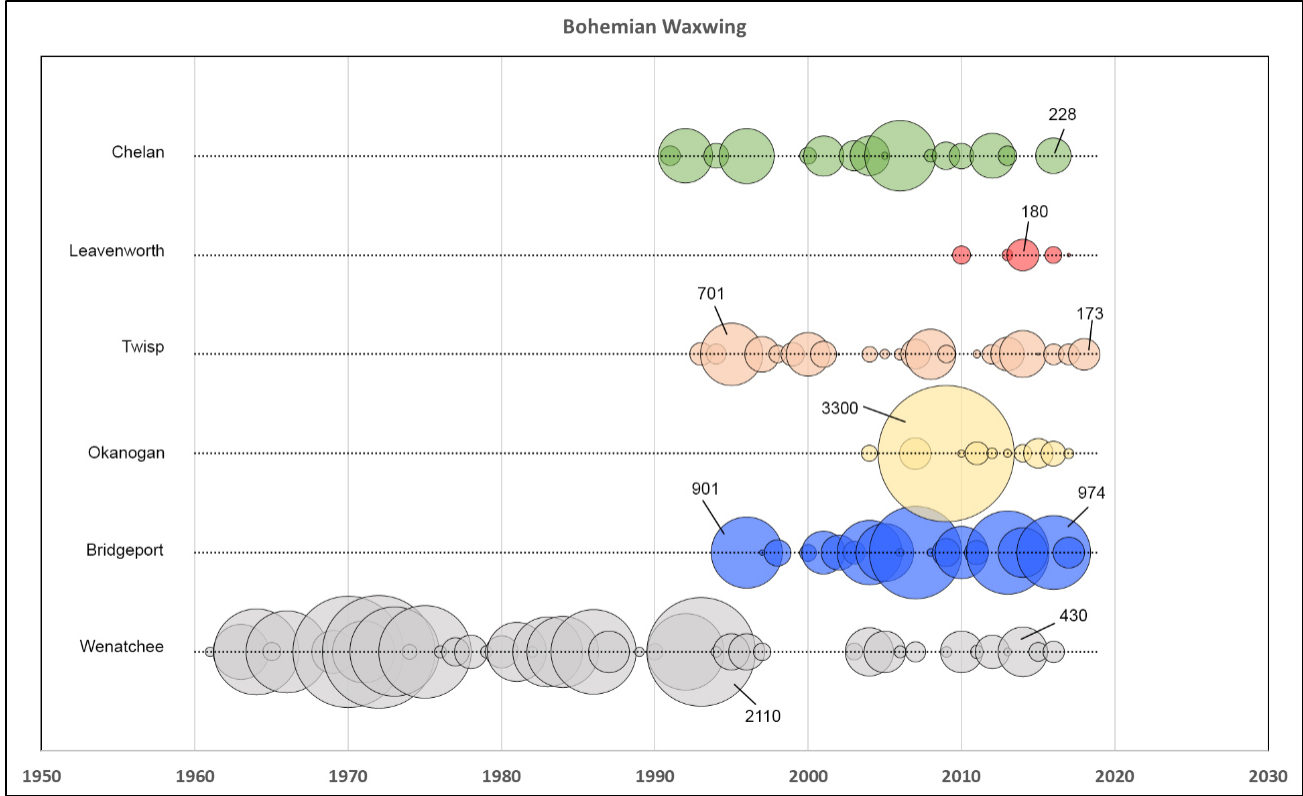


Number of birds / survey hour

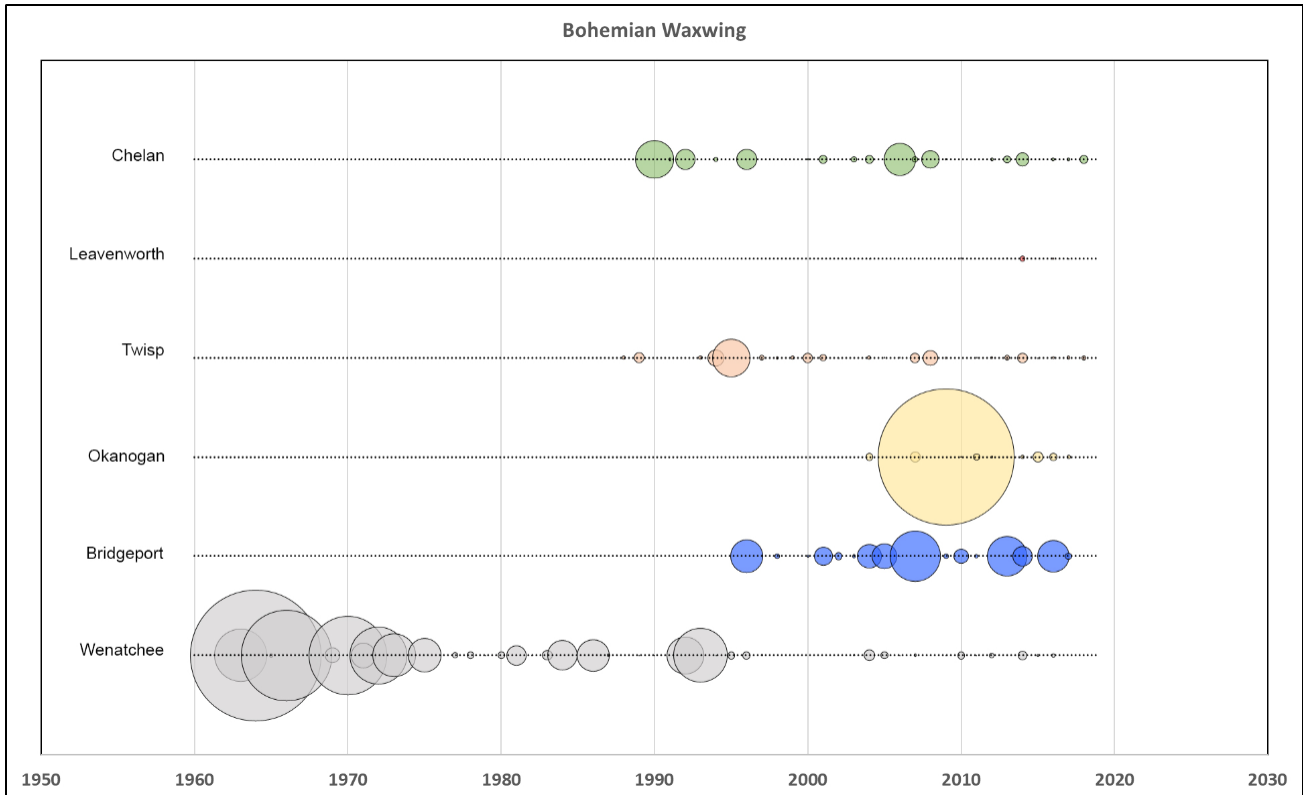


Bohemian Waxwing

Number of birds counted

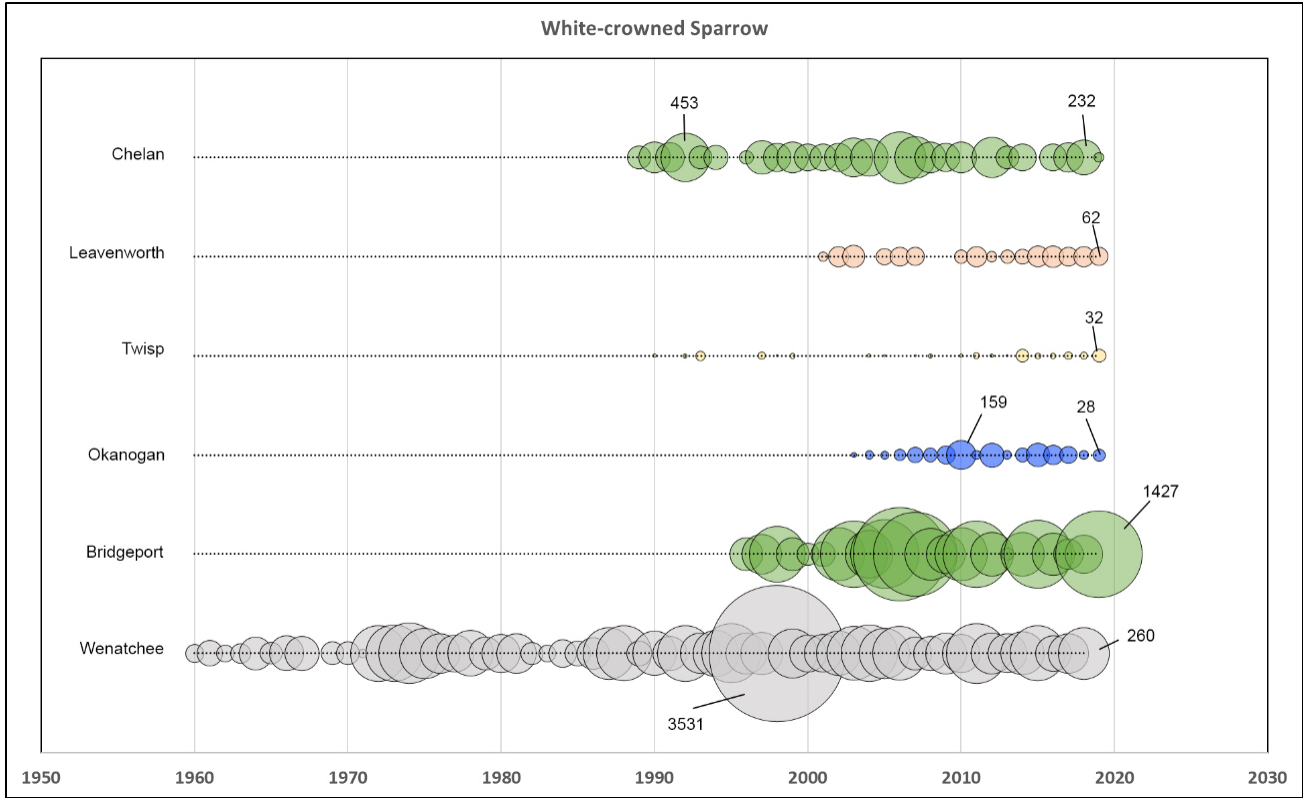


Number of birds / survey hour

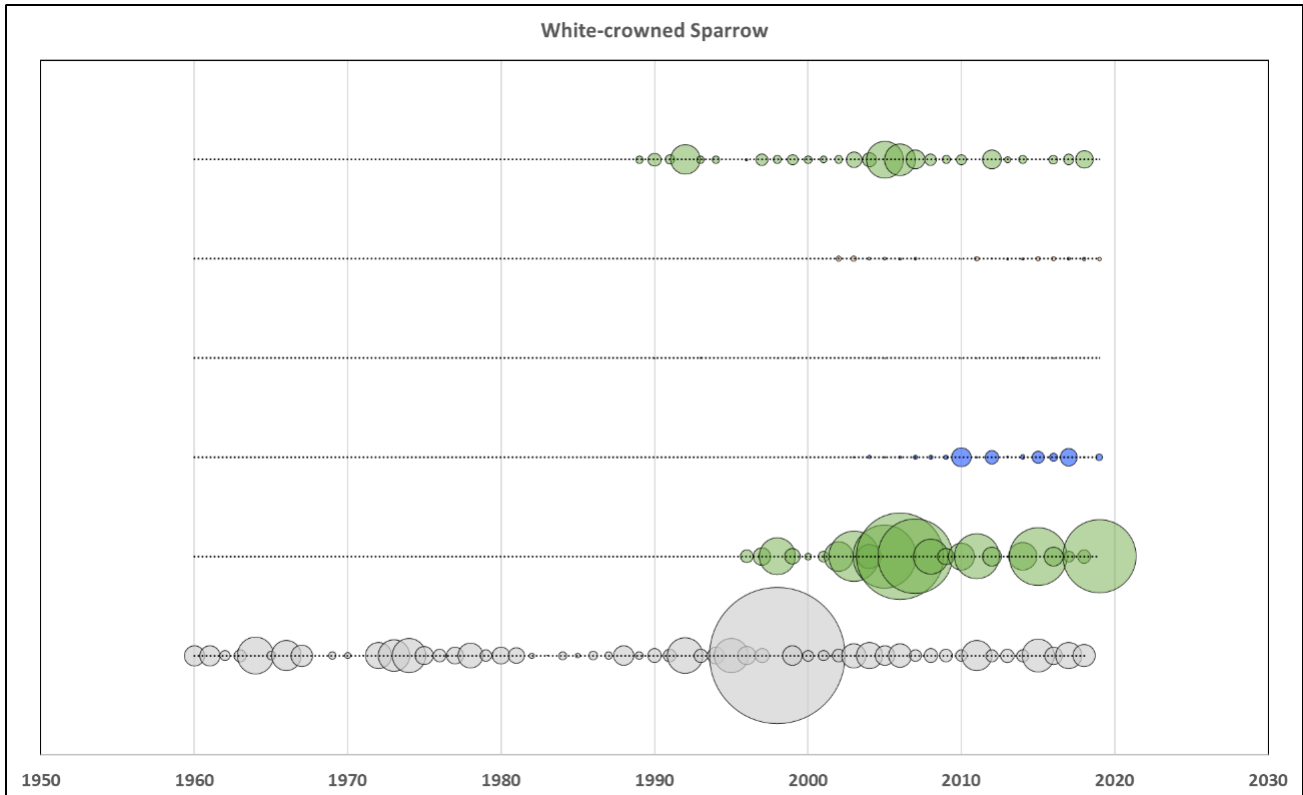


White-crowned Sparrow

Number of birds counted

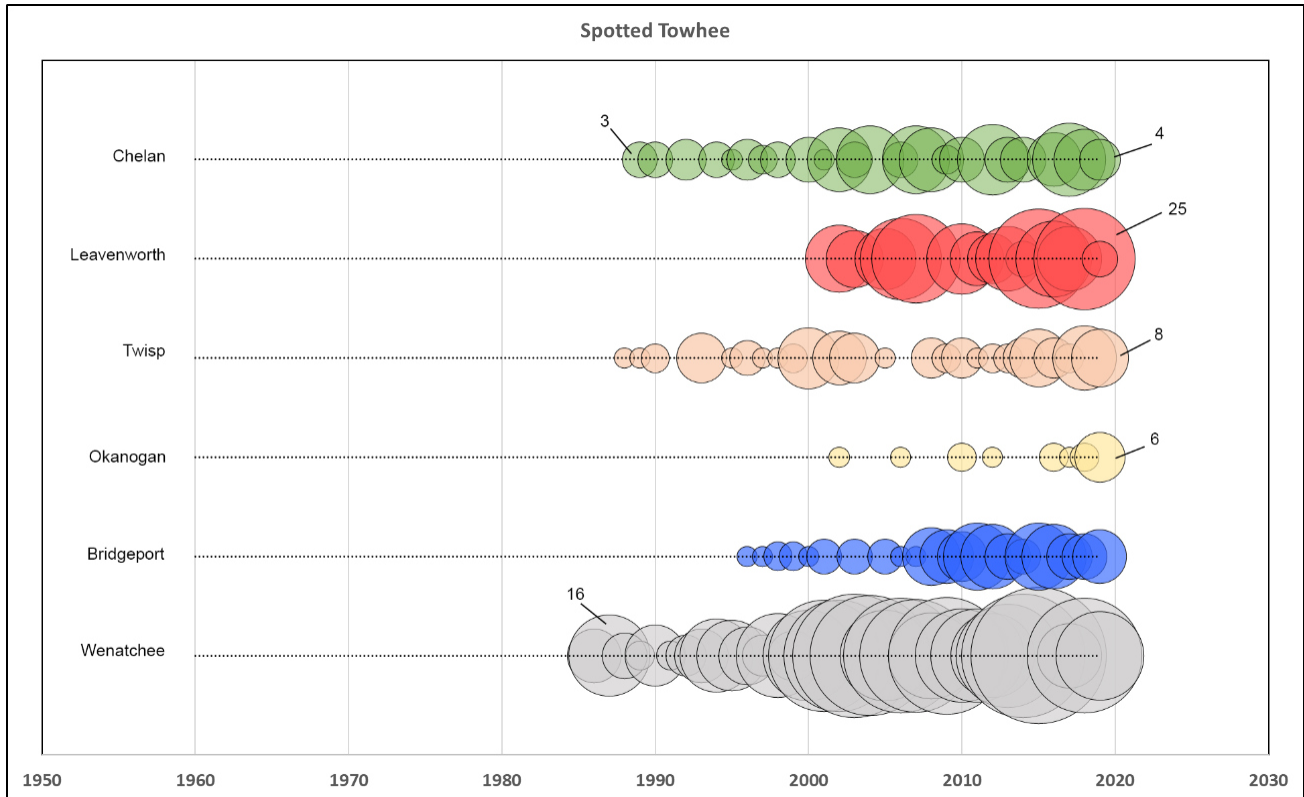


Number of birds / survey hour

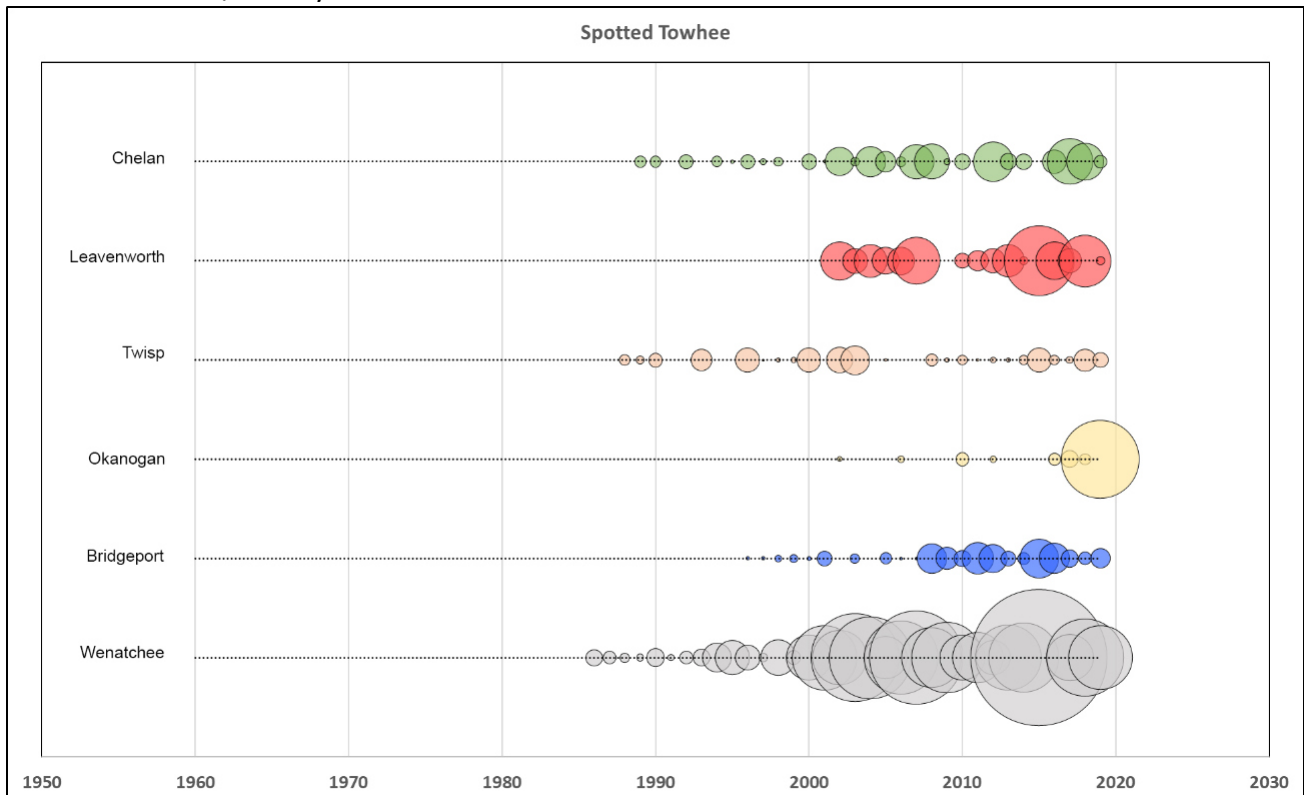


Spotted Towhee

Number of birds counted

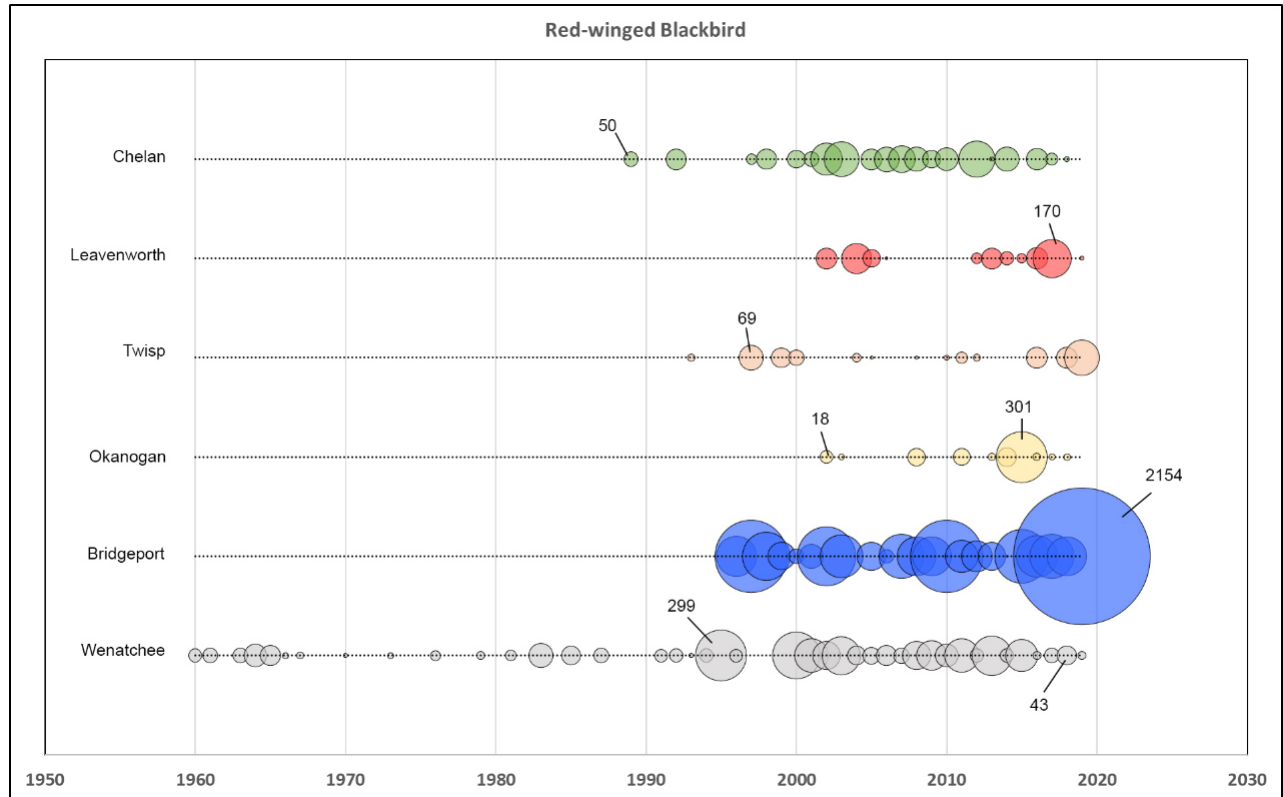


Number of birds / survey hour

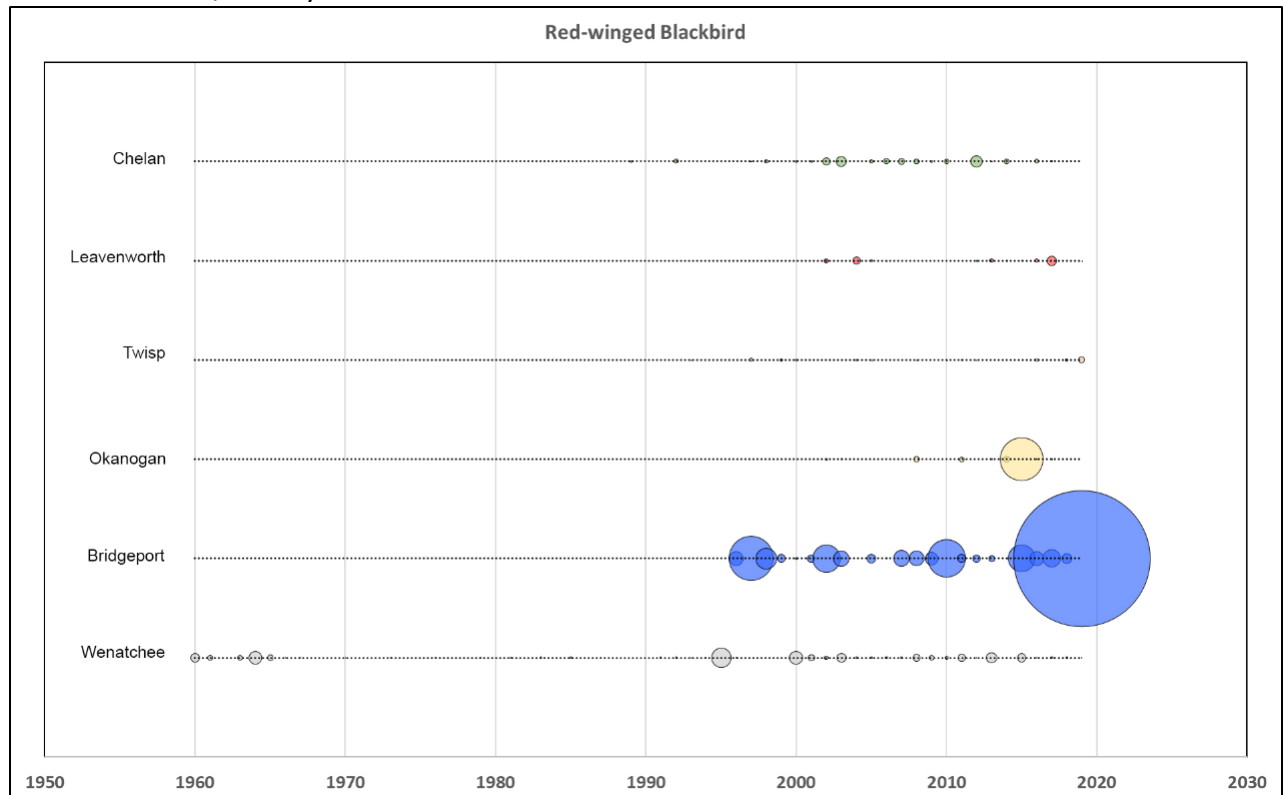


Red-winged Blackbird

Number of birds counted

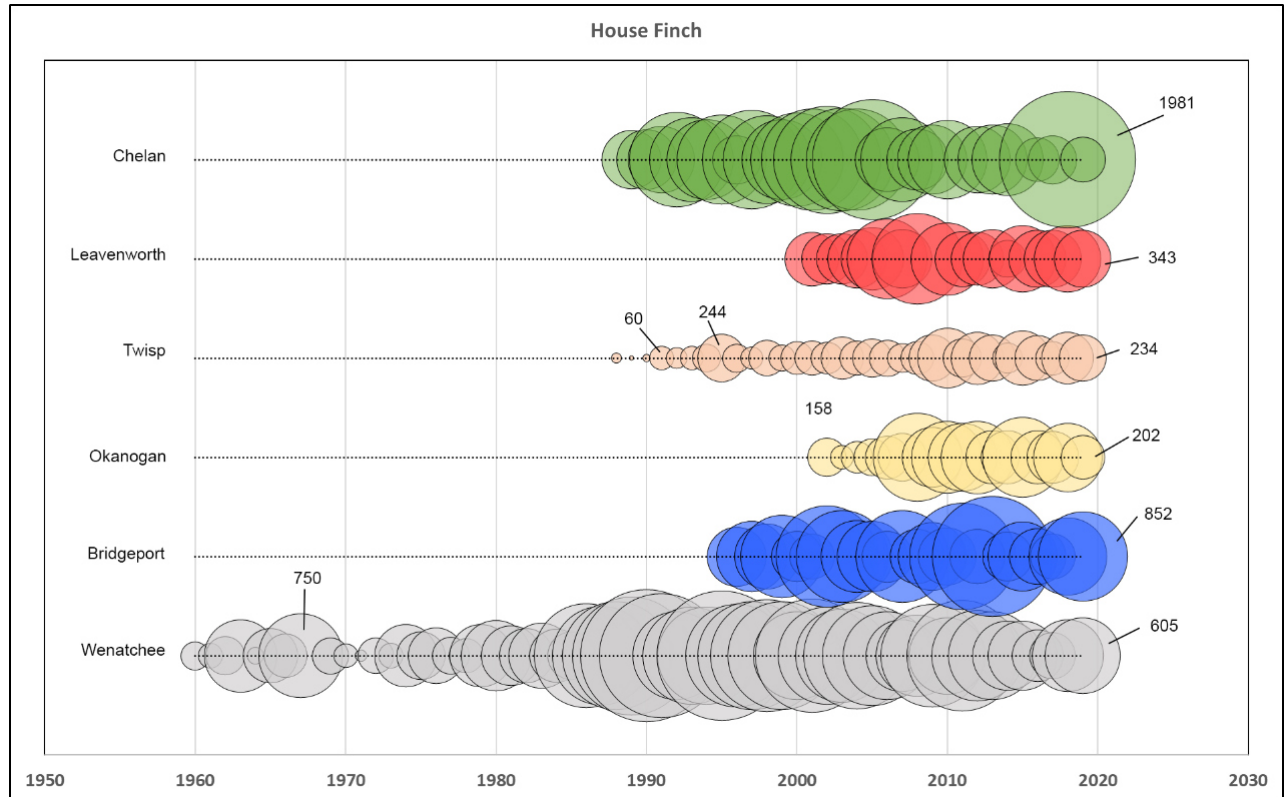


Number of birds / survey hour

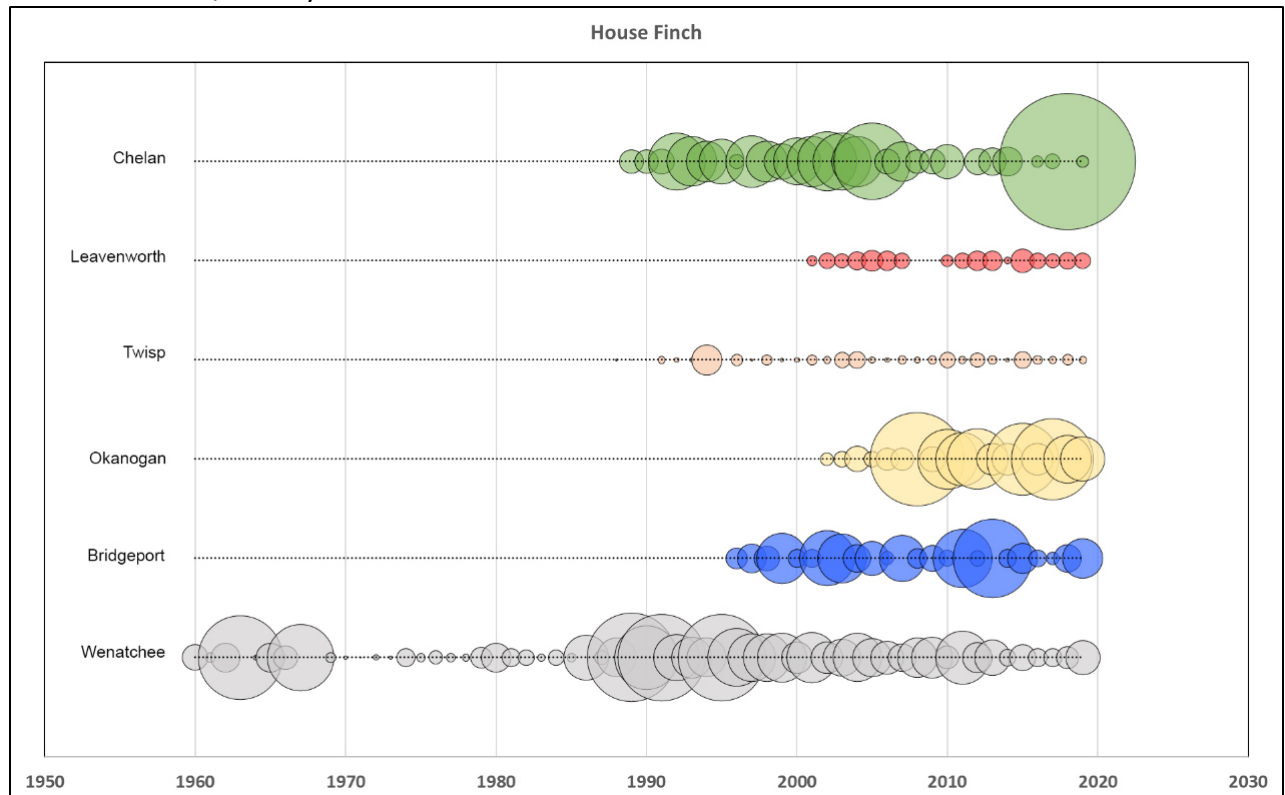


House Finch

Number of birds counted



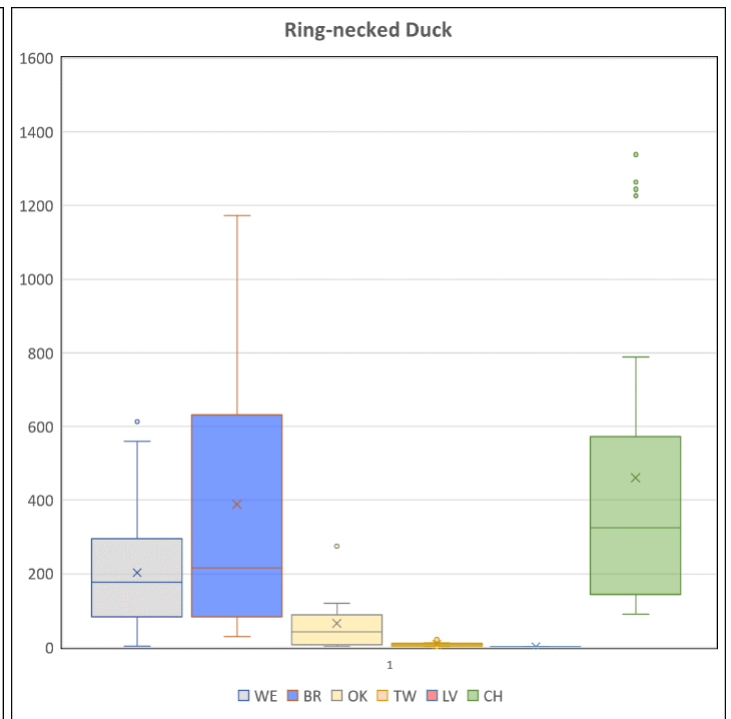
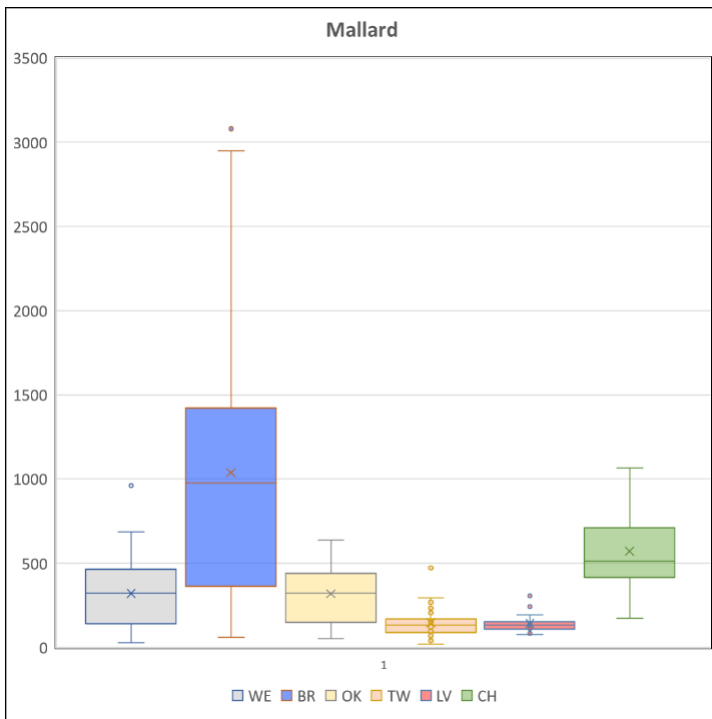
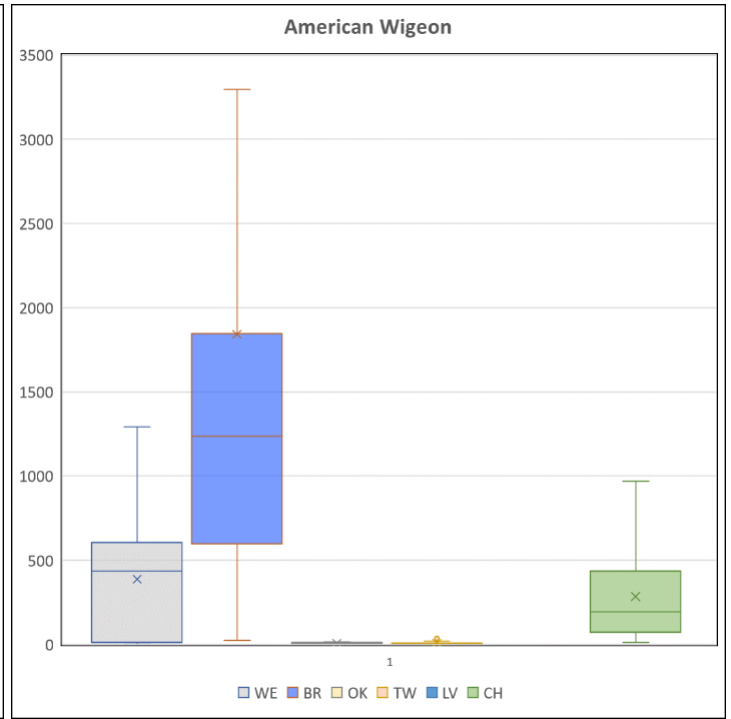
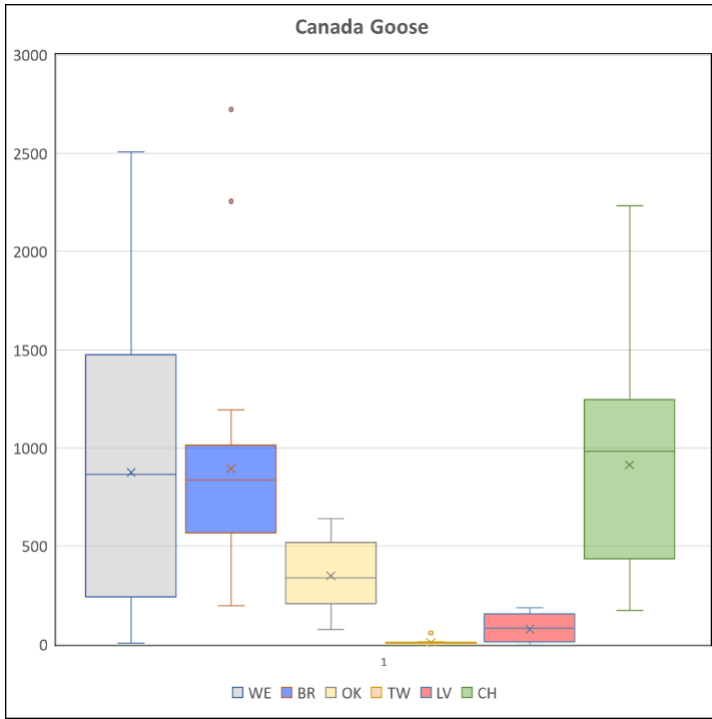
Number of birds / survey hour



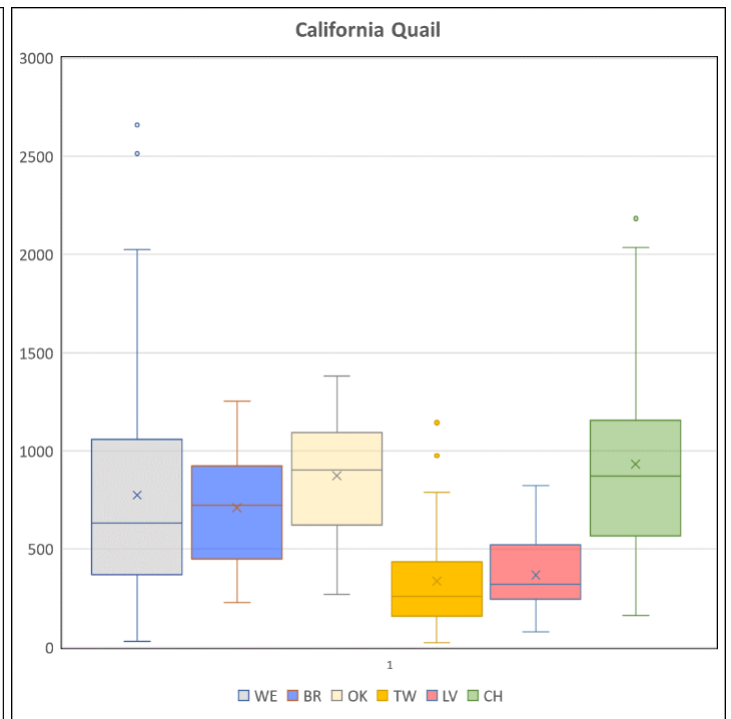
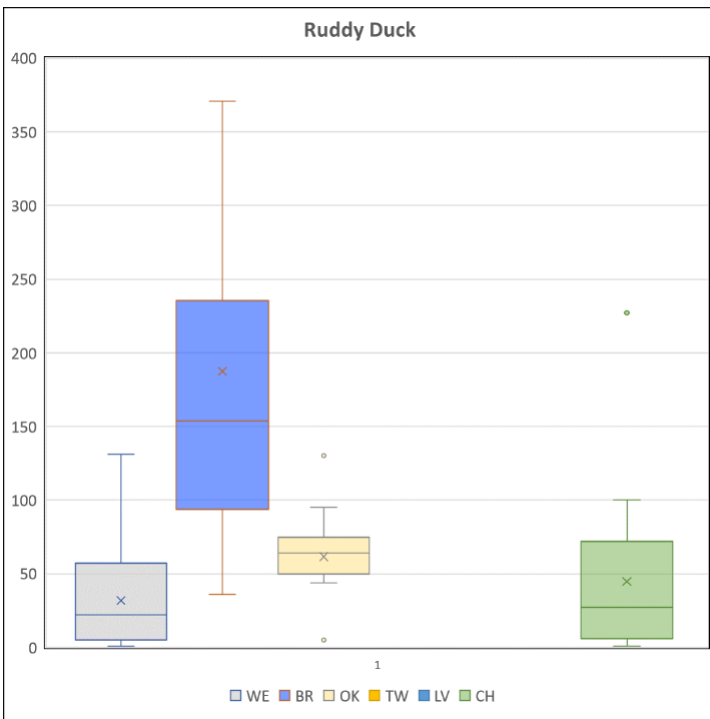
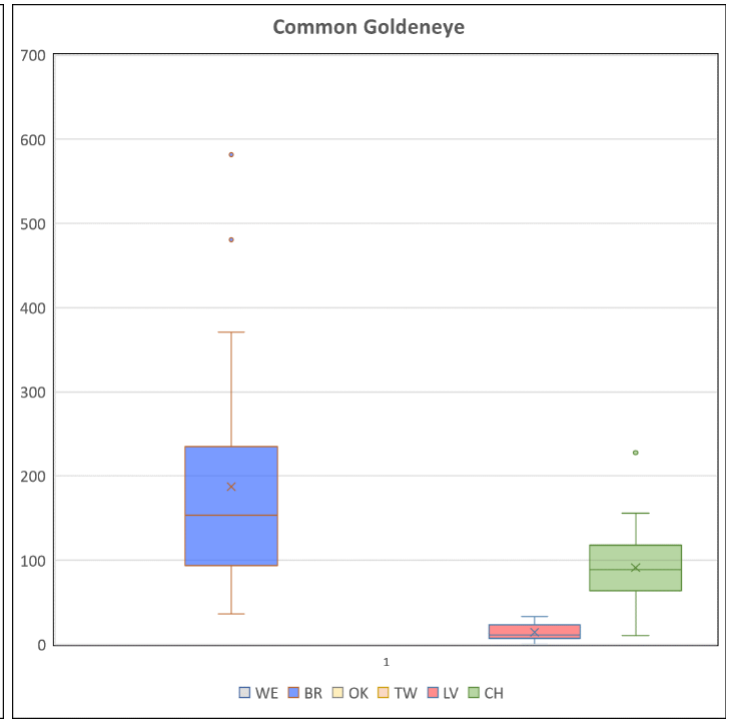
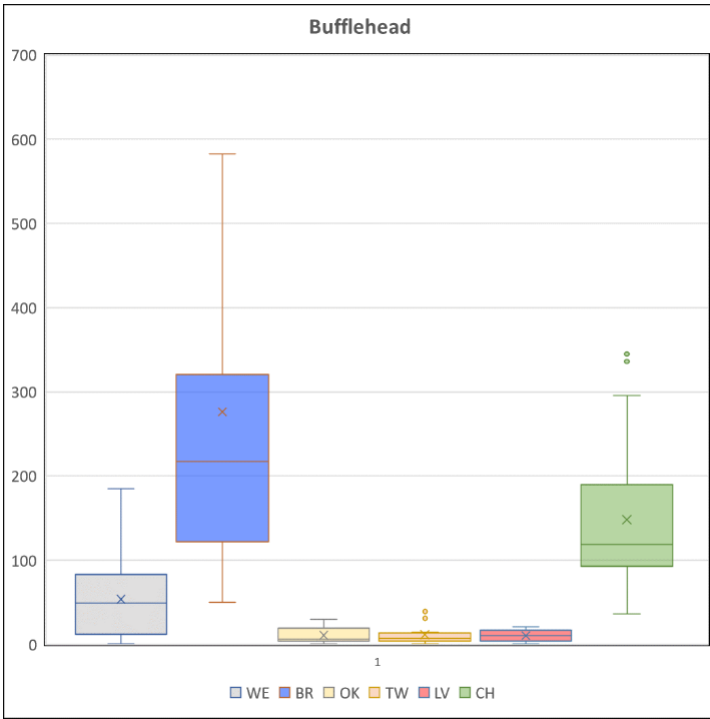
Section 3

Box-and-Whisker charts for 31
selected species

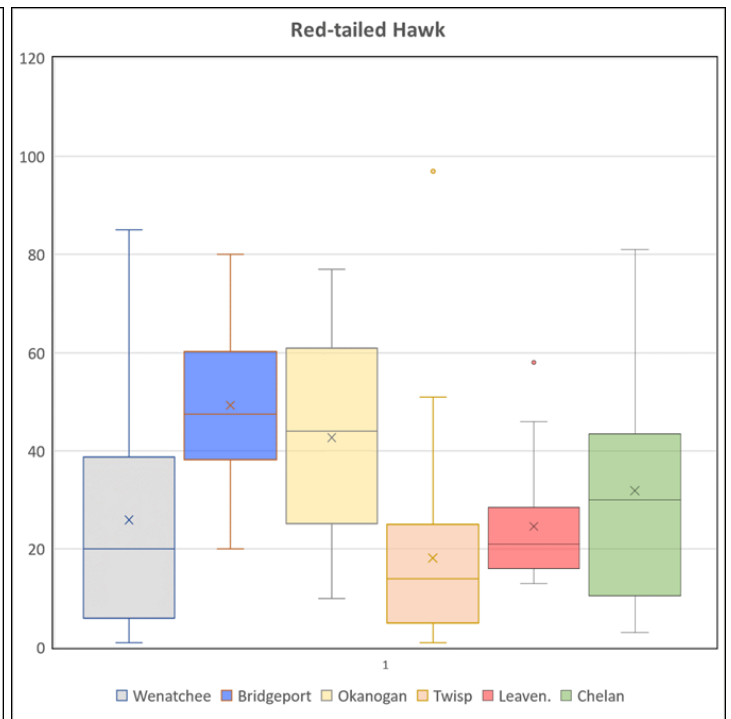
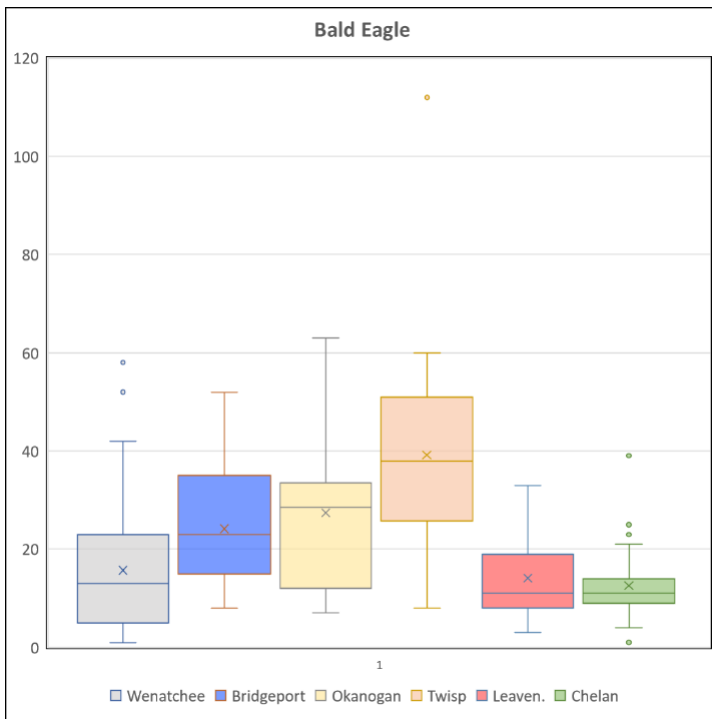
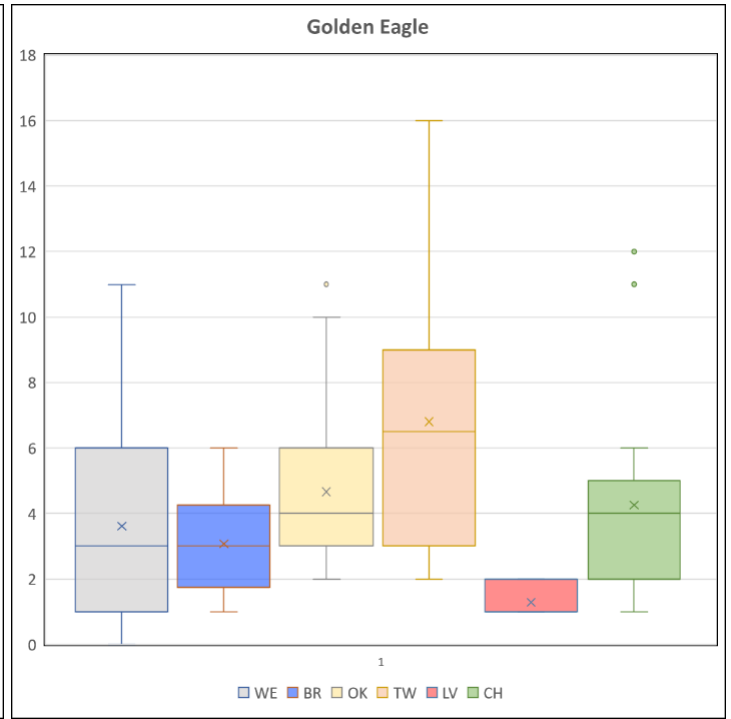
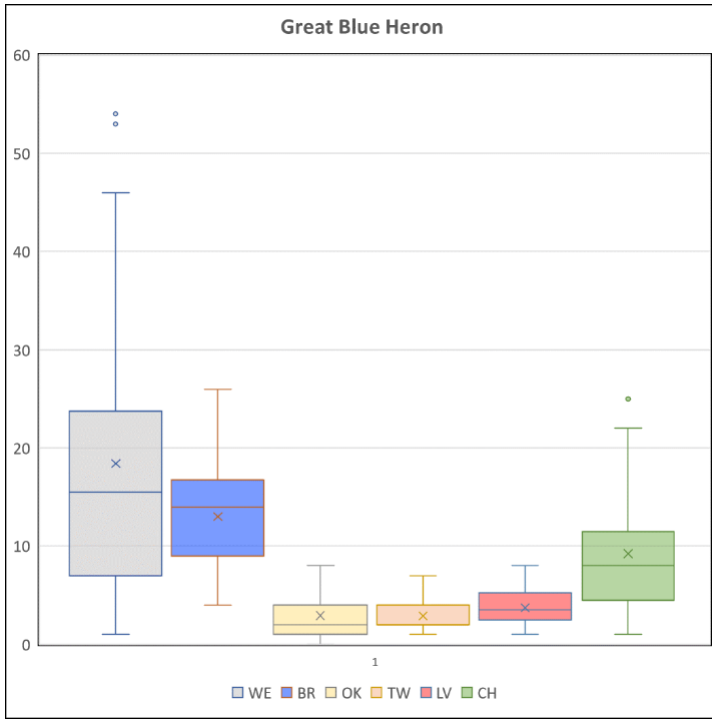
Species Statistics



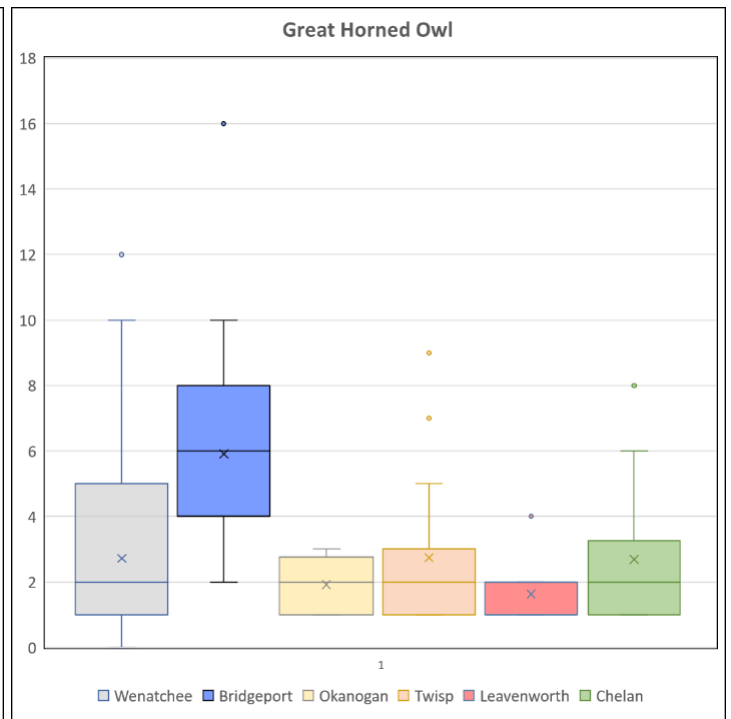
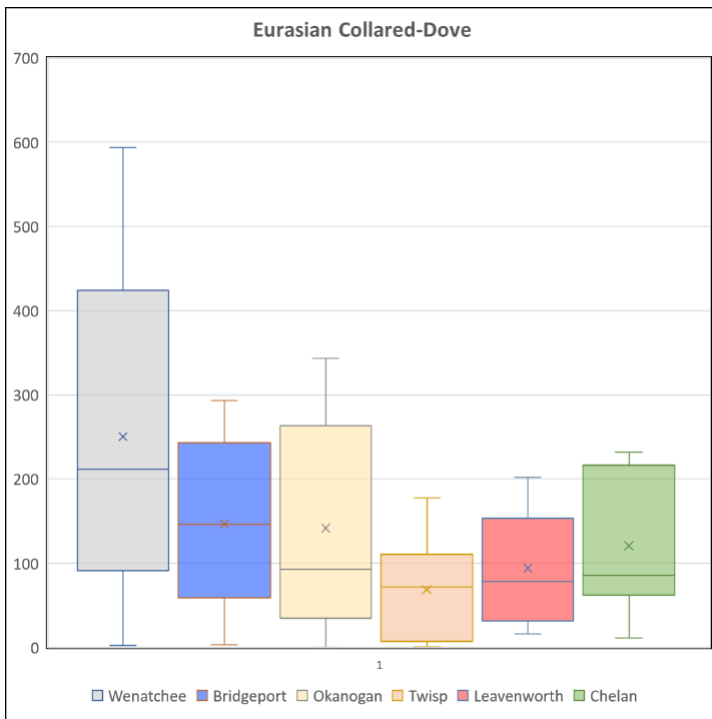
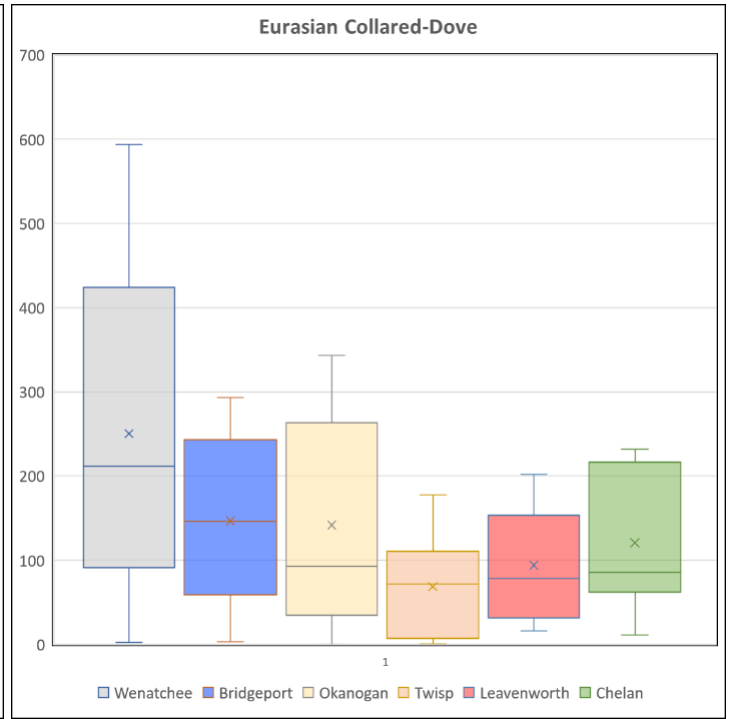
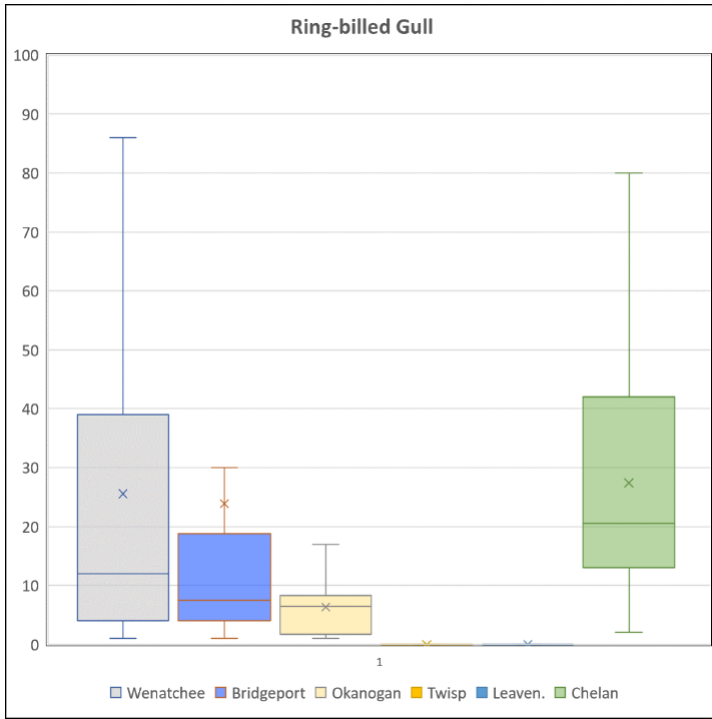
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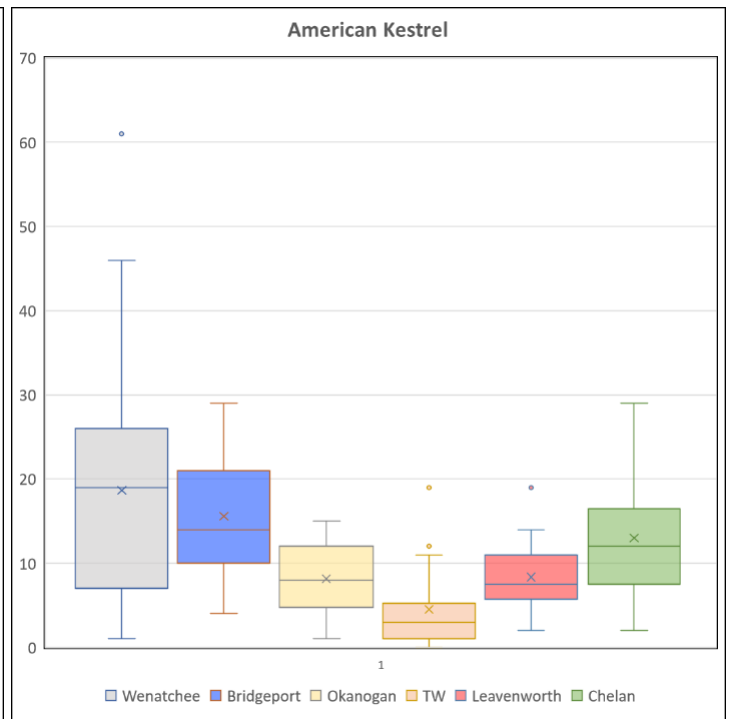
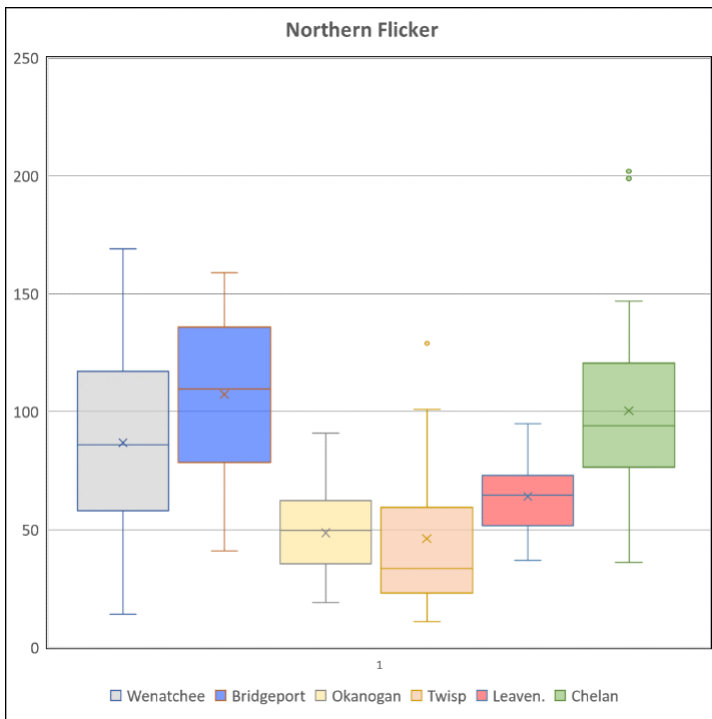
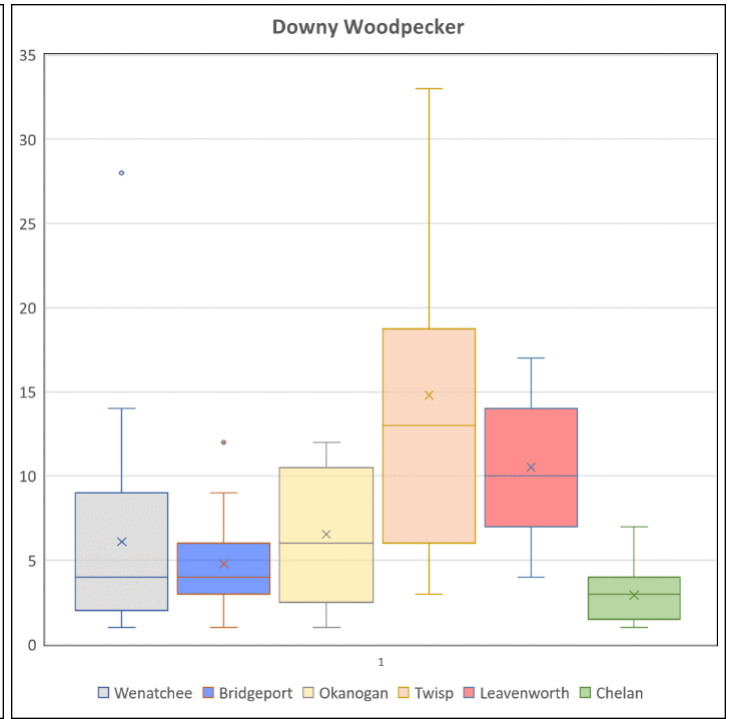
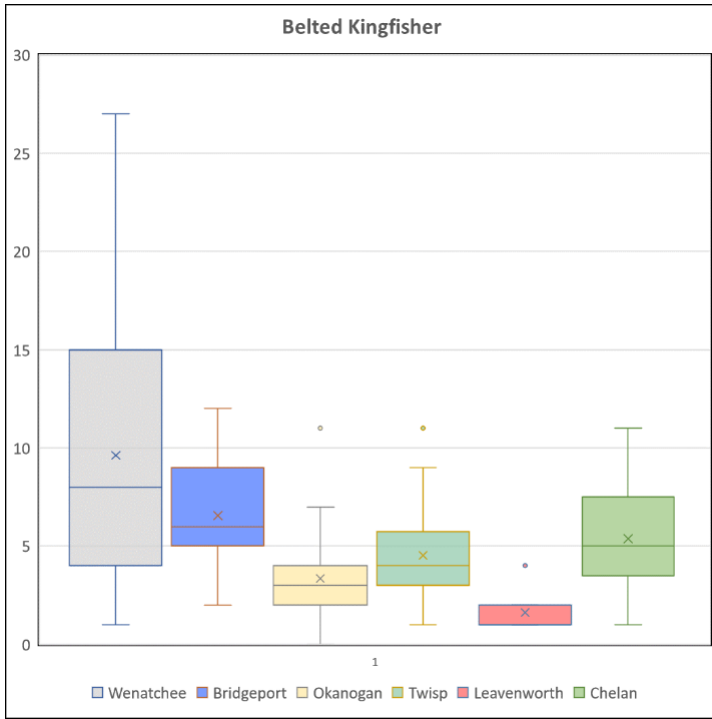
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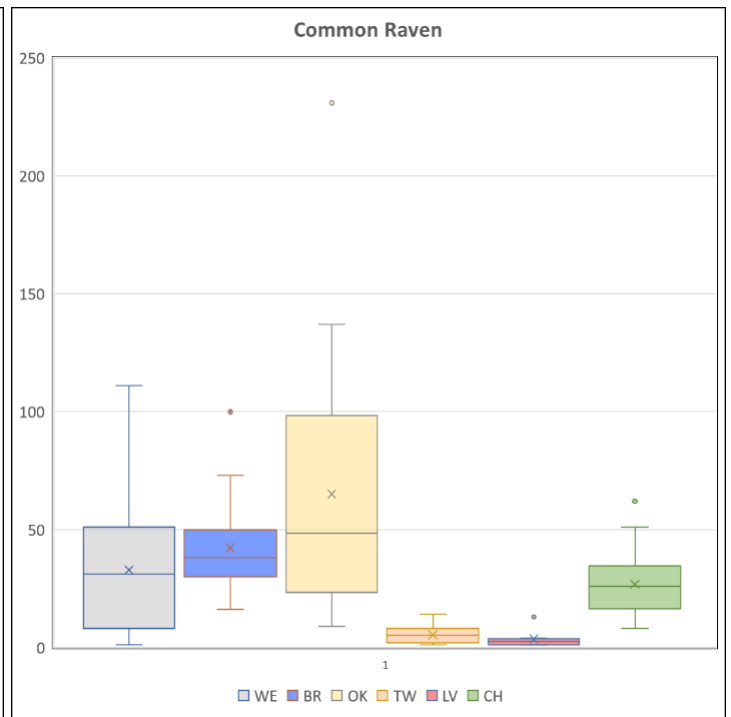
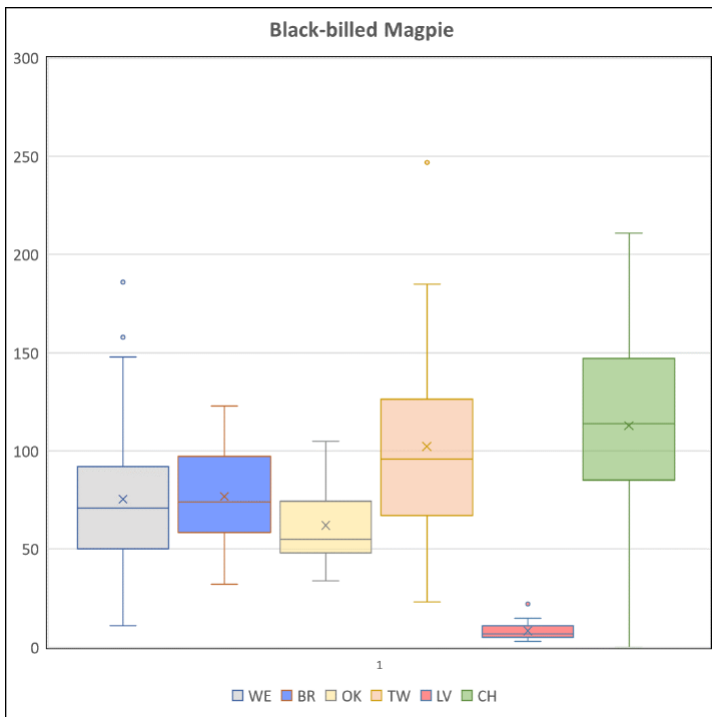
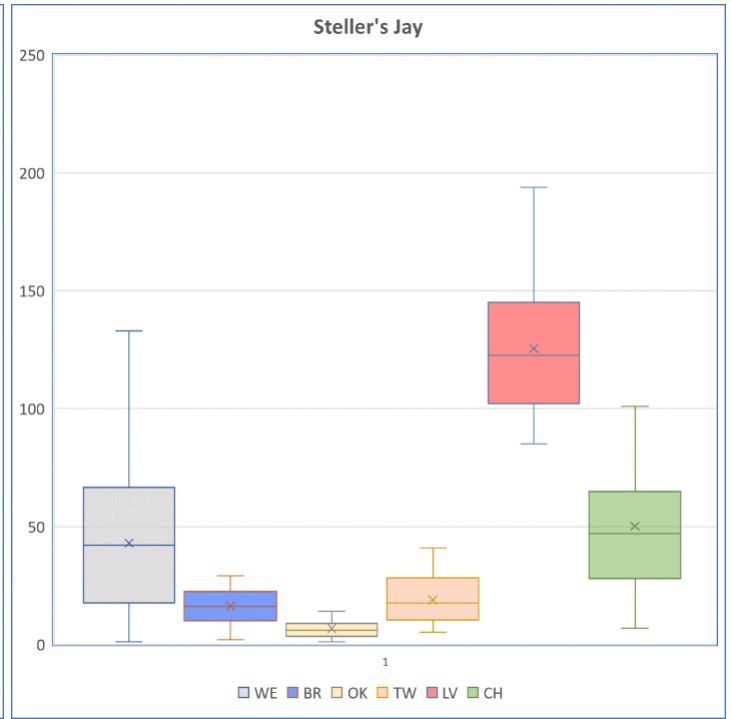
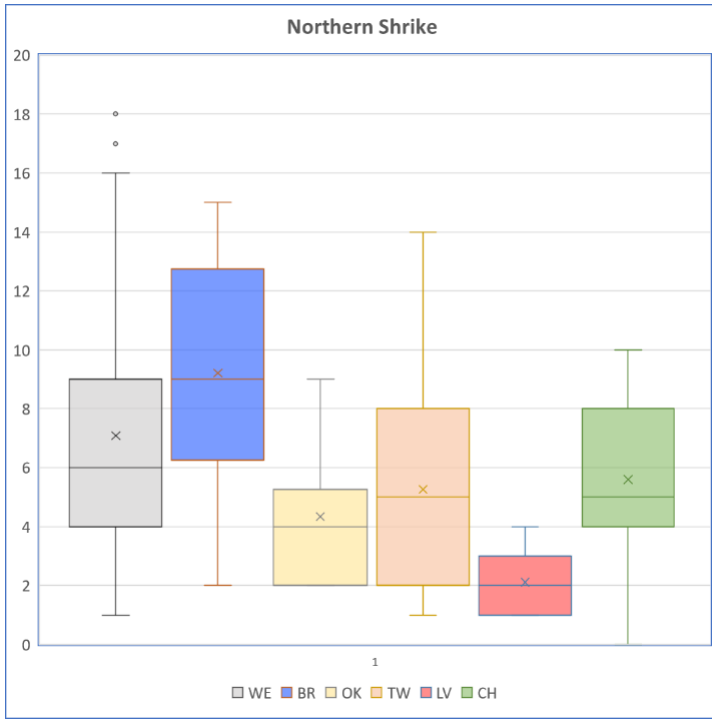
Species Statistics



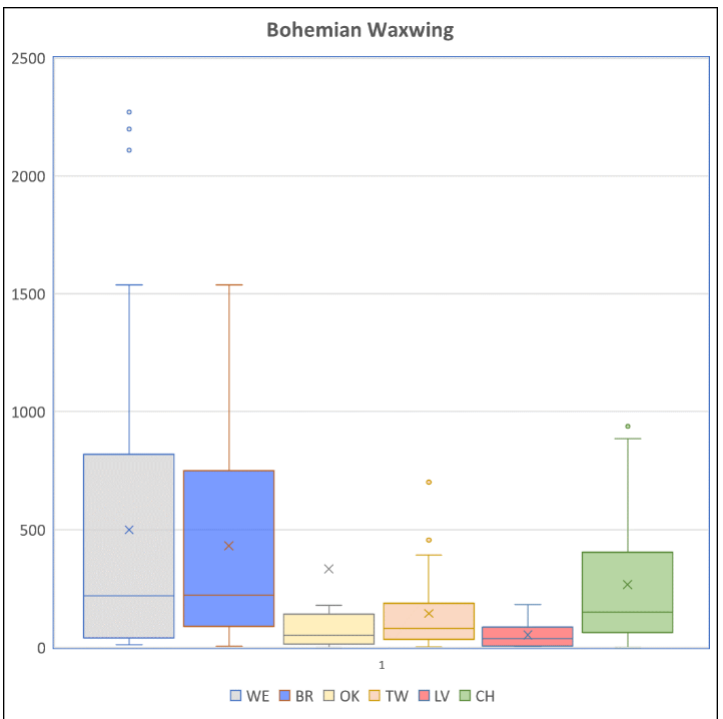
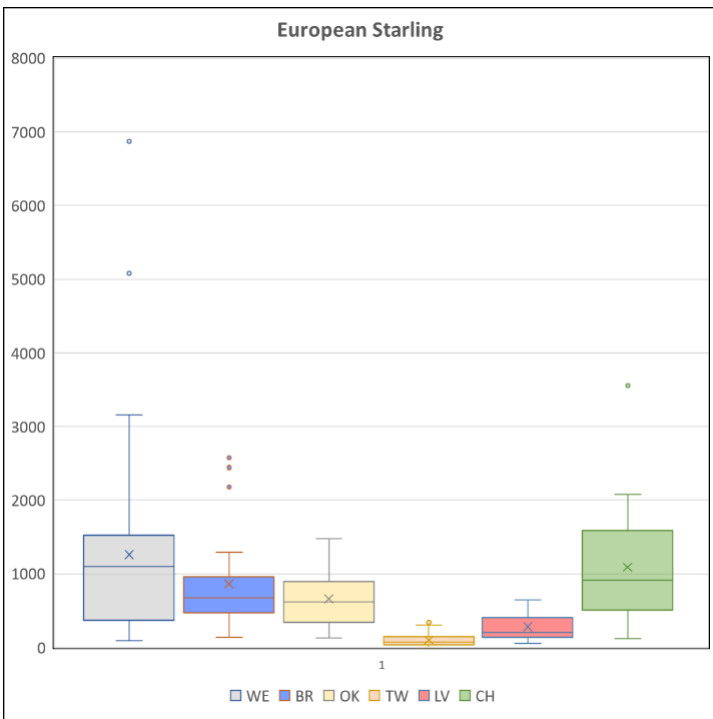
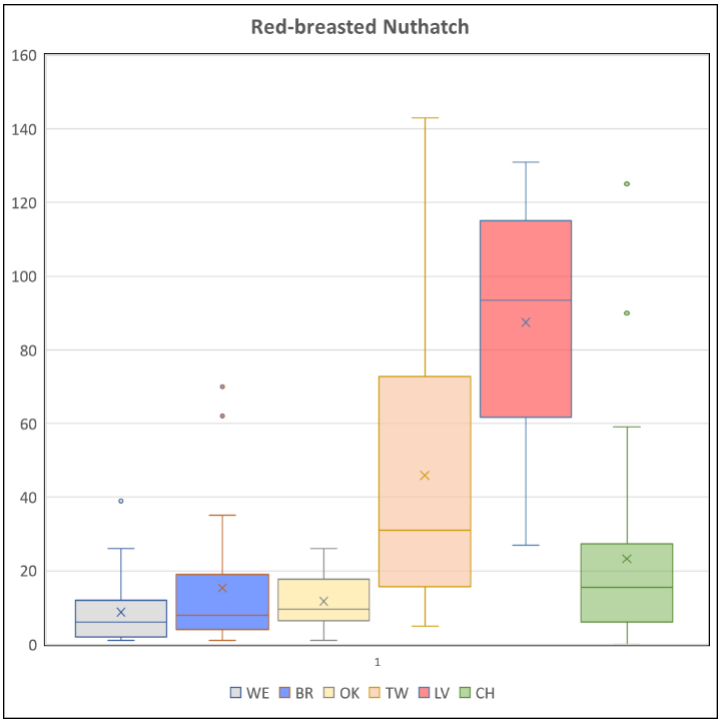
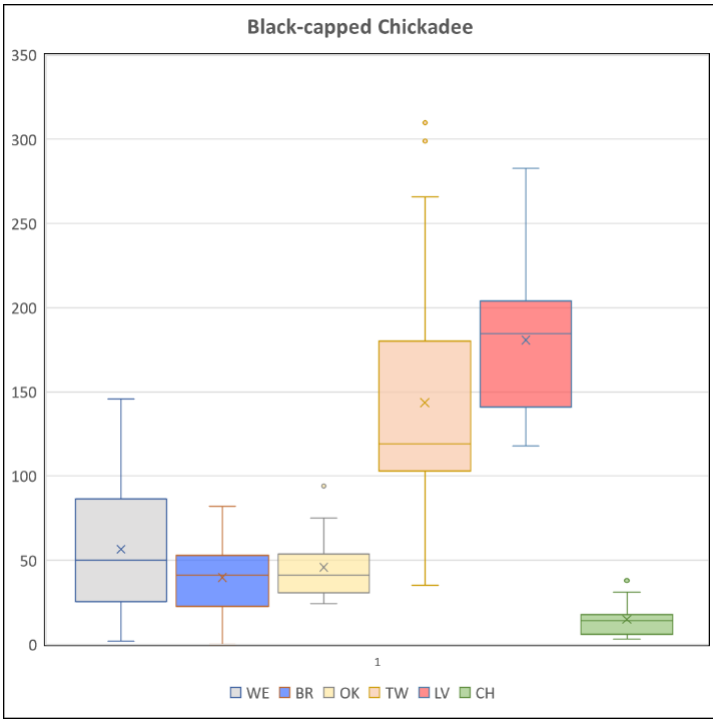
Species Statistics



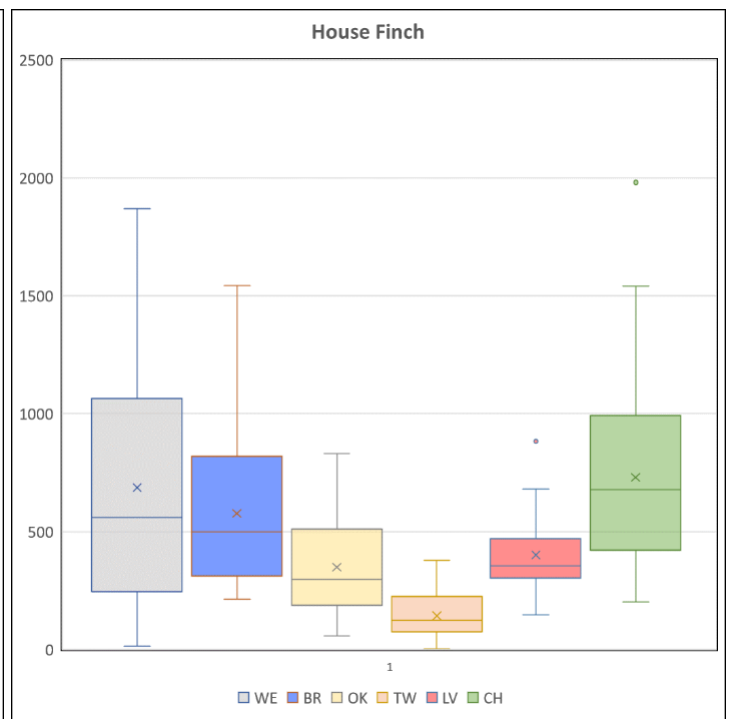
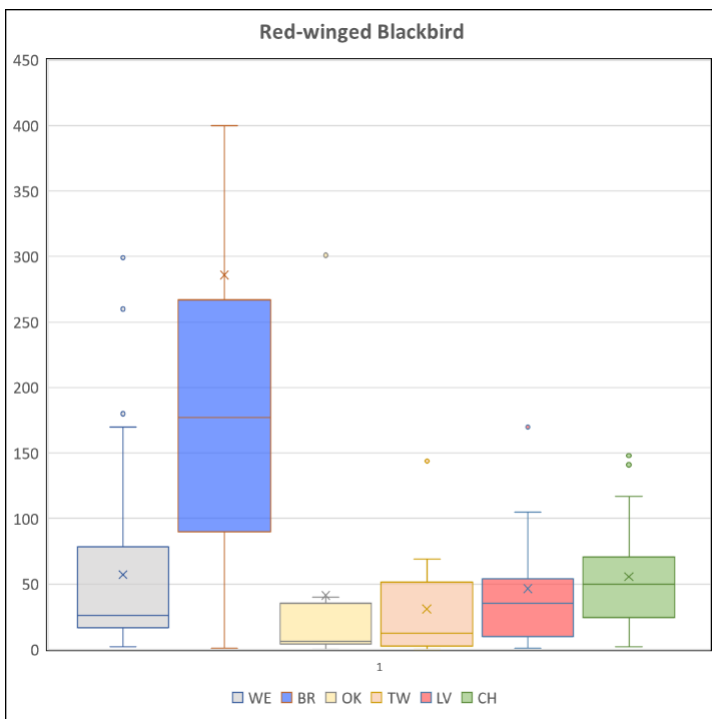
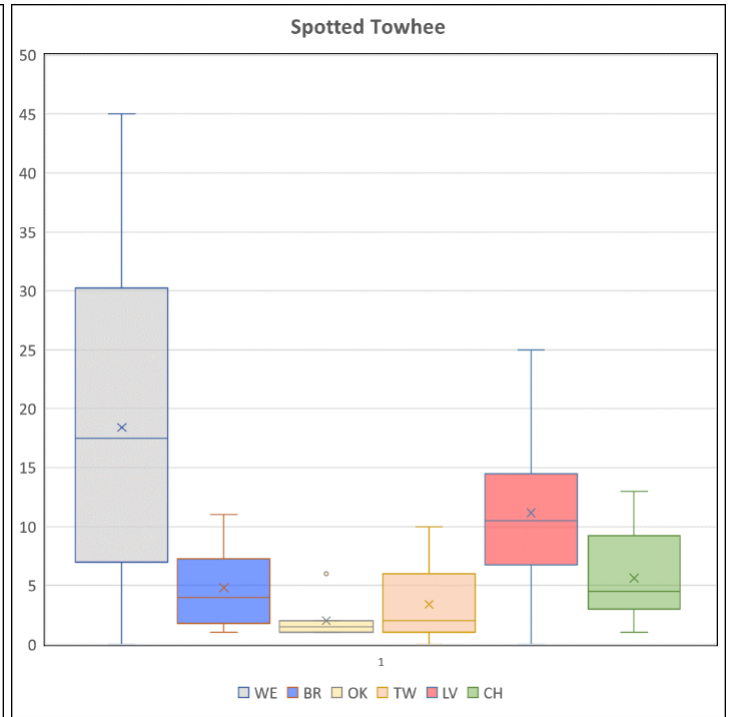
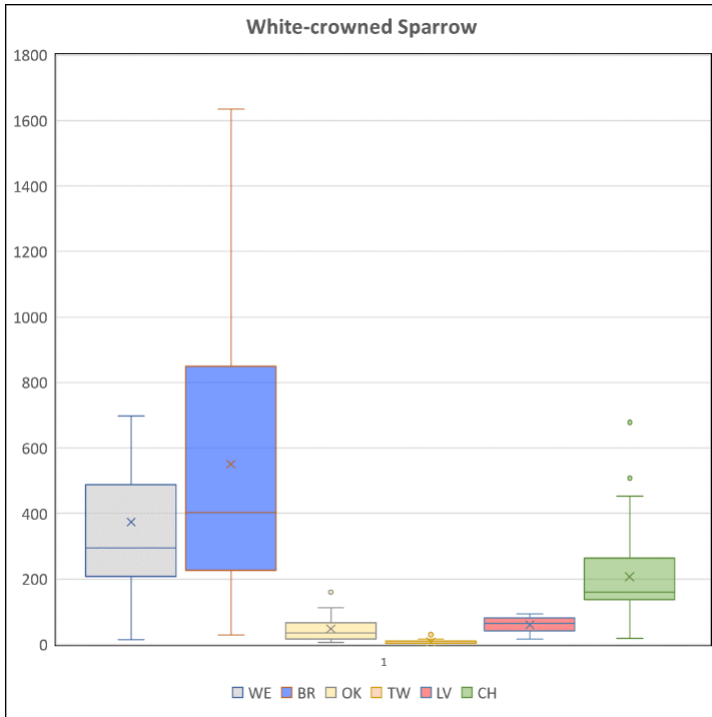
Species Statistics



Species Statistics



Species Statistics



Observations and Questions

General observations, thoughts, and questions about the graphs

- Long-term datasets like the CBC are highly valuable. This report looks at the data in a very granular way... by species and by location. Being able to visually or statistically discern trends is only possible when the data covers a long time frame.
- Many researchers use the CBC data in long-term studies of early winter bird populations across North America. An extensive Christmas Bird Count bibliography is available at <https://www.audubon.org/christmas-bird-count-bibliography>.
- The mainstem of the Columbia River hosts more winter waterfowl species than the other major rivers (Okanogan and Twisp). The Bridgeport, Chelan, and Wenatchee circles all show higher waterfowl numbers than Okanogan or Twisp. The size of the waterbody and its velocity play major roles in providing habitat for winter waterfowl.
- The onset of Eurasian Collared-Doves is clearly seen beginning about 2007. The number of birds seems to have leveled off in recent counts. Have we reached a carrying capacity? My intuition says 'no'.
- Canada Goose numbers appear to have increased over time and reached a seemingly stable level today. Are changes in hunting practices or regulations responsible?
- Like the Canada Goose, it appears that American Kestrel numbers have increased over time.
- Why are there no Ring-billed Gulls in Twisp or Leavenworth? Will we see them there in the future?
- The charts in this report do not show counts of Anna's Hummingbirds. The data, however, show that they were recorded in the 1974 counts in the Okanogan and Wenatchee circles. They were first reported in 2001 in Leavenworth, 2012 in Chelan, 2012 in the Okanogan circle, and 2020 in Twisp. There are no records of Anna's in the Bridgeport circle.

North Central Washington Christmas Bird Counts 638 Participants 1960-2020

Participants with names shown in **BOLD** participated in 10 or more counts

The information is derived from the CBC downloaded spreadsheets, historic reports. Steve Easley provided some of the Chelan participant information.

A Tim Abel, Cliff Adams, John Adams, Nikki Adams, Ted Always, Frank Anderson, LeRoy Anderson, Pat Anderson, Bill Ansert, Justin Anthis, Justin Anthis, Gertrude Appel, **Phil Archibald**, Ed Arnold

B William Baldwin, Susan Ballinger, Lee Barnhill, Bill Bartel, Sharon Bartel, Cherie Barth, Jamie Bass, Janet Bauer, Peter Bauer, **Denise Bayuszik**, Dave Beaudette, Susan Beery, Cheryl Belin, Gail Bender, **Joyce Bergen**, Joel Bernatz, Susan Berry, **Ken Bevis**, Mary Bider, Larita Bigelow, Eric Bindseil, Rachel Bishop, Mike Bjorstand, Sidra Blake, Bob Boekelhiede, Dan Boettger, Brenda Bracken, Ellen Brand, Bob Brennan, Tim Brennan, Ann Brinly, Randy Brook, Jean Brown, Jim Brown, Laura Brown, Wynne Brown, Dorsey Bruger, Laura Brumfield, Teresa Bulmer, Sharon Burchett, Dorsey Burger, Josh Burnell, Orion Burnell, Steve Burtchaell

C Mary Jean Cadman, John Callahan, Mike Camp, Art Campbell, Caryl Campbell, Philip Campbell, Allisa Carlton, Jean Carpenter, Vicki Carr, Rafe Carroll, Joan Casey, Dave Chantler, Dave Chavey, Dick Chavey, Keith Chavey, Monica Chavey, Amy Cheeseman, Phil Cheney, Phyllis Cheney, Loretta Chelsey, Allison Ciancibelli, Vicky Cibicki, Martha Claflin, Shey Claflin, Judy Clark, Patricia Clark, David Clement, Mary Cole, Julie Collins, Devon Comstock, Ann Condgon, Gordon Congdon, Jerry Converse, Sandy Converse, Anne Conway, Bryan Cook, Carmela Cook, Jim Cook, Kirsten Cook, Ann Cooley, Kelly Cordell-Stine, Nathan Coutsubos, Susan Crampton, Eric Craw, Marshall Craw, **Janet Crouse**, Michelle Crowell, Lindsay Currie

D Gretchen Daiber, **John Danielson**, **Matthew Danielson**, Jesse Davis, Kim des Rochers, **Heather de Saillan**, Jay Desgrosellier, Michelle Dewey, Ron Doane, **Wayne Doane**, Curt Dotson, Laurie Dowie, Elinore Drake, Stephanie Drake, Chuck Dronen, Ann Dubrosky, Jim Duemmel, Rebecca Dufrense, Chris Duhamel, Ty Duhamel, Jill Duncan, Scott Duncan, Lorenza Duque, Marleen Dutra

E **Steve Easley**, Kelly Edwards, Louise Edwards, Bridget Egan, John Ehernberg, Kathy Ehrenberg, Crystal Elliot, Joel Ellis, Thelma Emerson, Susan Ernsdorf, Rachel Evans, Shirlee Evans

F Dave Fairchild, Gene Fairchild, Cheryl Faust, **Ed Faust**, Carolanne Fenz, Dorna Ferrill, Annie Filer, **Heather Findlay**, Susan Fishburn, Brian Fisher, Jen Fisher, Katrin Fisk, Scott Fitkin, Robert Fleming, Pam Floyd, Donna Fondy, Vic Fondy, Tom Forker, Mike Freer, **Ron Friesz**

G Mary Gallagher, Tim Gallagher, Jeanie Garrity, Marcia Garton, Mary Gaylord, Gretchen Derisch, Lazo Gitchos, Victor Glick, Tom Golden, **Jenny Graevell**, **Wayne Graevell**, Denny Granstrand, Caroline Grubb, Barbara Guiland, Chris Gurke, Marty Gwinn

H Betty Hagenbuch, Ralph Hagenbuch, **Karen Haire**, George Halckas, David Hale, Larry Halford, Jeff Hambleton, Amy Hambly, Pat Hansen, Ric Hansen, Kathleen Hanson, Kay Hanson, Marion Hanson, Jean Hardie, Laura Hardy, Lisa Hardy, Eric Harlow, Daniel Harrington, David Harris, Ralph Harrison, Gretchen

Harsch, Chris Hartwig, Margaret Hartzell, Evelyn Hedges, **Neal Hedges**, Ken Heinle, Ken Hembery, Kay Hendrick, **Richard Hendrick**, **Bob Hensel**, Jane Hensel, Tyler Hicks, Mike Hiner, Brook Hinton, Tess Hoke, Andrew Holm, Bruce Honsinger, Gary Hoover, **Marvin Hoover**, **Sue Hoover**, Diana Hottell, Julie Hovis, Perri Howard, Alex Hulpher, Eugene Hunn, Zach Hurst, Steve Hyzer

I Gary Irle, Gordon Irle, Mark Isaak

J Ani Jaffe, Brian Jaffe, Burt Jahn, **Sylvia Jahn**, Thelma Jahn, Aileen Jeffries, Jeff Jendro, Ann Jensen, Ben Johnson, Jerry Johnson, Kate Johnson, Kevin Johnson. Mrs. Bob Johnson, Stuart Johnson, Tim Johnson, Mark Johnston, DJ Jones, John Juelson

K Anne Kahle, Bill Kampen, Sandi Kampen, Janice Kasala, Giff Kassebaum, Jim Kassebaum, Megan Kassebaum, Pat Kealoah, Dwight Keegan, Catherine Kent, Gordon Kent, Mary Kerr, Mary Kiesau, Carolyn Kindade, John King, Carolyn Kirby, Dee Ann Kirkpatrick, Ken Knittle, Russ Koppendrayer, Susan Koptonak, Fred Koster, Ann Krakowka, Harold Kronholm, Sherrie Krown, Karen Krystyniak, Doug Huehn, Gary Kuiper, Chas Kyger

L David Lafeber, Kristin Lafever, Bruce Lagerquist, Dorothy Lamberton, Beulah LaMotte, Vernon LaMotte, Randy Langseth, Larry Halford, Julia Leach, Larry Leach, Lisa Leber, Philip Lee, Patricia Leigh, Ken Libby, Marily Lietz, John Lindsay Juelson, Traci Lloyd, Lawrence Loeb sack, Hanet Loehr, Lincoln Loehr, **Kim Lohse**, Julie Longheed, Carolyn Loren, Philip Lorente, Clint Lougheed, Kim Louise, Drew Lovell, Andrew Lucock, David Luca, Larry Lund, **Mike Lundstrom**, Laura Luttrell, Mike Lynch

M Lindsey MacDonald, Patricia Madden, **Phyllis Madden**, Elaine Mahoney, Jerry Mahoney, George Makela, Randy Makela, Greg Malberg, Sheil Malberg, Rico Maletski, John Marshall, Dick Martin, Vickie Mathews, Dan Mathews, Victoria Mathews, Mary Mattison, Merry Maxwell, Charlie Maynard, Connie McCauley, Travis McCauley, Doris McConnell, George McCoy, Linda McCoy, Shirley McCoy, Gus McCutchen, Judy McCutchen, Mick McDevitt, Joyce McDonald, Don McIvor, John McNatt, Marjorie McNatt, Linda Medro, Francine MejiaFrancine Mejia, Linda Mendro, Sue Merrick, Kathy Merwin, Nancy Merwin, Jerry Merz, Ed Meyer, Barbara Meyers, Cori Michel, Janet Millard, Andy Miller, Jacob Miller, Paul Miller, Roxie Miller, Archie Mills, Anaka Mines, Jennifer Molesworth, Grace Moonie, **Will Moonie**, Peter Morrison, Joseph Moser, Ken Muir, Karen Mulcahy, Jenny Mullins, Kyle Mundy, **Heather Murphy**, Patrick Murphy, Phyllis Murra, Jocelyn Murray, **Richard Murray**, Linda Mycek, Wanda Myers

N Erna Nawratil, Kris Neff, Mark Nelson, Jermamy Newman, Faurest Nicks

O Denny O'Callahan, Marily O'Callahan, **Julia O'Connor**, Melissa O'Dell, Jeanette Offill, Pete Ohlosn, Therese Ohlson, Craig Olson, Marian Olson, Halford Opperman, **Bonnie Orr**, Dan Ortiz, Patricia Ortiz, Ruth Ortiz, **Manuel Ortiz-Torres**, **Ruth Ortiz-Torres**, Tricis Ortiz-Torres, Patty Ostendorff, **Howard Oswood**, Mark Oswood, Kathy Ovenell

P **John Page**, **John Page Jr.**, **Virginia Palumbo**, Logan Parr, Chris Parsons, **Jeff Parsons**, Alex Patrick, John Patterson, Amy Pavelchek, Emma Penhallegon, Jack Penhallegon, Dan Peplow, Susan Peplow, Christine Perkins, Linda Pershall, **Dan Peterson**, Pat Pettelle, Bryan Pfaender, Joan Pfeiffer, Judy Phelps, **Teri Pieper**, Ella Mae Pitcher, Emily Plott, Sage Pollack, **Von Pope**, Joshua Porter, **Theresa Poulson**, Jodie Powers. Catlin Price, Mike Price, Mark Pullen, Steve Pullette

R Steve Ralph, Sally Ranzau, Fred Rarden, Pat Rasmussen, Betty Ray, Kris Ray, Tom Redlinger, Laura Reichlin, Brian Reid, Aya Reiss, Gene Revelas, Barb Reynaud, Dave Reynaud, **Juliet Rhodes**, Connie Ringler, **Leslie Robb**, **Gail Roberts**, Jim Robertson, Ray Robertson, Arwen Robinson, Karleen Robinson, Mark Robinson, **Gretchen Rhode**, Kim Romain-Bondi, Richard Romea, Aaron Rosenblum, Dan Rossman, Rick Rottman, Deloris Rowe, Katja Rowell, Melanie Rowland, Richard Rowlett, Ina Ruble, James Ruble, Jane Ruble, **David Rudholm**, Frauke Rynd

S Suzanne Saberhagen, Paul Salladay, Susan Sampson, **Karen Sargent**, Ann Schaechtel, Don Schaechtel, Jason Schilling, Barb Schneider, Barb Schonewald, Doug Schonewald, James Schroeder, **Michael Schroeder**, Betsy Scott, Caitlin Scott, Dorothy Scott, Gregory Scott, John Scott, Richard Scranton, Kathy Seureau, Steve Shanewise, Wendy Sharp, Charlie Sheard, **Derek Sheffield**, Andy Shell, Marc Shelton, Alex Sherling, Amanda Sherling, Marilyn Sherling, Noreen Shinohara, Bob Shores, Jeanette Shores, **Libby Shriner**, Hillary Simms, **Roberta Simonds**, Barbara Smith, Cheryl Smith, **Daniel Smith**, **Jennie Smith**, Jerry Smith, Julie Smith, Kerry Smtih, Mrs. Merril Smith, Sarah Smith, **Sheryl Smith**, Shirley Smith, Edwin Smith, Sarah Smith, Ted Smith, Susan Snover, Ed Snow, Sally Soest, Mike Sorensen, Dave Spencer, **Meredith Spencer**, Richard Spencer, Greg Spies, **Beth St. George**, **David St. George**, Patrick St. Hilaire, Theresa St. Hilaire, Bren Starcher, Carolanne Steinback, Egon Steinbach, Leonard Steiner, **Daniel Stephens**, Andy Stepniewski, Kristin Stewart, Scott Stluka, Ed Stockard, Torre Stockard, Willy Stockman, Carrie Stokes, Vic Stokes, **Bernice Stout**, **Harold Stout**, Howard Stout, Lavon Stout, Kristi Streiffert, Tom Streiffert, Chris Strickwerda, Marilyn Strickwerda, Patrick Sullivan, Bob Sundstrom, Debbie Sutherland, Ryan Sutherland, Steve Sutherland, Ed Swan, Leahe Swayze, Christine Swenson, Steve Swerm, Shandor Szabados

T Angie Tangren, **Jerry Tangren**, John Tangren, Leigh Thomas, Rauny Thompson, Rebecca Thompson, Ron Thompson, **Todd Thorn**, Art Tiedemann, Kathe Tillman, Leigh Tolyns, Kathy Tomlinson, Meg Treborn, Reggie Trusel

U Don Utzinger

V Carmen Vanbianchi, Denise Varner, Vasiliki Vassil, Chris Vennum, Lou Verellen, Pam Vesterby, Joe Veverka, Dana Visalli

W Ted Wagner, Thor Wagner, Katie Waltz, Brian Waterman, Herman Waterman, Grace Watson, Mary Watson, Rich Watson, Simon Watson, Cricket Webb, Barbara Webster, Paul Webster, Dan Weinstein, Betsy Weiss, Jaime Welfelt, Lindsay Welfelt, Rick Welton, Alice West, Clifford West, Alexa Whipple, Nancy Whittier, Tracey Wiese, June Wil, Margaret Wilkinson, Sarah Wilkinson, Maizie Williams, Steph Williams, Jim Wilson, June Wilson, Peter Wimberger, Barb Wolfe, Brian Wood, Aja Woodrow, Doug Woodrow, **Kent Woodruff**, Dennis Wysong

Y Don Youkey

Z Jane Zanol, John Zanol, Dawn Zebley

The top 21 CBC volunteers are:

- | | |
|---------------------------|-------------------------|
| 1. Steve Easley (69) | 11. Phyllis Madden (22) |
| 2. Meredith Spencer (56) | 12. Howard Oswood (22) |
| 3. Richard Hendrick (45) | 13. John Page (22) |
| 4. Dan Stephens (42) | 14. Jenny Graevell (21) |
| 5. Michael Schroeder (32) | 15. Wayne Graevell (21) |
| 6. Wayne Doane (31) | 16. Gail Roberts (21) |
| 7. David St. George (29) | 17. Will Moonie (20) |
| 8. Jenny Smith (27) | 18. Teri Pieper (19) |
| 9. Phil Archibald (25) | 19. Dan Smith (19) |
| 10. Sue Hoover (23) | 20. Jerry Tangren (19) |
| | 21. Kent Woodruff (19) |

The number of individual volunteer efforts for each of the above individuals may be inaccurate. It could be that people recorded the names with different spelling, omitted names from a year's record, or typographical error on my part.

About this publication

The raw data represented in the publication were downloaded from the National Audubon website's [Christmas Bird Count page](#). The downloaded spreadsheets for each circle were edited in Microsoft Excel® to allow calculations. Each yearly column was converted to numbers to allow use of math functions. All the downloaded files were converted from Excel 97-2003 to Microsoft Excel 2016 .

All the graphs in Excel were sized to ensure that the output graphs would be consistent. Saving the spreadsheet as a Web page provides a folder of all graphs in the spreadsheet using .PNG format. Very handy.

The publication was prepared using [Affinity Publisher](#) by Serif. This program is a very capable and affordable page and document layout program.

Parent graphs were opened in Adobe Photoshop® and edited to include the CBC circle names and any additional annotations. Files were then saved as .PSD format to allow future edits and as .JPG or .PNG files for use in the publication.

Affinity Publisher created the base .PDF file of the publication. The highest resolution file is over 30mb. Lower resolution PDF files were created using Publisher to produce PDF files that are less than 25mb for download purposes.

The publication uses the Cambria font at 12pt for body text. Headings are Arial bold, 14pt.