2019 California Waterfowl Breeding Population Survey Report[1]

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Summary

The annual California Department of Fish and Wildlife waterfowl breeding population survey has been conducted since 1948. The survey methodology was redesigned and updated in 1991 and has been conducted in its current form since 1992. The purpose of the survey is to estimate waterfowl populations in major concentration areas of the state in order to inform management. Data from the survey were incorporated into the U.S. Fish and Wildlife Service Adaptive Harvest Management framework for Western mallards in 2008 and has since been an integral part of duck harvest management in the Pacific Flyway.

In 2019, the survey was conducted from 22 – 26 April in the Central Valley and 7 – 8 May in northeastern California. The total breeding population of ducks in the survey area decreased 14% from 2018. Mallards (*Anas platyrhynchos*) decreased 12% from 2018 and are 28% below the long-term average. Gadwalls (*Mareca strepera*) increased 8% from 2018 and are 29% above the long-term average. Cinnamon teal (*Spatula cyanoptera*) decreased 36% from 2018 and are 17% above the long-term average. Canada geese (*Branta canadensis*) in northeastern California decreased 11% compared to 2018 and are 11% above the long-term average. Winter precipitation was above normal across most of the survey area and May rains in the Central Valley should extend good habitat conditions. Central Valley water storage is well above average and water allocations for wetland management and rice agriculture are at 100%. Snow-water content in the Sierra and Cascade ranges should sustain unmanaged wetlands longer than normal throughout northeastern California. Water for managed wetlands should be available in most areas including Tulelake and Lower Klamath National Wildlife refuges, although water allocations at these refuges are subject to change as no formal agreements have been made to maintain habitat on these areas.

1 Data are preliminary.

Methods

The procedures used in conducting the California Department of Fish and Wildlife (CDFW) Waterfowl Breeding Population Survey (hereafter California Survey) generally follow those set forth in the U.S. Fish and Wildlife Service (USFWS) Standard Operating Procedures Manual (SOP) for the Waterfowl Breeding Population and Habitat Conditions Survey (USFWS and Canadian Wildlife Service 1987). Survey design and SOPs for the California Survey are as follows:

Strata.— The original survey included 11 strata which were: Sacramento Valley, Sacramento – San Joaquin Delta, San Joaquin Grasslands, San Joaquin Desert, Suisun Marsh, Napa and Santa Rosa Valleys, Salinas Valley, Owens Valley, Northeastern California, East Valley (i.e., Central Valley) and West Valley (i.e., Central Valley; Zezulak et al. 1991). Salinas and Owens Valleys were discontinued after 1994; therefore, population estimates in this report only include data from the 9 strata currently surveyed (Fig. 1).

Survey Timing.— In the Central Valley and Suisun Marsh, about half of all duck nests are initiated by the last week of April. A range of 48-54 days existed between 10% and 90% of nest initiation in the Suisun Marsh during 5 years of study (McLandress et al.1996). In northeastern California, nest initiations are later due to the increase in latitude, higher elevations and correspondingly cooler temperatures. About 50% of mallard nests in northeastern California are initiated by mid-May (Zezulak et al.1991). Based upon these regional nesting chronologies, surveys are conducted during the latter half of April in the Central Valley and by mid-May in northeastern California. Survey flights are scheduled to begin no later than two hours after sunrise in order to ensure adequate lighting and avoid detection problems. Surveys are completed no later than 1400 hours, which facilitates use of Sacramento Executive Airport as a daily stopping point (except in northeastern California).

Survey Sample.— The California Survey consists of nine strata (Fig.1; see Zezulak et al. 1991). A stratum is a defined geographic unit encompassing areas of similar waterfowl densities and is generally of a single or unique complex of habitat type(s). Most strata are continuous spatial units except the Northeastern stratum, where mountainous terrain separates each wetland complex (Fig. 1).

A transect is the sampling unit of the California Survey, which can have multiple segments, be continuous and or disjunct. Segments are a subunit of a transect, most of which total 18 statute miles (29 km). Latitude and longitude coordinates define each segment beginning and ending points. A randomly selected starting point for generating transects within the Central Valley was established just south of Red Bluff. Segments through most of the Central Valley are located at parallel 14 mi (22.5 km) intervals, except in the San Joaquin Desert where segments are spaced 28 mi (45 km) apart due to low waterfowl densities. East and West Valley starting points were randomly selected and transects were placed between the border of the intensive agricultural areas of the Central Valley and the 500 ft (152 m) elevation line. In most strata, transects are a continuous series of segments except for Suisun Marsh, Napa-Santa Rosa and

Northeastern strata. In these areas, segments are disjunct because they are designed to fit within the geographic features of the valleys (i.e., Napa-Santa Rosa and Northeastern) or to provide a representative sample of areas surveyed before the 1991 redesign (i.e., Suisun Marsh and Northeastern). Transects within the Central Valley are oriented 45° from true north. Most waterways in the Central Valley are oriented north-south or east-west, and the prescribed orientation is intended to minimize biases associated with transects that might run parallel or perpendicular to waterways.

Fixed-wing Flight Procedure.— The California Survey requires one CDFW pilot and two CDFW observer-biologists. The pilot's responsibility is navigation, including waypoint delineation of segment beginning and ending points. The pilot maintains an air speed of 90-110 mph (145-180 km/hr) and an altitude of 150 ft (45 m) above ground level. Each observer counts all ducks, geese, swans, American coots (*Fulica americana*) and Sandhill cranes (*Antigone canadensis*) within 660 ft (200 m) on each side of the aircraft, creating a total sample width of 1/4 mi (400 m). Observations are recorded using a voice recorder or a laptop computer that archives observations using the Hodges Survey Program (Jack Hodges, USFWS v2014).

Visibility Bias Correction.— A number of factors (e.g., flight speed, vegetation) preclude ground coverage of most segments. Therefore, the California Survey uses the double-sampling procedure (Koneff et al. 2008), similar to the USFWS SOP. This method incorporates a "complete count" of select segments to correct for detection bias, referred to as a visibility correction factor (VCF). A helicopter is used to obtain the VCF in California. The VCF is conducted in all strata except the Napa–Santa Rosa stratum. Segments were selected based on the relative abundance of waterfowl, representative habitats, and proximity to airports. The VCF crew includes two CDFW observer-biologists and a CDFW helicopter pilot. The helicopter is flown at 40-45 mph (65-70 km/hr) and an altitude of 100 ft (30 m) along segments. The helicopter crew records waterfowl in the same manner as fixed-wing observers.

As waterfowl populations within the California Survey area have decreased over time, VCF segments flown since 1992 have also declined. This is problematic because the VCF is only flown on a subsample of segments. Fewer samples can skew point estimates and inflate variation, even for common species. Because samples have been low on VCF segments, VCF estimates have only been used 1 (2017) out of the past 3 years (2016 – 2018). Therefore, changes to VCF segments were necessary to increase sampling by the helicopter crew. The Northeastern Stratum was changed for the 2019 survey to address declining VCF samples. The decision process was based on mallard numbers, as they are the most common species observed and drive flyway harvest management. Averages of fixed-wing data from the last 5 years (2014 – 2018) were generated for each survey segment, then each segment was ranked based on which quartile they best aligned with. Quartile values were used to guide sample distribution and avoid skewing toward the highest values. Values below the first quartile were not considered, since the primary objective was to increase the number of samples. Proximity to airports also guided which segments were selected.

Data Analysis.—The Survey Transcribe Program (Jack Hodges, USFWS v2014) is used to transcribe observations from sound files (.wav) and combine the observation data with GPS coordinates (decimal degrees). The program produces an ASCII file and a copy is converted into a CSV file which is edited based on criteria in Appendix I. The same process is completed for helicopter data. If computers are not available to record data, the Survey Transcribe Program is still used to transcribe voice recorder data. Once data are finalized, population estimates are generated using a customized program in R (G. Zimmerman USFWS 2015; R-Core Team 2018, R Studio Team 2018).

A "total indicated birds" (TIB) is calculated for each species on survey segments from both fixed-wing and helicopter data using criteria from previous research (Zezulak et al. 1991, Appendix I). The VCF is calculated for each species based on the ratio of TIB from the fixed-wing crew divided by the TIB from the helicopter crew on replicated segments. The current year VCF is compared to long-term VCF estimates at various pooling levels (e.g., 2 years, 5 years, 10 years, etc.), as well as the USFWS long-term average in the midcontinent. The current year VCF is used if specific criteria are met (Appendix II). The long-term average (CDFW or USFWS) is used for uncommon species (e.g. redhead (*Aythya americana*)). A density is derived by dividing the TIB by the segment area (mi^2). A mean density is calculated for each species within each stratum by averaging the densities of each transect. The stratum area for expansion is calculated by subtracting the transect area surveyed (i.e., segment area) from the stratum area. The mean density for each species is multiplied by the VCF then by the expansion factor to derive a population estimate for each stratum.

Results

The 2019 California Survey was flown from 22 – 26 April in the Central Valley and 7 – 9 May in northeastern California. Transect-segment 7-20 in the Northeastern stratum was not flown due to high winds. The survey was 100% complete in the Central Valley and 95% complete in Northeastern, for a total survey effort of 99%.

Total breeding ducks in the survey area decreased 14% from 2018 (mean ($\bar{x}$) = 470,750; ± Standard Error (SE) = 48,803; Coefficient of Variation (CV) = 0.10) and are 14% below long-term average (Table 1). The most abundant species of ducks were mallards ($\bar{x}$ = 239,831; SE = 32,223; CV = 0.13), followed by gadwall ($\bar{x}$ = 111,321; SE = 32,243; CV = 0.29) and cinnamon teal ($\bar{x}$ = 50,415; SE = 14,551; CV = 0.29). Mallards, gadwall and cinnamon teal comprised 85% of ducks observed. Mallards decreased 12% from 2018 and are 28% below the long-term average. Gadwalls increased 8% from 2018 and are 29% above long-term average. Cinnamon teal decreased 36% from 2018 and are 17% above long-term average.

Other, less numerous, duck species present in the survey include: American wigeon (*Anas americana*), American green-winged teal (*Anas carolinensis*), blue-winged teal (*Spatula dicors*), northern shoveler (*Spatula clypeata*), northern pintail (*Anas acuta*), wood duck (*Aix sponsa*), redhead, canvasback (*Aythya valisineria;* seen on VCF but not on fixed-wing), lesser scaup (*Aythya affinis*), ring-necked duck (*Aytha collaris*), Common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), ruddy

ducks (*Oxyura jamaicensis*) and common merganser (*Mergus merganser*). These species comprise 15% of total ducks (Table 1).

Other species counted on the survey included: American coots, Canada geese, Sandhill cranes and mute swans (*Cygnus olor*; Table 1). Statewide estimates for American coots decreased 32% from 2018 ($\bar{x}$ = 267,748; SE = 72,328; CV = 0.27) and are 8% above the long-term average (Table 1). Canada geese are counted in all strata (Appendix IV); however, the Northeastern stratum is used to monitor the traditional breeding population of Canada geese within California. Canada geese in Northeastern decreased 11% from 2018 ($\bar{x}$ = 48,588; SE = 14,417; CV = 0.30) and are 11% above long-term average. Sandhill cranes also nest in the Northeastern stratum and are down 38% from 2018 ($\bar{x}$ = 1,126; SE = 497; CV = 0.44), 39% below their long-term average. In 2007, CDFW began monitoring feral mute swans. Mute swan estimates increased 54% from 2018 ($\bar{x}$ = 2,326; SE = 573, CV = 0.25) and are 469% above their 13-year average.

January through April precipitation was generally above normal across most strata, although the Delta (z = –0.27), and San Joaquin Grasslands (z = –0.13) were slightly below normal (Table 2; NOAA 2019, Western Regional Climate Center 2019). Generally, rainfall was above average during January, February and March but well below average in most strata during April. Snow-water content in the Northeastern stratum was well above average, (Table 2, Table 3; NOAA 2019, Natural Resource Conservation Service 2019, Western Regional Climate Center 2019).

VCF Modifications.— Quartile values generated from total indicated mallards on each segment in the Northeastern stratum were as follows: 1st quartile = 12.2, 2nd quartile = 27.2 and 3rd quartile = 61.6 (Appendix V). Based on the selection criteria, 6 segments were eliminated because they were equal to or below the 1st quartile value. These included segments: 2, 12, 13, 14, 15, 17, 18 and 20. Segments 2 and 17 were historically surveyed VCF segments. Segments 1, 3, 6 and 8 were selected as each were above the first quartile (five-year mean = 29.0, 21.2, 98.6 and 134.4). These segments also allow for refueling at Susanville and Alturas airports (Appendix VI) Year-to-year values are summarized in Appendix VII for the 5 most common species observed.

Discussion

Waterfowl populations in the Central Valley continue to show little improvement despite normal precipitation compared to the long-term average. The breeding population of mallards in the Sacramento Valley, which averaged 130,000 between 1992 – 2011, has only averaged 46,000 over the past three years (Appendix IV). A cover crop program was recently created and is intended to increase habitat for upland nesting birds in fallow agricultural lands. This experimental program may provide insights into the decline of waterfowl populations in association with the loss of surrogate agricultural nesting habitat to orchard development over the past decade. Recent funding of the California Waterfowl Habitat Program, part of which incentivizes summer water management for duck broods, may also help reverse waterfowl

population declines in the Central Valley. For more information on these programs see the CDFW Lands Program page at: https://www.wildlife.ca.gov/Lands/CWHP/Private-Lands-Programs

In Northeastern California waterfowl populations continue to be at or above average for most species. Some decline was seen in mallards compared to 2018; however, habitat conditions in the region are favorable for a good production year. Cinnamon teal also showed a decline compared to 2018; however, the 2018 populations estimate was the highest on record, while the 2019 estimate was the second highest.

Water allocations in the Central Valley are forecasted to be at full allotment for wetland management and rice agriculture, which should be beneficial to breeding waterfowl in the region. Further, significantly above average May rains should improve brood production throughout the Central Valley. Above average rains and snowpack in northeastern California should maintain unmanaged wetlands in the region, as well as provide adequate water resources for wetland management. Currently, limited maintenance flows are being supplied to Unit 2 at Lower Klamath National Wildlife Refuge; however, the ability of this water to maintain current wetland conditions throughout the summer is unclear (J. Vradenburg, USFWS, personal communication).

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Figure 1. California Breeding Waterfowl Population Survey map.

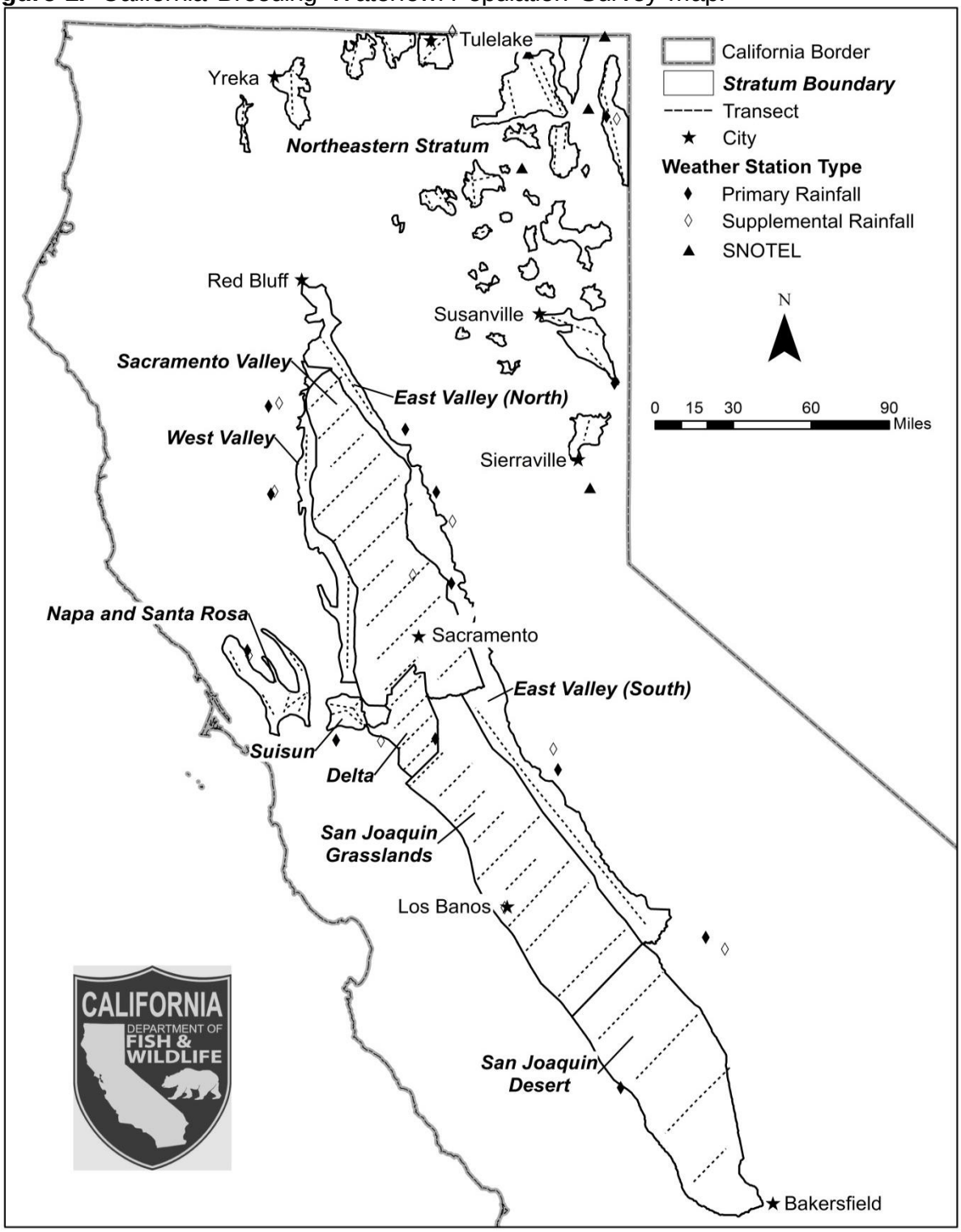


Table 1. California Breeding Waterfowl Population Survey estimates and standard errors.

	2019	SE	CV	2018	SE	LTA[1]	% Change From 2018	% Change From LTA
Mallard	239,831	32,223	0.13	272,859	42,037	334,108	-12%	-28%
Gadwall	111,321	32,243	0.29	102,637	28,768	86,620	8%	29%
American Wigeon	2,220	1,354	0.61	2,309	1,132	4,534	-4%	-51%
Green-winged Teal	6,159	3,532	0.57	3,358	1,241	3,799	83%	62%
Blue-winged Teal	511	495	0.97	0	0	0		
Cinnamon Teal	50,415	14,551	0.29	78,498	26,143	43,113	-36%	17%
Northern Shoveler	23,049	6,019	0.26	24,330	5,655	31,621	-5%	-27%
Northern Pintail	6,523	3,091	0.47	8,478	3,232	7,093	-23%	-8%
Wood Duck	10,462	3,255	0.31	15,391	4,969	8,326	-32%	26%
Redhead	5,051	2,812	0.56	13,263	7,789	3,958	-62%	28%
Canvasback	0	0		1,292	855	1,066		
Lesser Scaup	356	222	0.62	1,001	791	4,723	-64%	-92%
Ring-necked Duck	4,102	1,876	0.46	3,134	1,597	954	31%	330%
Goldeneye	711	689	0.97	0	0	300		
Bufflehead	2,672	1,269	0.47	9,168	5,405	3,299	-71%	-19%
Ruddy Duck	6,385	2,707	0.42	13,102	7,241	15,012	-51%	-57%
Common Merganser	1,193	687	0.58	359	338	525	232%	127%
TOTAL DUCKS	470,450	48,803	0.10	549,180	59,114	549,051	-14%	-14%
Canada Geese[2]	48,588	14,417	0.30	54,851	15,122	43,798	-11%	11%
Goslings[2,3]	4,181	1,395	0.33	2,251	970	3,015	86%	39%
American Coot	267,748	72,328	0.27	396,561	100,605	246,926	-32%	8%
Sandhill Crane[2,3]	1,126	497	0.44	1,823	1,147	1,832	-38%	-39%
Mute Swan[3,4]	2,326	573	0.25	1,514	390	409	54%	469%

[1]Long-term average (LTA); 1992 – 2019 for ducks and coots.
[2]Northeastern stratum estimates only, LTA for Canada geese = 1993 – 2019, LTA for goslings and Sandhill cranes = 2003 – 2019.
[3]VCF = 1, due to insufficient data.
[4]LTA = 2003 – 2019.

Table 2. Precipitation (inches)[1] across California Breeding Waterfowl Population Survey strata.

Strata[2]	Year	Jan	Feb	Mar	Apr	May[4]	Spring Total	Z-Score
Sacramento Valley	2019	40.32	69.11	34.00	10.96	---	154.39	1.18
(Strata 1)	LTA	30.40	30.14	22.16	12.50		95.20	
Sac/San Joaquin Delta	2019	6.26	12.69	6.19	1.36	---	26.5	-0.27
(Strata 2)	LTA	9.85	9.46	6.87	3.65		29.83	
San Joaquin Desert	2019	4.92	7.52	3.82	0.97	---	17.23	-0.01
(Strata 3)	LTA	5.26	4.47	5.07	2.48		17.28	
San Joaquin Grasslands	2019	9.81	20.65	11.15	1.74	---	43.35	-0.13
(Strata 4)	LTA	14.54	13.40	11.78	6.16		45.88	
Suisun	2019	6.50	13.99	7.30	1.33	---	29.12	2.71
(Strata 5)	LTA	4.08	4.11	2.69	1.35		12.09	
Napa/Santa Rosa	2019	6.50	13.99	7.30	1.33	---	29.12	1.19
(Strata 6)	LTA	5.13	5.48	4.80	1.67		17.09	
East Valley (North)[3]	2019	21.24	39.64	16.57	5.34	---	82.79	1.15
(Strata 10)	LTA	16.95	17.35	12.76	7.91		54.98	
East Valley (South)	2019	6.32	12.49	7.53	1.11	---	27.45	0.05
(Strata 10)	LTA	6.49	5.73	7.00	3.30		22.13	
West Valley	2019	21.36	39.24	20.51	2.73	---	83.84	1.84
(Strata 11)	LTA	14.65	14.55	11.77	4.72		45.68	
Northeastern CA	2019	7.19	11.00	5.87	5.04	7.20	36.30	-0.04
(Strata 9)	LTA	8.65	6.50	7.08	6.36	8.90	37.83	

[1]Data acquired from NOAA NCDC online database or RAWS station online data, long term averages derived from 1990-2019.
[2]For stratum with large area a sum of precipitation was calculated using numerous weather stations, see appendix III for detail.
[3]East Valley was separated at Sacramento due to differences in weather to be more informative however BPS data analyzes this stratum as one.
[4]May precipitation data not included in Central Valley areas because the survey is conducted in April.

Table 3. Snow-water content (inches)[1] across Northeastern California survey stratum, 2019.

Location	Year	Nov	Dec	Jan	Feb	Mar	Apr	Apr Z - Score	% of Apr 1 Avg
Adin Mountain[2]	2019	0.0	1.9	4.7	10.8	19.1	21.4	1.89	159%
	LTA[2]	0.9	3.5	6.6	9.4	11.4	8.3		
Cedar Pass[3]	2019	0.0	2.6	7.0	11.0	19.2	23.8	1.18	63%
	LTA	1.5	4.8	8.5	12.0	15.5	14.6		
Dismal Swamp[4]	2019	0.0	4.4	10.9	19.0	33.8	42.5	1.39	58%
	LTA	1.9	7.3	13.6	19.3	25.2	27.0		
Independence Lake[5]	2019	0.0	5.4	8.8	25.3	54.3	54.9	0.70	27%
	LTA	2.6	9.9	18.6	27.9	38.1	43.4		

[1]Data from NRCS snow telemetry stations, see appendix III for more details.
[2]LTA 1990-2019.

Appendix I. Guidelines for California Breeding Waterfowl Survey data

Definitions

Total Indicated Birds:	Drakes, Pairs and Groups combined.
Lone Drake:	Single isolated drake without a visible associated hen.
Flocked Drakes:	Four or fewer drakes in close association.
Pair:	Male and female in close association.
Group:	Five or more of mixed-sex grouping of the same species in close association which cannot be separated into singles and pairs.

Total Indicated Birds = Lone drakes x 1, Pairs x 2, Groups x 1 (AOU_Num)

- Redhead (1460): exclude groups greater than 8
- Ring-necked Duck (1500)
- Lesser Scaup (1490): do not count in Napa and Suisun Strata
- Ruddy Duck (1670)
- Canada Goose (1720): count all broods separately
- Greater white-fronted goose (1710)
- American Coot (2210)
- Sandhill Crane (2060)
- Mute Swan (1782)

Total Indicated Birds = Lone drakes x 2, Pairs x 2, Flocked Drakes x 2, Groups x 1

- Common Merganser (1290)
- Mallard (1320)
- Gadwall (1350)
- American Wigeon (1370): exclude groups
- American Green-winged Teal (1390): exclude groups greater than 8
- Cinnamon Teal (1410)
- Northern Shoveler (1420): exclude groups
- Northern Pintail (1430)
- Wood Duck (1440)
- Canvasback (1470): exclude groups
- Common Goldeneye (1510)
- Bufflehead (1530)
- Blue-winged Teal (1400)

Appendix II. Guidelines for Determining Annual Visibility Correction Factor (VCF).

California VCFs are to be used for most species. The preference is for the current year VCF to reflect habitat or general conditions, especially for mallards. Sample size and Coefficient of Variation (CV) rule: at least 40 observations for the helicopter and fixed wing crews with a CV of 20% or less. If VCF is 1.0 or less do not use. If current year does not meet criteria, use previous year until criteria are met. Pooling can be used if criteria cannot be met and single year estimate is deemed not reasonable (VCF of 1.5 or less for mallards). In the case of scaup, ring-neck duck, mergansers, and goldeneye (species with few detections/low abundance in California) use U.S. Fish and Wildlife Service VCF.

Appendix III. Weather station metadata.

Station Name	Station ID	Stratum	Type	Latitude	Longitude	Website	Notes
Juniper Creek RAWS	NWS 040308	Northeastern	Rainfall	41.33222	-120.4725	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCJUN	Main station
Ash Creek RAWS	NWS 040244	Northeastern	Rainfall	41.27694	-121.9794	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCASC	Main station
Tule Lake GHCND	GHCND:USC00049053	Northeastern	Rainfall	41.96667	-121.46667	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Main station
Doyle RAWS	NWS 040724	Northeastern	Rainfall	40.02222	-120.1056	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCDOY	Main station
Cedarville GHCND	GHCND:USC00041535	Northeastern	Rainfall	41.53333	-120.16667	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Surrogate station for Surprise Valley RAWS
Surprise Valley RAWS	NWS 043690	Northeastern	Rainfall	41.62028	-120.156667	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCSP3	Main Station
Paskenta Ranger Station	GHCND:USC00046726	West Valley and Sacramento Valley	Rainfall	39.88333	-122.53333	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Surrogate station for Thomes Creek RAWS
Thomes Creek RAWS	NWS 40816	West Valley and Sacramento Valley	Rainfall	39.86444	-122.6097	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCTHO	Main Station
Stoney Gorge	GHCND:USC00048587	West Valley and Sacramento Valley	Rainfall	39.38333	-122.55	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Surrogate station for Stonyford RAWS
Stonyford RAWS	NWS 041503	West Valley and Sacramento Valley	Rainfall	39.36694	-122.575	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCSTO	Main Station
Bangor RAWS	NWS 041201	East Valley(North) and Sacramento Valley	Rainfall	39.3975	-121.3861	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCBGR	Main Station
Cohasset RAWS	NWS 41211	East Valley(North) and Sacramento Valley	Rainfall	39.87167	-121.7689	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCCOH	Main Station
Lincoln RAWS	NWS 041907	East Valley(North) and Sacramento Valley	Rainfall	38.8825	-121.2683	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCLIN	Main Station
Santa Rosa RAWS	NWS 042009	West Valley and Napa/Santa Rosa	Rainfall	38.47861	-122.7119	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCSRS	Main Station
Santa Rosa GHCND	GHCND:USC00047965	West Valley and Napa/Santa Rosa	Rainfall	38.45	-122.7	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Surrogate for Santa Rosa RAWS
Martinez GHCND	GHCND:USC00045378	Suisun	Rainfall	38.0131	-122.1142	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Main Station
Los Banos RAWS	NWS 44003	San Joaquin Grasslands	Rainfall	37.05472	-121.0531	https: //wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCLAB	Main Station
Los Banos GHCND	GHCND:USC00045118	San Joaquin Grasslands	Rainfall	37.05	-120.86667	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Surrogate Station for Los Banos RAWS
Stockton Airport	GHCND:USW00023237	San Joaquin Grasslands and Delta	Rainfall	37.8891	-121.2258	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Main Station
New Melones Dam	GHCND:USC00046172	East Valley (South) and San Joaquin Grasslands	Rainfall	37.95	-120.53333	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Surrogate Station for Green Springs RAWS
Green Springs RAWS	NWS 43613	East Valley (South) and San Joaquin Grasslands	Rainfall	37.83306	-120.5	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCGSP	Main Station
Pine Flat Dam	GHCND:USC00046896	East Valley (South) and San Joaquin Desert	Rainfall	36.81667	-119.33333	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Surrogate Station for Fancher Creek RAWS
Fancher Creek RAWS	NWS 044516	East Valley (South) and San Joaquin Desert	Rainfall	36.88389	-119.4658	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCFAN	Main Station
Kettleman Hills RAWS	NWS 044602	San Joaquin Desert	Rainfall	36.03333	-120.0569	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCKET	Main Station
Sacramento Executive Airport	GHCND:USW00023232	Sacramento Valley and Delta	Rainfall	38.5069	-121.495	https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily	Main Station
Dismal Swamp	SNOTEL: 446	Northeastern	Snow	41.99	-120.18	https://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=daily_snowdelta_7day&state=ca	Main Station
Independence Lake	SNOTEL: 541	Northeastern	Snow	39.43	-120.28	https://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=daily_snowdelta_7day&state=ca	Main Station
Adin Mountain	SNOTEL: 301	Northeastern	Snow	41.24	-120.79	https://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=daily_snowdelta_7day&state=ca	Main Station
Cedar Pass	SNOTEL: 391	Northeastern	Snow	41.58	-120.3	https://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=daily_snowdelta_7day&state=ca	Main Station
Crowder Flat	SNOTEL: 977	Northeastern	Snow	41.89	-120.75	https://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=daily_snowdelta_7day&state=ca	Main Station

Appendix IV. Population estimates of mallards, gadwall, cinnamon teal and Canada geese by stratum 1992 – 2019. SV = Sacramento Valley, DE = Sacramento – San Joaquin Delta, SJD = San Joaquin Desert, SJG = San Joaquin Grasslands, SM = Suisun Marsh, NSR = Napa-Santa Rosa, EV = East Valley, WV = West Valley (see Fig. 1). LTA = long-term average.

Mallards										
Year	SV	DE	SJD	SJG	SM	NSR	NE	EV	WV	STATE
1992	163030	12453	5075	79859	29713	8969	44634	23687	8423	375843
1993	129527	8602	25643	63203	21847	9731	69231	28901	2323	359008
1994	114249	10143	17097	52107	18104	10160	66166	17483	6183	311692
1995	111410	10184	24056	71188	22705	14731	80861	23969	9422	368526
1996	205040	18519	12033	105438	26523	20231	92032	43230	12511	535557
1997	186048	8089	25207	114370	23054	11496	79169	51927	15585	514945
1998	148754	6741	17917	54344	18349	11582	67978	21957	12906	360528
1999	259325	5832	16693	70724	22127	14174	144884	17748	8556	560063
2000	147384	11263	23327	39461	8882	10278	83373	17249	6341	347558
2001	122509	12141	6093	33014	10881	10148	96756	7413	3249	302204
2002	116758	7816	8728	29121	10066	13672	64754	8229	6151	265295
2003	106957	12176	16362	58323	16669	11974	87611	19714	7270	337056
2004	97422	6303	14421	28513	14092	10881	70321	14474	5998	262425
2005	100143	9459	11345	42739	10883	18342	98220	22057	4681	317869
2006	120808	8196	10679	53264	12077	21486	128612	37242	7073	399437
2007	104601	8319	20904	47590	15691	32915	131267	20061	6976	388324
2008	92539	6465	17165	51548	10330	15516	85824	13689	4054	297130
2009	105141	4943	15818	39981	9094	12265	95913	14651	4153	301959
2010	102139	3948	14371	56255	14531	16137	128600	16586	15325	367892
2011	100972	7293	17693	38956	21501	18057	87095	17697	5450	314714
2012	85641	10136	33456	57816	14486	11058	138315	22645	8369	381922
2013	80903	5929	18323	33418	11580	13436	120132	12325	2590	298636
2014	67914	3826	8445	44586	8901	6156	90820	5850	2168	238666
2015	55086	9452	6568	24349	9704	7541	54182	1998	4986	173866
2016	69389	9240	7015	33952	13668	8790	99520	16122	6079	263774
2017	31134	6151	14913	21386	9921	10918	86637	13143	4188	198392
2018	56915	4850	12520	36929	14150	17363	109991	17749	2393	272859
2019	49307	6085	7893	31049	13625	15217	97628	14447	4580	239831
LTA	**111823**	**8377**	**15349**	**50482**	**15470**	**13687**	**92876**	**19366**	**6714**	**334142**
%Δ Prev.	**-13%**	**25%**	**-37%**	**-16%**	**-4%**	**-12%**	**-11%**	**-19%**	**91%**	**-12%**
% Δ LTA	**-56%**	**-27%**	**-49%**	**-38%**	**-12%**	**11%**	**5%**	**-25%**	**-32%**	**-28%**

Appendix IV. Continued…

Gadwall										
Year	SV	DE	SJD	SJG	SM	NSR	NE	EV	WV	STATE
1992	2332	0	2416	12701	4098	2853	9873	0	0	34274
1993	3654	0	4544	9187	4620	2484	41850	461	0	66800
1994	2084	0	2776	10852	5370	2368	29909	338	0	53696
1995	2927	175	2729	9566	9178	5461	64133	0	252	94421
1996	3214	0	2725	20205	10462	6615	45434	1326	0	89982
1997	8147	405	7387	13230	11024	15474	36903	1926	0	94496
1998	8826	0	5065	11096	9045	2908	41167	385	585	79078
1999	20160	184	2870	11995	5894	6403	40389	4539	0	92434
2000	5369	848	8247	19255	7363	8116	54162	358	272	103989
2001	3731	0	580	8208	4056	7419	44568	0	0	68560
2002	4506	215	3026	6118	4952	4742	34814	818	155	59345
2003	8572	495	2579	11471	5986	6767	40362	1568	238	78037
2004	3819	134	2933	12993	6797	5361	42716	1020	0	75773
2005	11455	0	3561	12600	9273	14309	128158	0	0	179356
2006	12910	376	5873	14647	7953	5973	74324	0	271	122326
2007	6216	463	6159	8547	5445	9152	101041	661	0	137686
2008	10601	250	3382	6225	4317	3841	39751	633	0	69000
2009	13950	120	2995	8580	6852	11299	63200	2505	0	109502
2010	5861	452	2829	9015	5780	3460	55128	0	238	82763
2011	6042	206	8693	11176	7450	9981	73263	1371	298	118479
2012	6116	322	2684	4070	5442	5393	27500	408	0	51936
2013	4259	741	4303	3123	4679	3474	52874	805	153	74410
2014	15113	0	8688	9890	5516	3167	50650	235	0	93259
2015	14492	123	1545	4425	3103	2407	30721	939	535	58290
2016	9432	495	3849	3379	4647	5613	30316	470	179	58380
2017	777	116	5768	5600	5308	4206	49603	220	167	71765
2018	10778	0	3160	5691	6100	8450	68244	214	0	102637
2019	9822	125	3104	6814	4914	6287	79781	474	0	111321
LTA	**7684**	**223**	**4088**	**9666**	**6272**	**6214**	**51815**	**774**	**119**	**86857**
%Δ Prev.	**-9%**	**NA**	**-2%**	**20%**	**-19%**	**-26%**	**17%**	**121%**	**NA**	**8%**
% Δ LTA	**28%**	**-44%**	**-24%**	**-30%**	**-22%**	**1%**	**54%**	**-39%**	**NA**	**28%**

Appendix IV. Continued…

Cinnamon Teal

Year	SV	DE	SJD	SJG	SM	NSR	NE	EV	WV	STATE
1992	3226	385	3611	19469	2149	395	28505	2928	0	60668
1993	3332	0	4972	10890	2497	1223	30591	2268	0	55773
1994	4846	321	4017	16585	1793	329	22388	1222	0	51503
1995	4575	195	5486	14380	3402	1000	18117	3893	282	51330
1996	22944	1666	4466	15300	3987	4883	27305	5885	2407	88842
1997	5381	917	10872	14012	1280	470	13649	1308	0	47889
1998	3843	229	2151	11113	533	235	15979	1744	0	35828
1999	9450	410	4487	12096	1335	841	10716	390	0	39725
2000	2979	0	3472	2340	930	456	14512	0	0	24689
2001	4019	266	1666	5053	496	273	13926	507	385	26592
2002	1789	0	2086	3936	807	547	4843	0	0	14008
2003	4353	0	2436	6019	1329	799	13459	988	0	29382
2004	3485	0	1857	7511	2764	305	18975	565	0	35461
2005	6056	0	4274	7613	1363	1602	14106	2971	0	37984
2006	10318	362	2264	11445	2021	743	26285	4131	0	57570
2007	2039	243	2282	2563	1358	749	28965	1851	0	40050
2008	7054	0	1462	9853	1849	719	21724	445	0	43105
2009	7483	235	1469	7922	328	241	32748	447	0	50872
2010	2856	170	5860	11849	872	175	22884	3564	246	48478
2011	11347	271	10158	10841	1260	1944	26339	1545	0	63704
2012	5125	278	869	2343	2198	855	14932	0	0	26600
2013	4594	548	857	1732	1020	281	13528	0	0	22560
2014	2871	734	0	5157	1366	502	19774	465	0	30870
2015	13127	0	0	1547	1594	1506	10407	0	354	28534
2016	2465	245	2288	1545	1684	1730	18868	1396	0	30221
2017	410	245	1523	3087	897	0	26883	930	0	33975
2018	4102	0	3047	4630	3140	1871	60779	930	0	78498
2019	3013	674	2098	3306	2059	680	37731	853	0	50415
LTA	**5610**	**300**	**3215**	**8005**	**1654**	**905**	**21747**	**1472**	**131**	**43040**
%Δ Prev.	**-27%**	**NA**	**-31%**	**-29%**	**-34%**	**-64%**	**-38%**	**-8%**	**NA**	**-36%**
% Δ LTA	**-46%**	**125%**	**-35%**	**-59%**	**25%**	**-25%**	**73%**	**-42%**	**NA**	**17%**

Appendix IV. Continued…

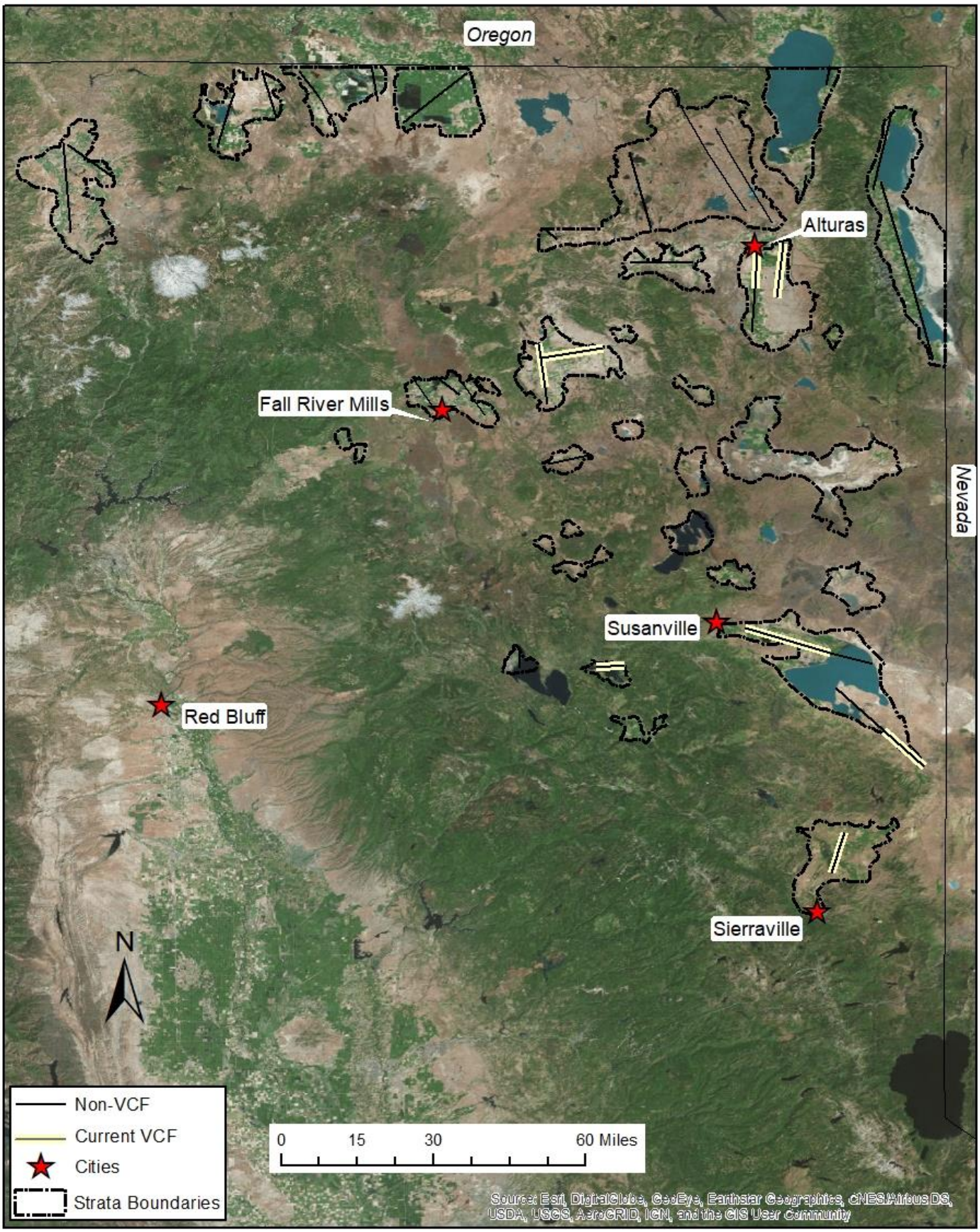
Canada Geese										
Year	SV	DE	SJD	SJG	SM	NSR	NE	EV	WV	STATE
1993	590	0	0	0	98	72	50405	134	0	51299
1994	354	0	0	0	0	0	59291	468	0	60113
1995	708	0	0	0	0	72	53060	0	0	53840
1996	236	0	0	0	0	72	45298	0	0	45606
1997	1651	457	0	74	147	216	32735	134	51	35466
1998	884	141	0	0	33	216	68929	936	559	71699
1999	649	0	0	3261	229	974	96673	268	508	102562
2000	1592	35	0	0	180	902	47903	134	0	50745
2001	1474	739	0	741	131	1804	52754	0	1067	58709
2002	825	317	0	371	0	1118	47136	1338	203	51308
2003	1297	106	0	519	115	1154	32495	1806	203	37695
2004	354	176	0	296	65	2706	27424	401	0	31422
2005	1484	169	0	711	0	3113	36230	561	1035	43302
2006	0	0	0	0	20	130	19792	0	244	20185
2007	356	567	0	0	0	291	31629	337	154	33333
2008	189	150	0	238	0	0	9874	0	0	10451
2009	4338	0	0	0	0	0	31989	703	0	37030
2010	860	0	0	541	0	865	13999	1394	1324	18983
2011	4670	330	0	618	512	2068	36248	4253	794	49493
2012	3855	0	0	308	459	2209	41926	4651	1951	55359
2013	3327	551	0	929	342	1998	68248	4473	956	80823
2014	3049	296	0	2496	197	1692	31209	3378	183	42499
2015	2623	254	0	267	79	2169	44322	1609	794	52117
2016	8377	423	264	2226	175	2477	44323	3619	796	62679
2017	7211	313	0	1233	287	2603	55224	3268	2091	72230
2018	4064	587	243	1151	556	1554	54851	3491	1582	68079
2019	7943	1377	0	2384	501	5106	48588	3615	1463	70977
LTA	**2332**	**259**	**19**	**680**	**153**	**1318**	**43798**	**1517**	**591**	**50667**
%Δ Prev.	**95%**	**135%**	**NA**	**107%**	**-10%**	**228%**	**-11%**	**4%**	**-8%**	**4%**
% Δ LTA	**241%**	**432%**	**NA**	**250%**	**228%**	**287%**	**11%**	**138%**	**148%**	**40%**

Appendix V. Five-year average of total indicated birds (mallards) on northeastern segments to inform changes to visual correction subsample.

Segment	TIB[1]	Comment
1	29.0	Selected 2019
2	10.8	Historic, discontinued.
3	21.2	Historic, selected 2019
4	63.4	
5	84.2	
6	98.6	Selected 2019
7	140.0	
8	134.4	Selected 2019
9	61.6	
10	22.0	
11	33.6	
12	2.8	
13	13.8	
14	7.2	
15	12.2	
16	32.8	
17	7.0	Historic, discontinued.
18	19.6	
19	27.2	
20	8.0	
21	60.0	Historic, discontinued.
Min	2.8	
Quartile 1	12.2	
Quartile 2	27.2	
Quartile 3	61.6	
Max	140.0	

[1]Five-year average of total indicated birds (mallards).

Appendix VI. Visual Correction Factor segments in Northeastern California stratum, 2019.



Appendix VII. Year-to-year statistics to compare visual correction factor (VCF) estimates of the five most common species. Fixed-wing and Helicopter values represent total indicated birds.

Species[1]	Year	2016	2017	2018	2019[3]
MALL	Fixed-Wing	787	621	921	921
	Helicopter	925	1043	988	1656
	VCF	1.18	1.68	1.07	1.8
	VCF CV[2]	0.14	0.22	0.12	0.10
GADW	Fixed-Wing	167	232	254	588
	Helicopter	268	304	313	1041
	VCF	1.60	1.31	1.23	1.77
	VCF CV	0.42	0.10	0.14	0.15
CITE	Fixed-Wing	52	28	64	130
	Helicopter	113	80	109	370
	VCF	2.17	2.86	1.70	2.85
	VCF CV	0.77	0.53	0.32	0.37
CAGO	Fixed-Wing	213	116	0.54	0.16
	Helicopter	155	128	0.83	0.27
	VCF	109	116	1.06	0.22
	VCF CV	384	670	1.74	0.16
AMCO	Fixed-Wing	1211	892	1189	1285
	Helicopter	1907	784	2846	2362
	VCF	1.57	0.88	2.39	1.84
	VCF CV	0.25	0.30	0.15	0.18

[1]MALL = mallard, GADW = gadwall, CITE = cinnamon teal, CAGO = Canada goose, AMCO = American coot.
[2]CV = coefficient of variation
[3]2019 represents first year of modification to subsample in Northeastern stratum.