Channeled Scablands Spring Waterfowl Surveys 2016-2019 Report

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Cover photo: Turnbull National Wildlife Refuge, Cheney, WA during fixed-wing Aerial Survey. Photo by DU.

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Acknowledgements

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Executive Summary:

The Channeled Scablands of Eastern Washington (CSEWA) contains one of the most understudied and undervalued wetland complexes for waterfowl in the Pacific Flyway. This unique natural geological feature formed thousands of years ago, when Glacial Lake Missoula's ice dam collapsed repeatedly, releasing an intense mega flood that scoured the land within the course of days. What was left behind was an intricate network of tens of thousands of geomorphic basins across a vast landscape that supports a diverse and dynamic wetland complex for waterfowl and many other migratory birds returning to breed in Washington and seeking vital resources enroute to destinations that lie beyond.

Studies of waterfowl spring migration have highlighted the importance of readily available, food-rich habitats for meeting energetic and nutritional needs of birds migrating to northern breeding areas. The quality and availability of habitats during this energetically demanding period directly influences the condition of hens arriving on the breeding grounds and their subsequent nest initiation, clutch size, and ultimately recruitment of offspring into the population. While conceptionally straightforward, in practice, documenting and characterizing species composition and abundance for multiple species with disjunct migration chronologies during a period of high turnover of local populations is extremely difficult.

Past studies have identified Southern Oregon-Northeastern California (SONEC), as one of the most important spring staging areas in the Pacific Flyway, particularly for northern pintail. However, parallel studies using surveys to document spring waterfowl are lacking in many other major regions of the Pacific Flyway. This has led to knowledge gaps regarding the relative contribution and importance of these other geographic regions to the complete network of migration sites. As such, pertinent prioritization of all regions within the flyway with respect to conservation of spring migration habitats is problematic. An unfortunate and undesirable result of this may be insufficient recognition of unstudied regions and a corresponding reduction in access to important conservation resources in these regions to effectively address flyway-level efforts and needs. The CSEWA is one example of this waterfowl conservation conundrum.

In 2015, seeking to fill this knowledge gap, the Washington Department of Fish and Wildlife, Turnbull National Wildlife Refuge, and Ducks Unlimited initiated the first-ever landscape-scale study of waterfowl spring migration ecology in the CSEWA. This study documented abundance and species composition of migrating waterfowl, migration timing, and relative habitat use where habitats were categorized by waterbody type, size, and land cover. The study team, comprised of natural resource professionals and volunteers, conducted weekly aerial and ground surveys from mid-February to late-April during 2016-2019, within an area of ~6,960 sq km (2,687.5 sq mi) or ~27% of the CSEWA region. Aerial surveys were performed from fixed wing aircraft along 11 linear transects which covered 283.3 sq km (109.4 sq mi), approximately 4.1% of the survey area. Ground surveys were conducted weekly from a vehicle to quantify available wetland habitats, and abundance and species composition of birds within each habitat type. Eight survey routes representative of the CSEWA collectively covered approximately 370 road miles.

<u>Species composition and abundance</u>

Twenty-seven species of waterfowl were observed during the surveys. Of these, ten are considered high priority species by the Intermountain West Joint Venture. The five most abundant species detected were (in descending order): northern pintail, mallard, American wigeon, lesser/greater scaup (predominantly lesser scaup), and bufflehead. Total bird use-days (BUD) for all species during our survey years averaged over 5.7 million and peaked in 2019 at over 6.9 million. While the total BUD did not significantly differ between years, there was a marked difference in the distribution of BUD during the survey period across years that appears to have been largely influenced by timing of the spring thaw.

Dabbling ducks comprised most of the use-days accounting for over half of total BUD on average throughout the study. Diving ducks, geese, swans and coots each accounted for less than 20% of total BUD. American Coot was the only species where abundance estimates declined annually.

Migration phenology

While the timing of migration initiation and peak numbers of ducks varied somewhat across years, ducks generally began arriving in the CSEWA by the second or third week in February and reached peak abundance about the third week in March each year. Diving duck numbers peaked consistently a week later than dabblers in all years. Patterns for geese, swans and coots were more variable across years. Geese and swans generally hit peak numbers in mid-March with coots reaching peak numbers in the second to third week of April.

Habitat selection

Waterbodies > ½ acre were the most frequent habitat type for all waterfowl use observations, except for mallards, pintails, and wigeon which were observed in sheetwater habitat more than any other type. Further, approximately 90% of bird observations in sheetwater habitats (all species and groups) were on agricultural sheet water (versus native sheetwater such as vernal pools and rangelands). Perennial agriculture sheetwater was used more often than flooded annual crops by all species except for geese, which used them about equally.

Agricultural sheetwater habitats in the CSEWA, particularly perennial agriculture, are often historical wetlands that have been ditched, drained, and converted for production of hay. These hayfields typically contain deep, productive soils with connectivity to ground and surface water sources; when flooded in the spring, they provide high-value foraging habitat for waterfowl.

Importance of Channeled Scablands wetlands in the Pacific Flyway

Due to the recognized importance of SONEC to spring migrating waterfowl, comparisons were made between results of this study and studies done there. Corrections for geographic size and length of the migration season were made to strengthen these comparisons. These comparisons indicated a similar or greater number of birds per day, peak population, and bird-use days for many species of waterfowl in the CSEWA when compared to SONEC. Species for which indices were higher in the CSEWA included mallard, cinnamon/blue-winged teal, bufflehead, ring-necked duck, goldeneye, redhead and Canada geese. Those species with indices that were very similar in both locations include northern pintail, American wigeon and scaup spp., except for peak numbers of northern pintail, which were higher in the CSEWA than in SONEC.

The CSEWA appears to support many waterfowl species during spring migration at densities comparable to SONEC, but disproportionately high densities for some species, such as mallard and cinnamon teal, which had 5.5 and 6.8 times more use days than expected. Because cinnamon teal have the narrowest population distribution and most southerly breeding range of all the North American teal, the CSEWA may be especially important to this species. This species tends to use smaller wetlands with tall emergent vegetation, and the CSEWA contains a high density of smaller isolated wetlands compared to SONEC and thus can support larger numbers of cinnamon teal.

Most of the flood-irrigated habitats in the CSEWA are passively flooded during spring snow melt, rains, and over-bank flooding rather than being actively flooded through water diversions from streams and rivers as is common in SONEC. As a result, conversion of flood irrigation to pivots has been relatively rare in the CSEWA, unlike SONEC where it remains a threat. If conventional flood-irrigated habitat becomes scarcer in traditional migration stopover locations in the arid west, the passively flooded habitats available in the CSEWA during spring may become even more important to waterfowl in the Pacific Flyway.

This study represents a significant step in improving understanding of spring migration ecology and the relative importance of the CSEWA to Pacific Flyway waterfowl. Ongoing threats and challenges that include continued land conversion, climate change, and limited conservation funding must be overcome to ensure this important area for spring migrating waterfowl is preserved and maintained well into the future. A variety of policies and programs are needed to provide the necessary funding, mechanisms, and flexibility to implement large-scale conservation approaches in this diverse landscape. Elevation of the importance of this area for non-breeding waterfowl in the Pacific Flyway by relevant agencies and organizations is supported by the study results and urgently needed to secure its preservation.

Future conservation activities should prioritize agricultural sheetwater habitats due to their oversized importance to waterfowl during the spring period. Cost-share funding and technical assistance should be strongly directed to working lands in support of agricultural practices that preserve and maintain these valuable habitats on the landscape. Complementing activities could include land protection where the threat of conversion is high and hydrologic restoration where it benefits desirable agricultural habitats or restores wetlands, among others. These data provide powerful insights for targeting future on-the-ground conservation efforts and set an important baseline for future studies illustrating the importance of wetlands within the Channeled Scablands to waterfowl of the Pacific Flyway.

Introduction:

The Channeled Scablands (CS) of eastern Washington extend from Spokane west to the Columbia River near Vantage and southwest to the Snake River near Pasco (Figure 1). The scablands were created by mega floods during the last ice age (10,000 to 20,000 years ago). The floods were caused when part of a glacier blocked the Clark Fork River in Montana, forming an ice dam and creating Glacial Lake Missoula. The ice dam eventually collapsed under the pressure of the water held in the lake, estimated to be as much water as Lake Erie and Lake Ontario combined. More than 500 cubic miles of water tore across the CS at about 80 miles per hour carving canyons, cutting waterfalls, and sculpting a series of braided waterways. Geologists estimate the ice dam formation and collapse happened upwards of 40 times. This resulted in what we see today, a series of mostly dry coulees and basalt plateaus, speckled with lakes, pothole wetlands and seasonal wetlands, and surrounded by shrub steppe and dryland agriculture. The lakes, potholes, and other wetlands are largely dependent now on winter snow and spring rains, cut off from the river that carved them.

The CS contains migratory stop-over habitats for a variety of waterfowl, including ducks, geese, swans, and many other migratory bird species. High quality spring migration stop-over habitats in sufficient quantity are critical to maintaining waterfowl populations. These stopovers provide crucial resources, including food to fuel their long-haul flights, safe places to roost, and somewhere to ride out unfavorable events such as storms and cold fronts. This allows waterfowl to arrive on their breeding grounds in good condition, and thereby increase the success of nesting and fledging young.

Though the CS of eastern Washington has been recognized as a continentally important area for waterfowl (U.S. Department of the Interior et al. 2012), data on spring migration timing, duration, species composition, population numbers, and habitat use in this area at a broad scale are lacking. A study of 18 restored wetland basins at four project sites on Bureau of Land Management (BLM) lands in the CS was conducted in 2012 to document use by waterfowl and other birds during spring and summer (Bonsignore et al. 2013). Additionally, Turnbull National Wildlife Refuge (TNWR), in the heart of the CS, has a long-term waterfowl monitoring program on the Refuge (U. S. Fish and Wildlife Service 2007). However, these wetlands on TNWR and BLM represent a unique set of restored wetlands managed for wildlife. Over 70% of the wetlands in the CS are in private ownership, and over 70% of those wetlands are estimated to be impacted by agricultural drainage ditches. Additionally, waterfowl in the CS use a variety of habitats, some of which were not represented in either of those data sets, such as flooded agricultural fields.

Seeking to fill this knowledge gap, the Washington Department of Fish and Wildlife (WDFW), U.S. Fish and Wildlife Service (USFWS) TNWR, and Ducks Unlimited (DU) initiated a large-scale spring migration survey effort from 2016-2019 in the CS (Figure 1, Table 1) utilizing aerial surveys and ground surveys. Volunteers from the Spokane Chapter of the Audubon Society and Professor Stephen Hayes and students at Gonzaga University (GU) joined in this effort once field surveys began. The U.S. Geological Survey (USGS) defines the CS as a 38,850 sq km (15,000 sq mi) area bounded by the Spokane River on the north, the Columbia River on the West, and the Snake River on the south, to the state border on the east. For this project, we used the USGS definition of the CS minus the portion west and south of Moses Lake and the deep Palouse soils area in the east (red polygon in Figure 1). We removed these portions because the Columbia Irrigation Project has transformed the landscape west and south of Moses Lake in ways that make it less comparable to the remainder of the non-irrigated scablands, and the deep Palouse soils were not scoured by the floods. We estimate the total area of the reduced CS as ~25,900 sq km (~10,000 sq mi). Due to limited staff time and funds our survey area did not cover the full extent of the reduced CS. We instead focused the survey effort on the two annual breeding pair survey (aka BPOP) polygons from the Pacific Flyway (USFWS 2014) that comprise the core of the CS (green polygons in Figure 1). These two polygons cover approximately 6,960 sq km (2,687.5 sq mi), ~27% of the CS as defined for this project.

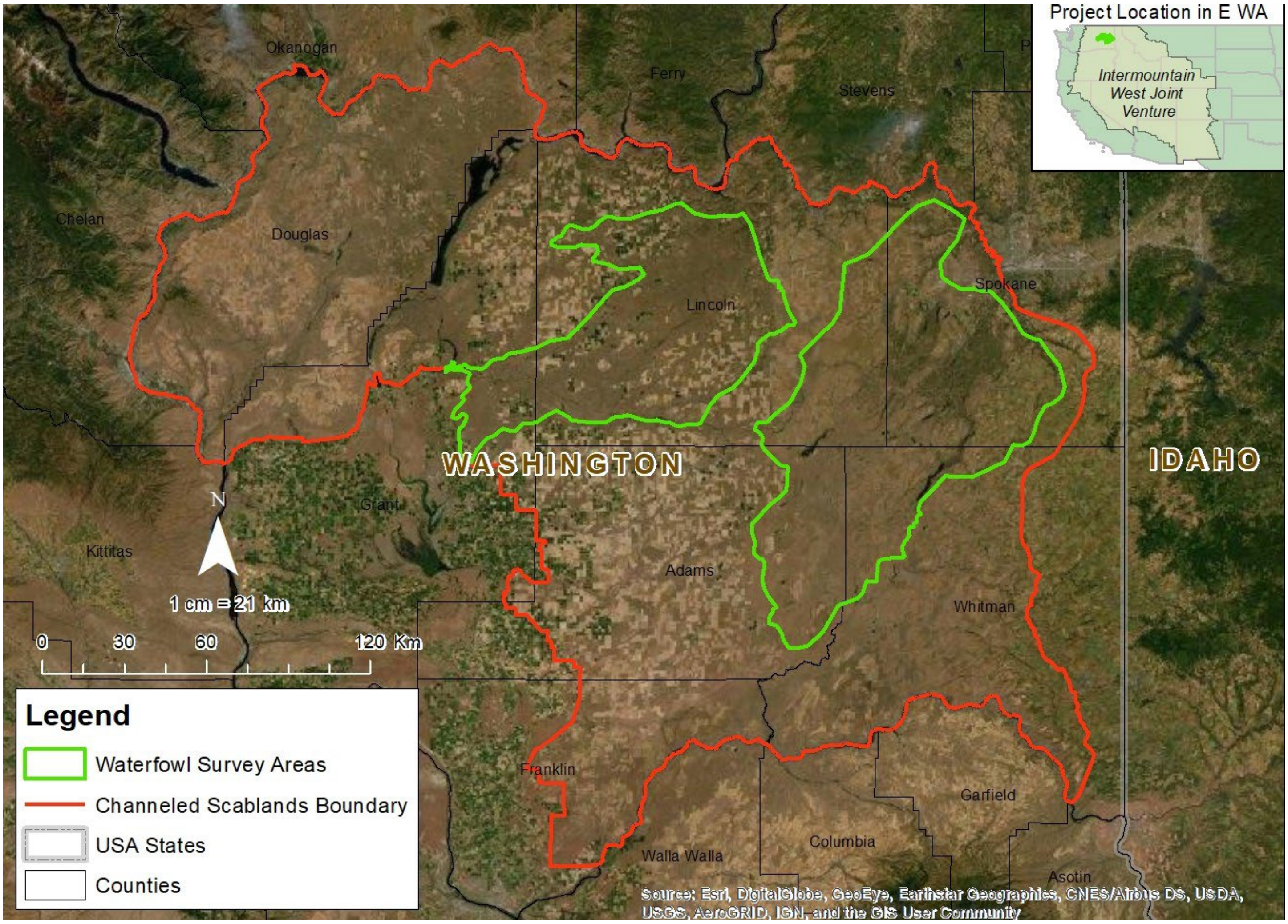


Figure 1: Survey areas within the non-irrigated portion of the eastern Washington Channeled Scablands, in relation to the state and the Intermountain West Joint Venture boundaries.

Table 1: Number of aerial surveys and ground surveys for each year of the project (2016-2019).

	2016	2017	2018	2019	TOTAL
# OF AERIAL SURVEYS	4	8	8	8	28
# OF GROUND SURVEYS	85	88	97	83	353

The goals of this project were to better understand waterfowl spring migration ecology in the CS, investigate the relative importance of the area for spring migrating waterfowl in the Pacific Flyway, and use this information to prioritize habitat conservation activities and improve management of these habitats for the long-term benefit of waterfowl and many other species. The urgency of this study and the resulting knowledge is elevated by the potential impacts of climate change in this area on wetlands and waterfowl habitats, which depend largely on winter precipitation in the form of snowpack, and where climate models predict there will be longer, hotter summers, decreased snowpack, increase in winter rains, and an earlier spring freshet (Halabisky et al. 2017).

The primary metrics in this study were: (1) abundance estimates of daily populations of migrating waterfowl; (2) species composition; (3) timing of migration (i.e., dates of initiation, peak, end of migration season); and (4) relative habitat use where habitats were categorized by waterbody type, size, and land cover (i.e., native or agricultural).

Annual Weather Conditions Compared to the Long-Term Average

Temperature, precipitation, and snowfall data for the three survey years were used to characterize the spring migration setting for comparison to long-term conditions (Appendix 4) and to explain annual and seasonal differences in bird numbers observed during the study. Monthly and partial water year totals for precipitation and snowfall from October of the previous year through the survey period (February – April) were used to predict the potential recharge of spring wetland habitat. Monthly averages of high and low temperatures and the number of days with daily highs below freezing during January and the survey months were thought to be the factors most influencing the availability of open water for migrating waterfowl.

Snowfall and precipitation during the three years of the study were above average for potential wetland recharge (Table 2). From October 2016 – March 2017 ('16/'17 column), total precipitation was nearly double the long-term average with above-average snowfall from December through March. February snowfall was nearly triple the long-term average. The 2017/2018 partial water year was considerably drier than the previous year, but still received above-average precipitation and snowfall. February snowfall was also substantially greater than average. The last year of the study 2018/2019 received near-average levels of precipitation but well above average snowfall with February receiving over four times the average monthly total. The result of these above-average hydrologic inputs was the recharge of ample wetland habitat during the spring migration period. This coincides with a long-term spring wetland condition index reported by Turnbull National Wildlife Refuge that found that over 80% of the refuge wetlands were at greater than 75% capacity for all three years whereas during the previous four years (2013-2016) less than 50% of the wetlands were at this level (Figure 2).

Table 2. Total monthly snowfall and precipitation in inches for the portion of the water year with the greatest influence on wetland conditions during spring migration: October – March. For example, '16/'17 refers to October 2016 – March 2017.

Snowfall	'16/'17	'17/'18	'18/'19	30yr Average
October	0	0	0	0
November	3.3	7.2	2.6	7
December	19.1	16.7	11.7	15
January	13.6	8.2	5.2	11
February	19.1	12.0	29.9	7
March	5.4	4.9	3.8	4
Total	60.4	49.0	53.2	44.0
Precipitation				
October	6.2	1.4	1.6	1.18
November	1.6	2.9	2.0	2.3
December	1.5	2.9	2.6	2.3
January	1.9	2.6	1.8	1.79
February	4.4	1.6	2.4	1.33
March	4.2	1.3	0.7	1.61
April	1.6	2.0	1.5	1.28
Total	21.3	14.6	12.5	11.8

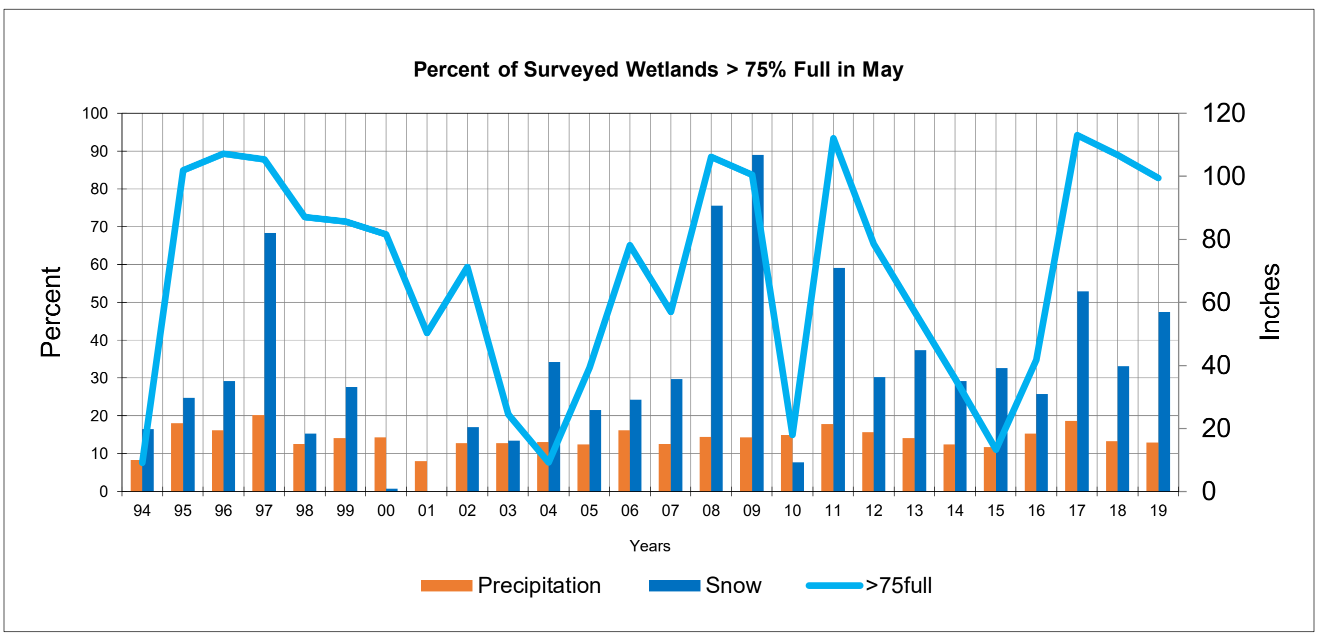


Figure 2. Turnbull NWR May Wetland Condition Index and annual snowfall and precipitation 1994-2019.

Although wetland recharge was ample during each year of the study, temperatures during the survey periods varied substantially, resulting in seasonal variations in the availability of open water between years (Table 3). The 2017 survey period started out colder than average, resulting in little melting and runoff of accumulated snow into February. Near average temperatures returned in late February and March, opening seasonal wetlands and most surface water. Of the three years, 2018 was the warmest with maximum and minimum temperatures above or near average, and the fewest number of days where the maximum daily temperature was below 32◦F. These warmer temperatures result in earlier availability of shallow open water and an earlier opening of the deeper water bodies. The 2019 survey year started out warmer than average in January but quickly dropped to substantially below average temperatures in February and early March that coincided with heavy snowfall. Near average temperatures did not return until later in March resulting in a later availability of open water habitat through the remainder of the survey period.

Table 3. Average daily maximum and minimum temperatures and the number of days with a maximum temperature at or below 32°F for the month prior to surveying and the three months covering the survey period.

Average Max Temp (°F)	2017	2018	2019	30yr Average
January	27.1	38.1	35.7	34
February	36.0	37.3	28.4	40
March	47.5	48.2	44.6	49
April	55	56.1	57.3	57
Average	48.2	44.9	41.5	45.0

Average Min Temp (°F)	2017	2018	2019	30yr Average
January	13.6	29.5	26.2	25
February	22.7	23.3	14.5	26
March	34.1	30.9	24.7	32
April	37.5	37.4	38.7	37
Average	27.0	30.3	26.0	30.0

Days with High ≤32°F	2017	2018	2019	30yr Average
January	21	4	6	10
February	7	6	19	9
March	0	0	4	2
April	0	0	0	0
Average	7	3	7	5

Aerial Surveys:

The methodology used for the aerial surveys closely followed the methodology used for the annual breeding pair waterfowl surveys (aka BPOP) in the Pacific Flyway (USFWS 2014). However, a fixed-winged platform was used instead of a rotary due to the number of flights planned and the lower cost of the aircraft. Aerial surveys followed linear transects located within the two green polygon survey areas (Figure 3) and transects were generated in ArcGIS and oriented northeast to southwest, in the direction of the ice age carved flood tracts. We followed a stratified random approach to selecting the initial transect within each polygon, and all other transects were based off this transect. Transects were spaced using a set distance of 9.65 km (6 mi) between transects to minimize double-counting birds that might get flushed during the survey, maximize coverage of the survey areas, and keep total survey length short enough that the survey could be flown in a single day. Eleven transects were created (Figure 4) and totaled approximately 708 km (440 mi) in length and 400 m wide (200 m from each side of the plane). The eleven transects covered 283.3 sq km (109.4 sq mi), approximately 4.1% of the survey area. The same transects were used all four years. To ensure that the wetland habitat within the transect buffers reflected that available in the survey area we compared the percentage of USGS National Wetlands Inventory (NWI) wetland types within each. The percentage of the various wetland types closely matched between the two areas, differing at most by 0.3% in any one type, and with a total wetland habitat percentage of 4.7% in the survey area compared to 5.1% in the transect buffers.

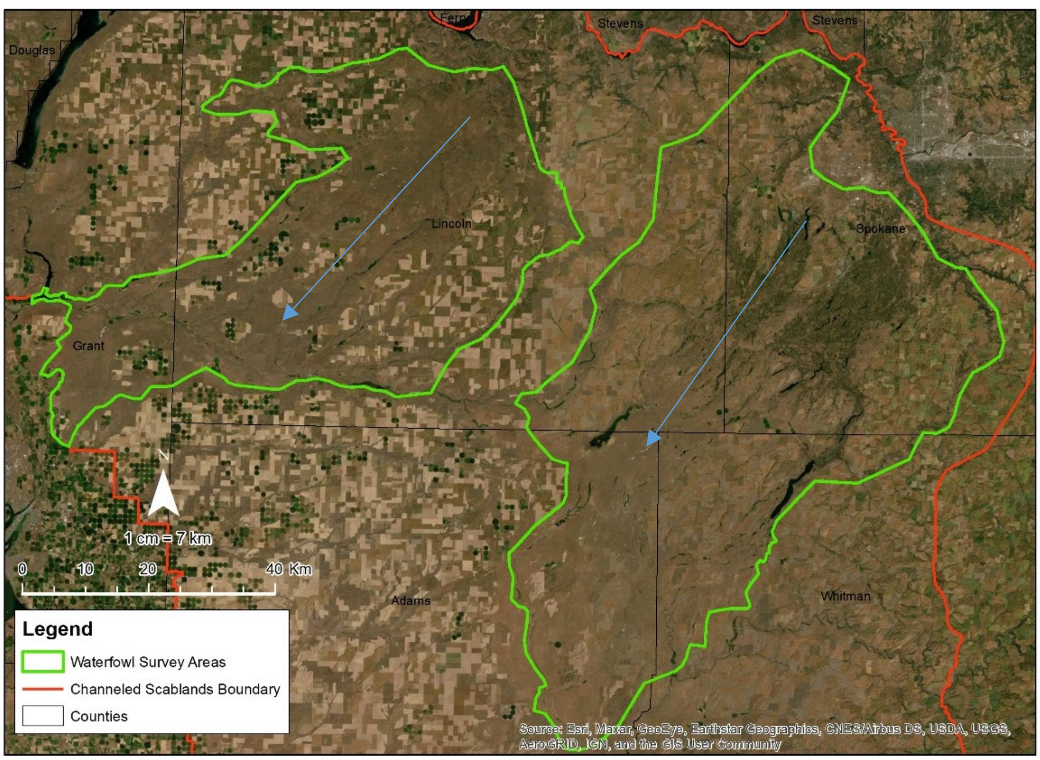


Figure 3: Northeast-southwest orientation of the major ice age flood tracts in the survey area.

Figure 4: Survey areas with the eleven aerial transects used for fixed-wing surveys.

Protocol

Aerial surveys started the second week of February and ended in late April. They were conducted every other week during the 2016 season, however ground surveys in 2016 detected a large pulse of birds missed by the aerial surveys due to the every-other week schedule that year. Therefore, we changed the protocol to weekly from 2017 onward. We only include aerial data from 2017-2019 in the results below.

Flights were carried out in a Cessna 182 fixed-wing aircraft with experienced WDFW staff performing the counts. One surveyor (Matthew Wilson, WDFW Waterfowl Specialist) was present for all fixed-wing surveys to ensure consistency. These transects were flown in a single day-long survey and flights followed WDFW safety protocol. The standard elevation was 70 m (200 ft) above ground level and typical speed was 160 kph (100 mph).

Data Collection

Staff performing aerial surveys were equipped with a GPS unit containing the survey transects to follow during the flight, an audio recording device, and reference guides for identifying waterfowl species from an aircraft. Birds were counted within a 200 m transect on each side of the plane. Data were recorded by each surveyor for their assigned side of the aircraft using the audio recorder. Data recorded included the time (hour, minute, second), count of individual birds, and species. Additional notes were recorded, including flight details, weather, and ground conditions (such as frozen). Audio files were transcribed into Excel and then imported into a master Access database for analyses.

Analyses

Population estimates for each species and group (dabblers, divers, mergansers, geese, swans, and coots) were calculated using the aerial data only. Weekly population point estimates for the entire survey area (two green polygons in Figure 3) were calculated for each survey period (typically a week but were sometimes longer or shorter due to weather), using the total number of birds counted on all transects (flown once per survey period), divided by the area covered by all transects and then multiplied by the total area of both survey polygons combined.

We then use that number to represent waterfowl abundance in the CS in several ways: the average number of birds per day, peak waterfowl abundance, and total annual bird use-days.

The average birds per day estimates for each survey year were calculated by averaging the weekly point estimates for that year.

Timing of the peak waterfowl abundance was represented by the survey week that had the highest point estimate for each species and group in each year.

Total annual bird use-days were calculated by multiplying the point estimate for each survey period by the number of days in that survey period; use-days for each survey period were then summed by year, then divided by the total number of survey days in that year, and then multiplied by the average annual survey length of 72 days to allow for comparison between years.

Days in a survey period were calculated as the number of days from the midpoint of the preceding survey date to the midpoint of the following survey date. For the first survey period, where there is no preceding survey, the days following the survey to the midpoint of the next survey day were doubled. For the last survey period, the number of days to the midpoint of the preceding survey were doubled. The duration of the combined survey periods was 65 days in 2017, 73 in 2018, and 77 in 2019, resulting in an average of 72 survey days per year.

Results

Waterfowl Species Richness

During all years of aerial and ground surveys, we observed 27 species of waterfowl (Table 4). Ten are considered high priority by the IWJV (IWJV 2019): mallard, northern pintail, American wigeon, cinnamon teal, redhead, greater and lesser scaup, tundra and trumpeter swans, and American coots. Also, cavity-nesting ducks, including bufflehead and goldeneye, are considered priority species by the State of Washington. In descending order, the top five most abundant species detected (from raw counts of all aerial surveys combined) were northern pintail, mallard, American wigeon, scaup species combined (most observers did not differentiate between lesser and greater), and bufflehead.

Table 4: Species of waterfowl and coot observed on aerial and ground surveys during the 2016 - 2019 spring waterfowl migration project in the Channeled Scablands.

GUILD	SPECIES	OBSERVED DURING
DABBLERS	American green-winged teal	Aerial and Ground
	American wigeon^	Aerial and Ground
	Blue-winged teal	Aerial and Ground
	Cinnamon teal^	Aerial and Ground
	Eurasian wigeon	Ground
	Gadwall	Aerial and Ground
	Mallard^	Aerial and Ground
	Northern pintail^	Aerial and Ground
	Northern shoveler	Aerial and Ground
	Wood duck	Aerial and Ground
DIVERS	Barrow's goldeneye	Aerial and Ground
	Bufflehead	Aerial and Ground
	Canvasback	Aerial and Ground
	Common goldeneye	Aerial and Ground
	Common merganser*	Aerial and Ground
	Hooded merganser*	Aerial and Ground
	Red-breasted merganser*	Aerial
	Redhead^	Aerial and Ground
	Ring-necked duck	Aerial and Ground
	Ruddy duck	Aerial and Ground
	Scaup spp.^	Aerial and Ground
GEESE & SWANS	Canada goose	Aerial and Ground
	Lesser snow goose	Aerial and Ground
	Greater white-fronted goose	Ground
	Tundra swan^	Aerial and Ground
	Trumpeter swan^	Aerial and Ground
COOTS	American coot^	Aerial and Ground

^IWJV priority species.

*Mergansers were summarized separately for aerial data but included in Divers for ground data.

Some species or morphs were seen infrequently on the aerial surveys, such as only once or twice during the entire four years. They are included in the aggregate results shown below (i.e., all ducks, all dabblers, all divers, all geese), but are not broken out individually. We report those observations here as a reference for future work in this area. Wood ducks: 2 birds were observed on 3/27/19, and 3 birds on 4/30/19. Lesser snow goose blue-morph: 12 were observed on 3/12/18. Lesser snow goose white-morph: 4 birds were observed on 3/18/19. Small Canada goose: 250 observed on 4/16/19. Unknown/unidentified goose: 144 observed on 2/22/18, and 10 on 3/18/19. Blue-winged teal: 10 were observed on 3/23/2017. Ruddy duck: 60 birds were observed on 4/11/17 and 22 on 4/30/19. Other observations of these species were made during ground surveys, and data are available by contacting WDFW. Observations of undifferentiated birds were included in aggregate results as well, but not analyzed separately (e.g., unknown ducks, unknown divers, unknown geese).

Average Birds Per Day

The average birds per day for each species and group for each survey year is presented in Table 5. Average birds per day varied across years with numbers generally increasing for most species from 2017 to 2019. Average birds per day (all species combined) was over 85,000 when averaged across all three years, and increased from approximately 57,000 in 2017 to nearly 109,000 in 2019. The average ducks per day (divers and dabblers combined) was also greatest in 2019, and lowest in 2017 (Figure 5). In 2019, the average number of ducks present daily was approximately 72,500; 85% of those were dabbling ducks and 15% were diving ducks. In 2018, approximately 62,000 ducks were present daily; 74% were dabbling ducks and 26% were diving ducks. The average number of ducks per day was approximately 43,000 in 2017, with 85% as dabbling ducks and 15% diving ducks.

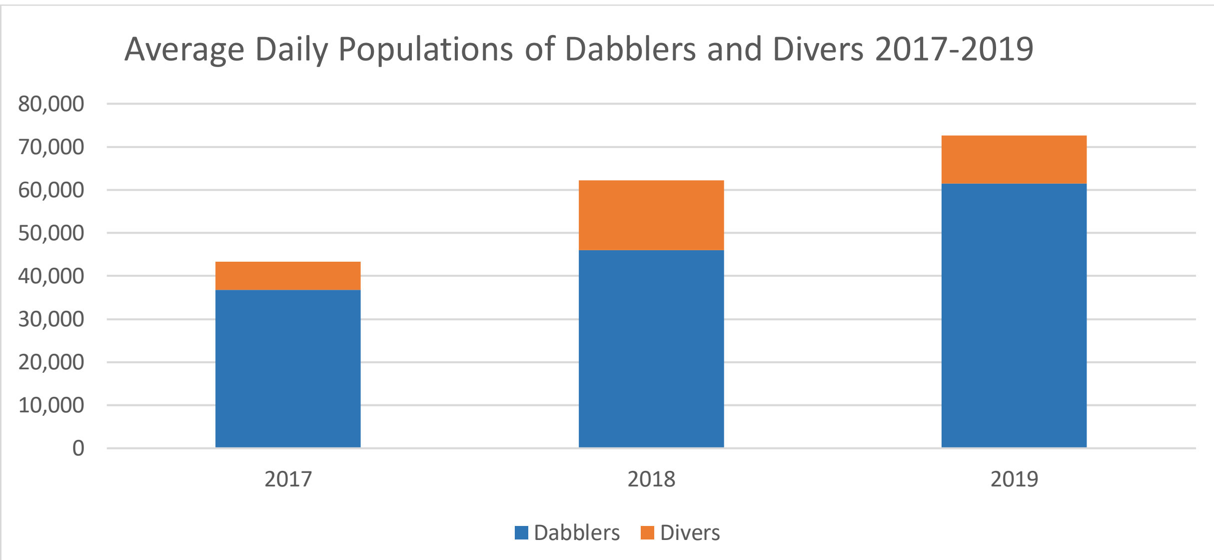


Figure 5: Average birds per day during the survey period for dabbling and diving ducks from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

The estimated average birds per day for geese, swans, and coots varied across years (Figure 6). For swans and geese, the average birds per day numbers were lowest in 2017. Goose numbers increased over 300% from 2017 to 2018 and 2019. Swans were observed in small numbers, lowest in 2017 and 2018 with an apparent 600% increase in 2019. Coot numbers were relatively stable in 2017 and 2018 with a nearly 50% apparent decrease in 2019.

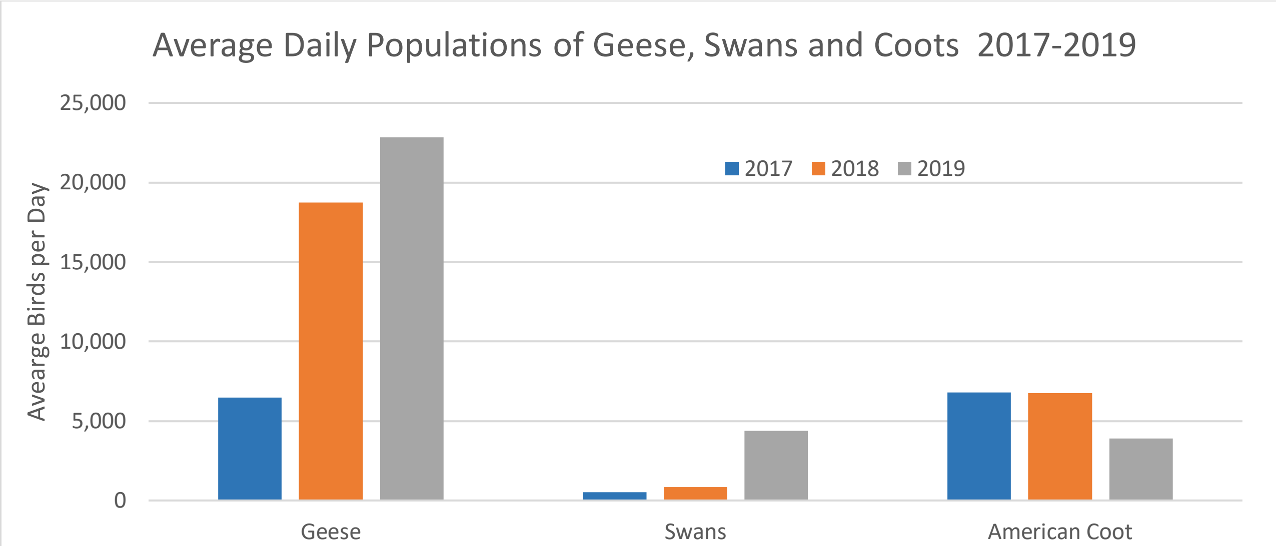


Figure 6: Average birds per day for geese, swans, and American coot from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

Table 5. Average birds per day estimates during spring migration for each species and group (dabbling and diving ducks, geese, swans, mergansers and American coot) from 2017-2019 in the Channeled Scablands. Percentage of each group or species from the total waterfowl average birds per day is given.

Species or Group	2017	%	2018	%	2019	%	Average (2017-2019)	%
Dabblers	**36,860**	**64.2%**	**46,065**	**51.4%**	**61,427**	**56.5%**	**48,110**	**56.5%**
Northern Pintail	15,543	27.1%	17,144	19.1%	36,210	33.3%	22,966	27.0%
Mallard	13,222	23.1%	18,992	21.2%	15,921	14.6%	16,045	18.8%
American Wigeon	6,204	10.8%	6,876	7.7%	6,956	6.4%	6,679	7.8%
American Green-Winged Teal	316	0.6%	2,589	2.9%	1,619	1.5%	1,508	1.8%
Cinnamon/Blue-Winged Teal	1,250	2.2%	37	<0.1%	359	0.3%	549	0.6%
Northern Shoveler	132	0.2%	141	0.2%	292	0.3%	188	0.2%
Gadwall	193	0.3%	286	0.3%	55	0.1%	178	0.2%
Divers	**6,554**	**11.4%**	**16,102**	**18.0%**	**11,127**	**10.2%**	**11,261**	**13.2%**
Scaup spp.	1,781	3.1%	9,453	10.6%	1,496	1.4%	4,243	5.0%
Bufflehead	2,690	4.7%	2,727	3.0%	4,085	3.8%	3,167	3.7%
Ring-necked Duck	1,099	1.9%	3,157	3.5%	3,642	3.4%	2,633	3.1%
Goldeneye	608	1.1%	590	0.7%	273	0.3%	490	0.6%
Redhead	107	0.2%	169	0.2%	777	0.7%	351	0.4%
Canvasback	18	<0.1%	6	<0.1%	596	0.5%	207	0.2%
Geese	**6,483**	**11.3%**	**18,719**	**20.9%**	**22,816**	**21.0%**	**16,006**	**18.8%**

Canada Geese	6,483	11.3%	18,240	20.4%	22,005	20.2%	15,576	18.3%
Swans	**525**	**0.9%**	**848**	**0.9%**	**4,367**	**4.0%**	**1,913**	**2.2%**
Tundra Swan	0	0.0%	0	0.0%	2,574	2.4%	858	1.0%
Trumpeter Swan	0	0.0%	80	0.1%	393	0.4%	158	0.2%
Mergansers	**160**	**0.3%**	**863**	**1.0%**	**236**	**0.2%**	**420**	**0.5%**
American Coot	**6,787**	**11.8%**	**6,744**	**7.5%**	**3,916**	**3.6%**	**5,816**	**6.8%**
Total Waterfowl	57,705		89,547		108,727		85,327	

Waterfowl Use Days

Total use-days for all species (combined) during our survey years averaged over 5.7 million and peaked in 2019 at over 6.9 million (Table 6). On average, dabbling ducks accounted for 55% of the total bird use-days, diving ducks 14%, geese 18%, swans 2% and coots 8%. Estimated total use-days for ducks only was highest in 2019 at approximately 4.6 million (Figure 7). Dabbling ducks comprised the greatest percentage of overall duck use-days, accounting for 84%, 72% and 84% in 2017, 2018, and 2019, respectively.

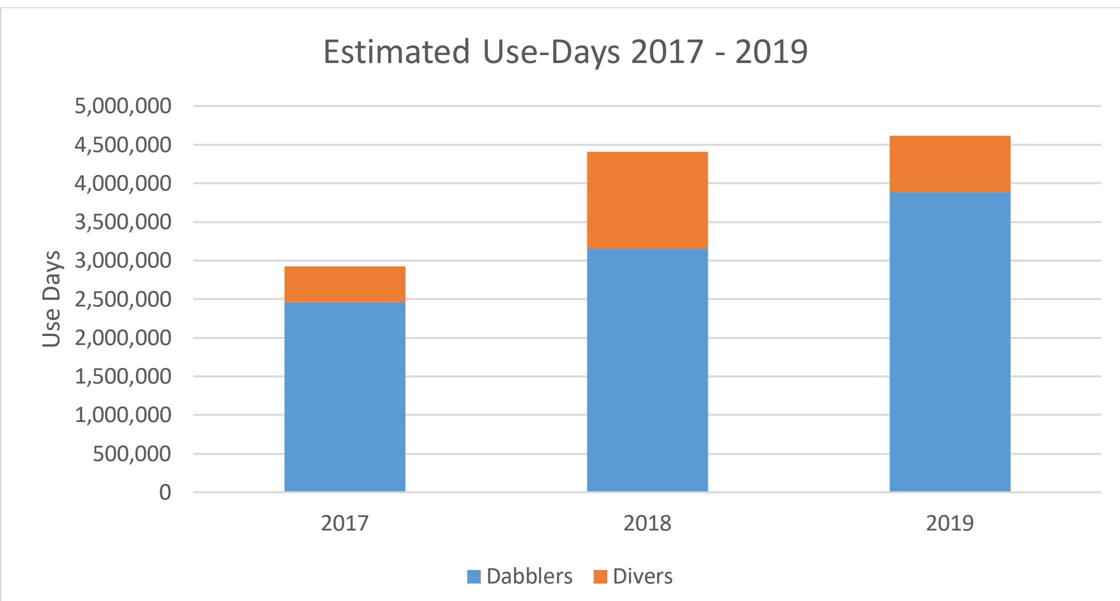


Figure 7: Total annual estimates of bird use-days for dabbling and diving ducks from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

Canada geese were widespread and abundant in the CS during spring migration, with a minor component of lesser snow geese counted annually. For all geese combined, the peak in total estimated bird use-days was in 2019 at just over 1.4 million (Table 6 and Figure 8). Geese exhibited a similar annual variation in bird use-days as dabbling ducks, with 2017 having the lowest number of bird use-days and 2019 the highest. However, the difference in geese numbers between 2017 and both 2018 and 2019 was quite large, with bird use-days in 2017 being less than a third of those in 2018 and 2019.

Swans were present on the landscape in low numbers compared to other groups, but their numbers also appear to have increased annually with an apparent substantial increase in use-days in 2019 (Table 6 and Figure 8). Annual bird use-days by coots exhibited an opposite trend compared to other waterfowl. Use-days declined from 2017 to 2019, with less than half the number of coot use-days in 2019 as in 2017.

Table 6. Estimated bird use-days during spring migration for each species and group (dabbling and diving duck, geese, swans, mergansers and American coot) from 2017-2019 in the Channeled Scablands. Percentages are the percent of each group or species from the total waterfowl use-days.

Species or Group	2017	%	2018	%	2019	%	Average	%
Dabblers	2,458,570	61%	3,154,028	50%	3,885,295	56%	3,165,964	55%
Northern Pintail	988,065	24%	1,122,576	18%	2,185,899	31%	1,432,180	25%
Mallard	869,337	22%	1,300,132	21%	1,056,277	15%	1,075,249	19%
American Wigeon	457,101	11%	519,595	8%	474,603	7%	483,766	8%
American GW Teal	20,820	1%	178,513	3%	129,437	2%	109,590	2%
Cinnamon/BW Teal	96,725	2%	2,666	<1%	19,712	<1%	39,701	1%
Northern Shoveler	10,492	<1%	10,493	<1%	15,714	<1%	12,233	0%
Gadwall	16,030	<1%	20,053	<1%	2,665	<1%	12,916	0%
Divers	468,926	12%	1,252,660	20%	729,295	11%	816,960	14%
Scaup spp.	137,807	3%	766,313	12%	117,732	2%	340,617	6%
Bufflehead	186,985	5%	188,594	3%	248,892	4%	208,157	4%
Ring-necked Duck	73,142	2%	241,447	4%	252,258	4%	188,949	3%
Goldeneye	37,313	1%	43,050	1%	20,011	<1%	33,458	1%
Redhead	8,069	<1%	12,771	<1%	51,600	1%	24,147	0%
Canvasback	993	<1%	485	<1%	23,732	<1%	8,403	0%
All Geese	406,738	10%	1,228,269	20%	1,437,236	21%	1,024,081	18%
Canada Geese	406,738	10%	1,189,738	19%	1,354,092	20%	983,523	17%
Swans	32,074	1%	50,647	1%	260,666	4%	114,462	2%
Tundra Swan	0	0%	0	0%	163,646	2%	54,549	1%
Trumpeter Swan	0	0%	5,440	<1%	22,331	<1%	9,257	0%
Mergansers	13,458	<1%	59,832	1%	17,288	<1%	30,193	1%
American Coot	630,424	16%	521,134	8%	300,193	4%	483,917	8%
Total Waterfowl	4,040,100		6,281,424		6,939,369		5,753,631	

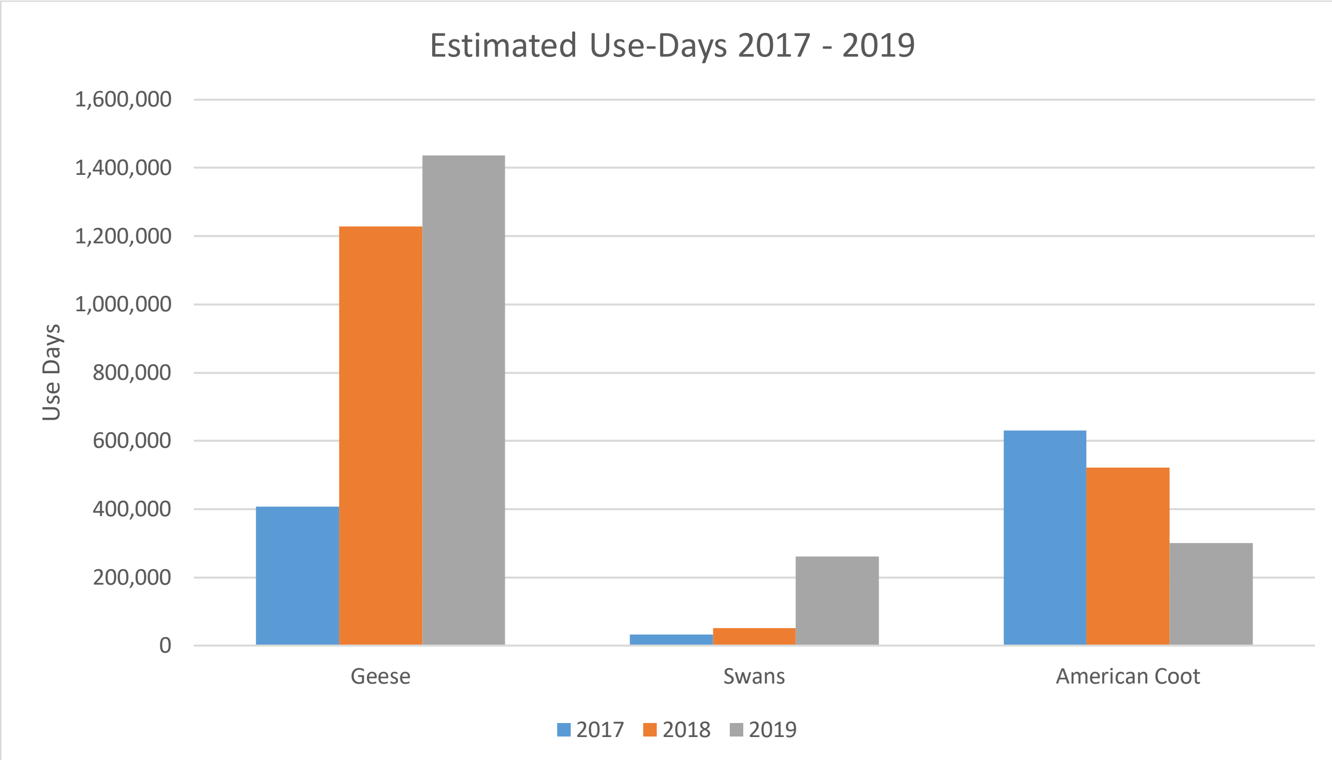


Figure 8. Total number of bird use-days for geese (not including snow geese), swans (trumpeter and tundra combined), and American coot from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

Waterfowl Peak Abundance

Weekly (i.e., survey period) point population estimates for waterfowl species or groups were used to illustrate the timing of migration and peak abundance on the landscape for each species or group (Table 7 and Figures 9, 10, 11 and 12). Survey week dates (e.g., week 6 in 2017 was 3/12- 3/18) can be found in Appendix 5. Some birds were present when surveys started, though in very low numbers. Some birds were still present when surveys were discontinued in late April, and not all species' numbers may have peaked by the time surveys were discontinued. However, these surveys achieved the objective of determining the onset, peak, and duration of most of the waterfowl migration.

The distribution and timing of ducks followed a similar pattern across all three years (Table 7, Figure 9). Ducks began arriving in the CS by the second or third week in February, except in 2019, when birds were only present in small numbers until mid-March (due to frozen conditions earlier) and then rapidly increased. Total duck numbers peaked about the third week in March of each year. Diver numbers peaked consistently a week later than dabblers in all years.

Table 7. Peak weeks in waterfowl abundance during spring migration for each species and group (dabbling and diving duck, geese, swans, mergansers, American coot, and all waterfowl) from 2017-2019 in the Channeled Scablands. "All waterfowl" represents the single week during migration that had the highest number of all waterfowl combined, and is not the total of different species' or groups' peaks.

Species or Group	2017	Week	2018	Week	2019	Week	Average (2017-2019)
Dabblers	**80,343**	**6**	**120,957**	**7**	**242,307**	**6**	**147,869**
Northern Pintail	40,368	6	55,822	7	198,548	6	98,246
Mallard	29,435	6	39,533	7	38,058	7	35,675
American Wigeon	16,634	7	21,572	10	18,010	8	18,739
American GW Teal	983	6	9,975	7	8,452	8	6,470
Northern Shoveler	442	7	688	11	1,499	13	876
Gadwall	909	10	688	10	246	13	614
Cinnamon/BW Teal	2,899	10	246	11	1,671	13	1,605
Divers	**16,044**	**7**	**57,837**	**8**	**23,169**	**7**	**32,350**
Scaup spp.	7,002	7	46,953	8	5,479	8	19,811
Bufflehead	6,486	5	4,447	5	12,580	7	7,838
Ring-necked Duck	3,857	7	8,206	8	6,314	8	6,126
Goldeneye	1,990	7	1,106	7	885	8	1,327
Redhead	319	7	713	11	2,776	12	1,269
Canvasback	123	7	49	10	3,931	7	1,368
All Geese	**15,430**	**5**	**55,208**	**6**	**117,615**	**6**	**62,751**
Canada Geese	15,430	5	54,913	6	117,271	6	62,538
Swans	**1,990**	**5**	**4,324**	**6**	**27,174**	**6**	**11,163**
Tundra Swan					20,589	6	6,863
Trumpeter Swan			467	2	2,138	6	868
Mergansers	418	10	1,744	6	1,007	6	1,056
American Coot	34,619	10	25,037	10	13,047	11	24,234
All Waterfowl	107,787	7	143,806	7	447,070	6	232,888

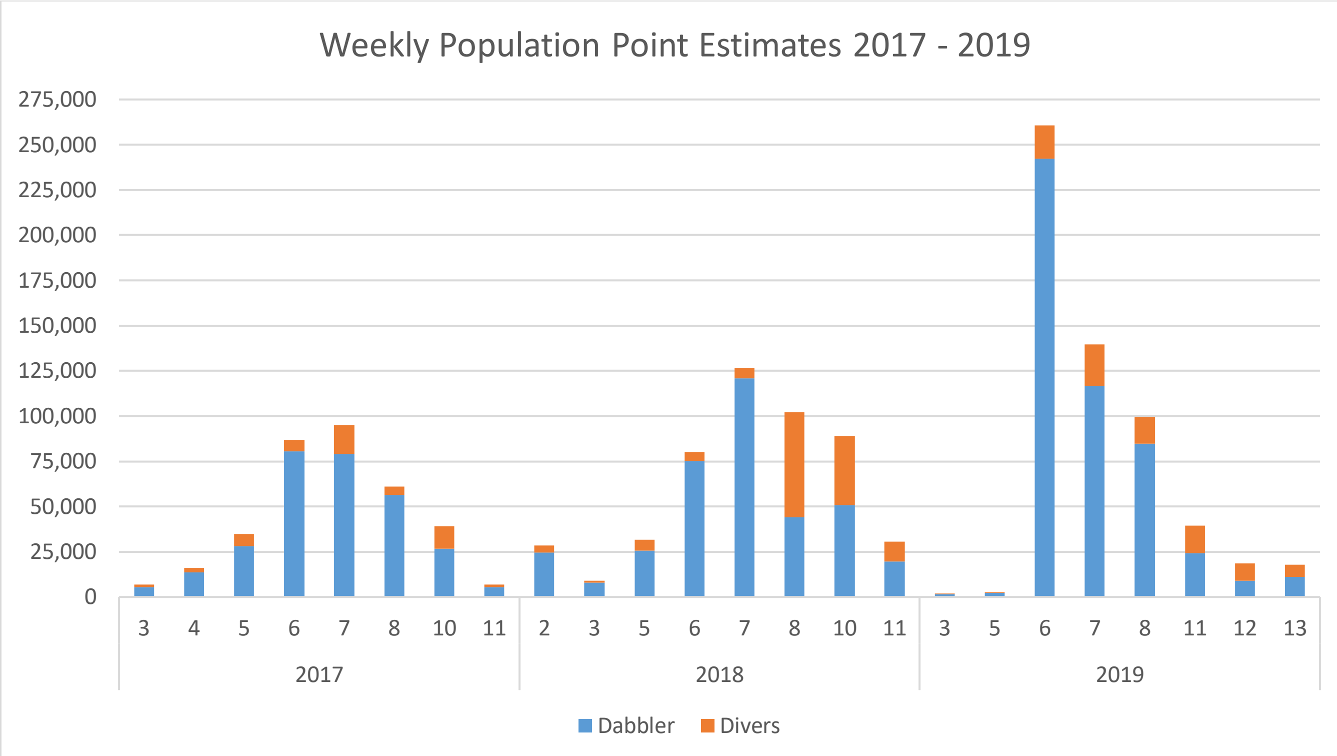


Figure 9: Weekly population point estimates for dabblers (blue) and divers (orange) from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

The temporal distribution of geese varied across the three survey years with increasing numbers and peak abundance each year. The greatest peak in goose numbers occurred in 2019 with approximately 117,000 birds estimated on March 18 (week 6; Figure 10). It was also in 2019 that approximately 6,000 "small" Canada geese occurred on April 16; the only time this group of geese were observed during aerial surveys.

Swan numbers and temporal distribution throughout the survey seasons varied annually, but numbers generally increased each year (Figure 11). Peak abundance for tundra swans occurred in 2019 with over 25,000 birds. Tundra and trumpeter swans occurred in smaller numbers and less frequently in this landscape than other species, but their peak numbers also occurred about mid-March annually. It should be noted that though unidentified swans represented the greatest number within this group in 2017 and 2018, this was due to visibility from the air, and later assessments suggest the majority of these were tundra swans.

The average peak population of American coots was over 24,000 birds (Table 7). The temporal distribution of American coots did not follow the same pattern as other waterfowl (Figure 12). This species consistently peaked in the second to third weeks of April, several weeks later than ducks, geese, and swans, for all three years of monitoring. Coot abundance declined during the three years of surveys, though the significance of this remains unknown.

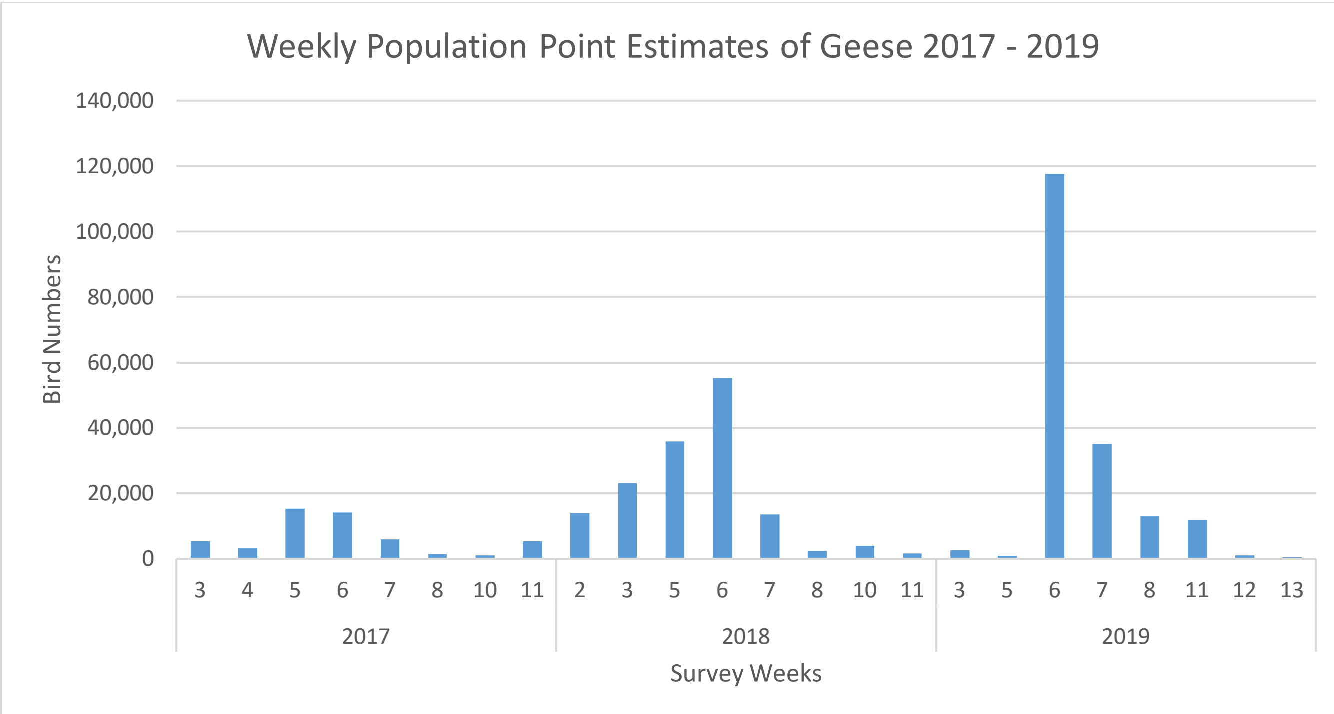


Figure 10: Weekly point estimates of population for geese for each survey week from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

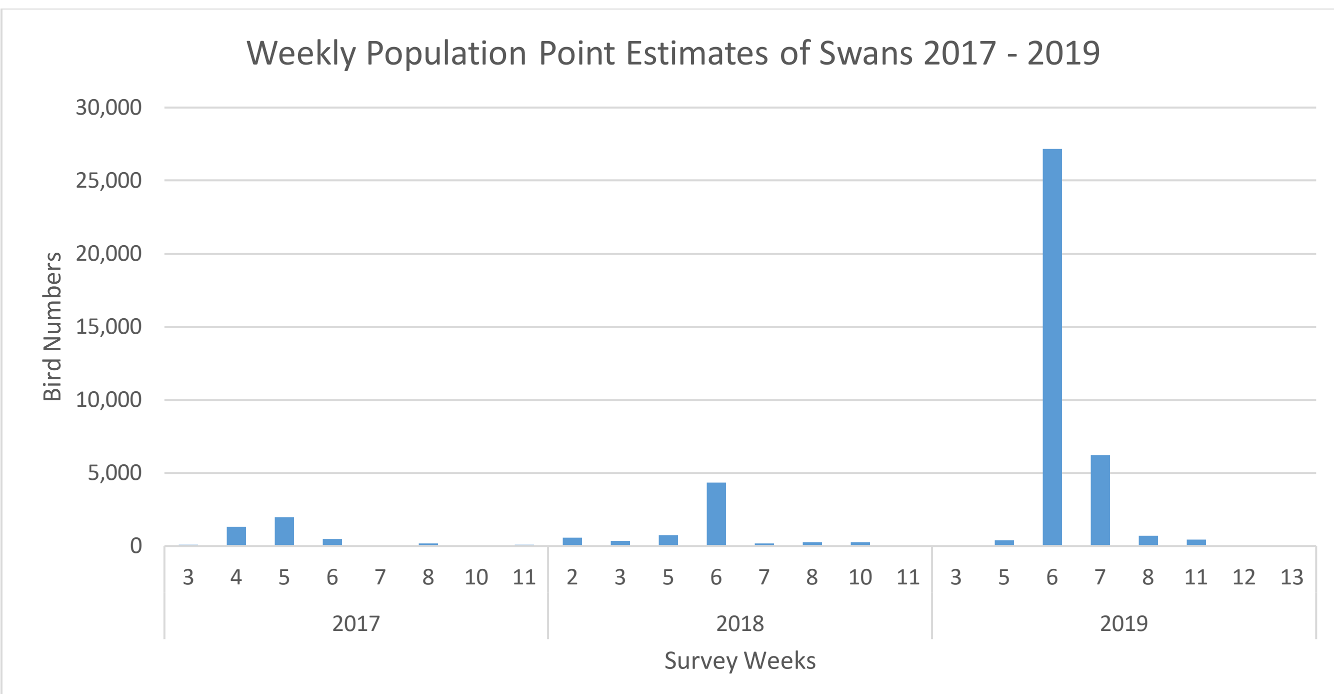


Figure 11: Weekly point estimates of population for Tundra, Trumpeter, and unidentified swan species for each survey week from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

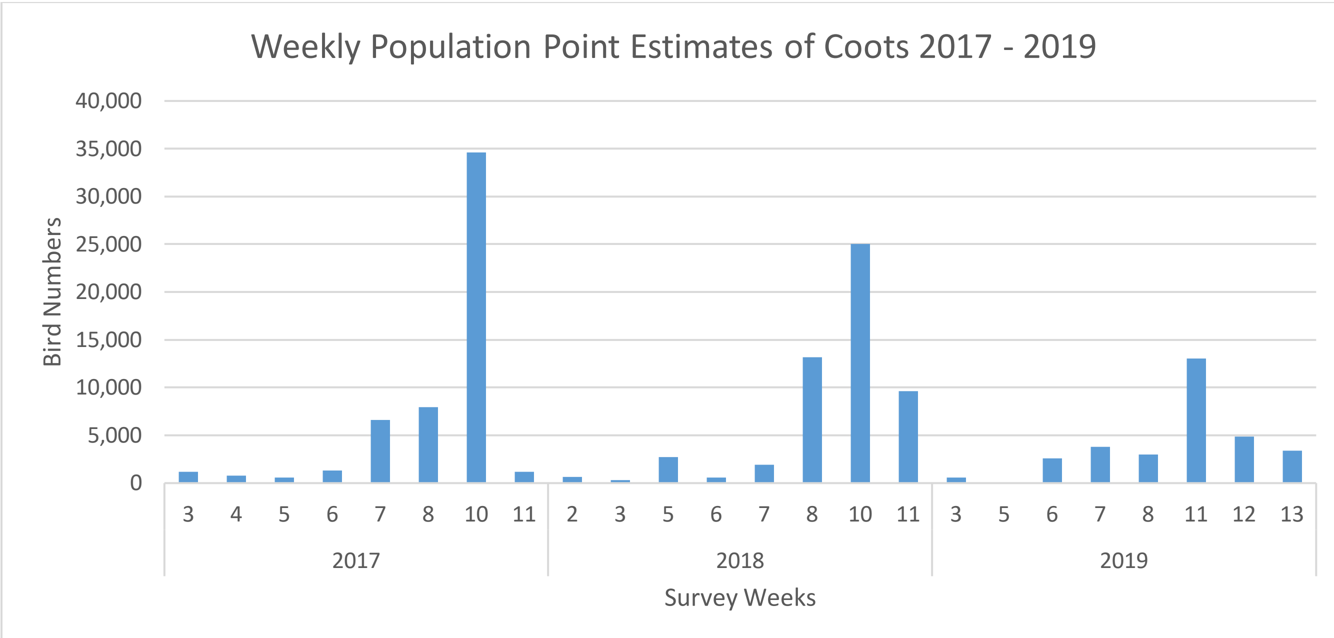


Figure 12: Weekly point estimates of population for American coots for each survey week from the 2017-2019 spring waterfowl migration surveys in the Channeled Scablands.

Discussion:

Importance of the Channeled Scablands to Waterfowl

A major purpose of this study was to evaluate the importance of the CS during spring waterfowl migration in the Pacific Flyway. There are two datasets available that can be used for rough comparisons to help achieve this purpose. A significant, relatively recent study of spring waterfowl migration was undertaken in 2002 and 2003 in the Southern Oregon and Northeastern California (SONEC) region (Fleskes and Yee 2007). They used many of the same metrics employed in this study—average birds per day, bird use-days, and peak abundance—making comparisons particularly valuable. The other data set is from mid-winter surveys, historically conducted throughout the states in the Pacific Flyway in January (USFWS 2021). These surveys were less structured than other waterfowl survey methods (Heusmann 1999) but provide a useful estimate of winter abundance in the flyway and in other states to compare to our population estimates. Mid-winter surveys have been largely discontinued in the flyway, so data from the 5 years prior to our study (2011-2015) were used to calculate an average winter abundance for species and groups for the flyway.

Comparison to the SONEC

The SONEC region is recognized as an exemplary region with a composition of habitats that support over 128 million use days in the spring (Fleskes and Yee 2007). Comparison of its spring waterfowl use metrics with the CS can be made, but within the context of area and the availability of potential waterfowl habitats in both regions. The SONEC region covers over 70,000 square kilometers in 7 different sub-regions, while the CS survey covered an area only 10% of the size of SONEC. This difference alone requires that the comparison of waterfowl metrics of the CS study with those reported by Fleskes and Yee (2007), birds per day and peak populations, be adjusted based on differences in the total area surveyed. Using the assumption that the composition of potential waterfowl habitat is similar between the 2 regions, expected values can be represented as a ratio of the CS values to the SONEC. The expected ratio of birds per day and peak populations based on the difference in survey area is approximately 1: 10, or 10% of the SONEC values. Expected ratio values for waterfowl-use days require adjustment for both the difference in total area and the length of the spring migration season. The expected use days based on the differences in total area (10%) and further adjusted by the 60% shorter length of the spring migration season (72 vs 115 days) results in an expected use days for the CS that is 6% of the values reported by Fleskes and Yee (2007). Comparison of expected to observed ratios provides a basis upon which spring migration use of the CS study area can be evaluated by testing the hypothesis that resource densities in both are equal. Observed values similar to the expected value indicate the CS may have a similar availability of resources on a per unit basis as the SONEC for these groups or species. Observed values greater than the expected value indicate the CS may have a greater availability of resources on a per unit basis than the SONEC. Those species or groups with lower-than-expected percentage values relative to the SONEC were either inadequately surveyed or their necessary requirements were not met at the same density as the SONEC. The actual percentage of each metric estimated for the CS compared to the SONEC are reported for each waterfowl group and individual species in Table 8.

In general, waterfowl in the CS have near or greater than expected values for all three metrics (Total Waterfowl, Table 8). There are several notable deviations from the expected percentage of the SONEC populations observed for several individual dabbling and diving duck species and Canada geese. Mallards, cinnamon/BW teal, bufflehead, ring-necked ducks, goldeneyes, redheads and Canada geese all exhibited greater values than expected for average bpd, peak populations, and bird use-days. Species with much lower-than-expected values were American green-winged teal, northern shoveler, gadwall, canvasbacks and ruddy ducks. American wigeon and scaup spp. numbers individually met expected values, and northern pintail peak numbers were higher than expected.

Table 8. Observed and expected average birds per day, peak populations and use days of the CS Strata (2017-2019) as a percentage of the 2002-2003 average values for the SONEC (Fleskes and Yee 2007). Values more than 3% different are considered notable. Bold black values are greater than expected and red less than expected.

	Av BPD %SONEC	Av Peak % SONEC	Av Use Days %SONEC
Expected %	10%*	10%*	6%**
Species or Group			
Dabblers	8%	13%	5%
Northern Pintail	9%	**16%**	4%
Mallard	**59%**	**74%**	**33%**
American Wigeon	8%	10%	5%
Green-Winged Teal	**2%**	**4%**	**1%**
Northern Shoveler	**0%**	**0%**	**0%**
Gadwall	**1%**	**2%**	**1%**
Cinnamon/BW Teal	**61%**	**25%**	**41%**
Divers	9%	13%	6%
Scaup spp.	12%	**32%**	8%
Bufflehead	**17%**	**22%**	**10%**
Ring-necked Duck	**45%**	**45%**	**27%**
Goldeneyes	**41%**	**46%**	**24%**
Redhead	**29%**	**49%**	**18%**
Canvasbacks	**1%**	**5%**	**0%**
Ruddy Ducks	**0%**	**1%**	**0%**
Geese	6%	13%	3%
Canada Geese	**90%**	**198%**	**48%**
Swans	8%	**16%**	4%
American Coot	9%	**20%**	6%
Total Waterfowl	8%	12%	6%

*Expected based on difference in total area between CS Strata and SONEC.
** Expected based on difference in total area and the length of the migration period.

Use-days of total waterfowl, dabblers, divers, swans, and coots in the CS were near the expected percentage indicating this region supports overall waterfowl migration at densities comparable to the SONEC. Species with observed use near expected values were northern pintail, American wigeon, and scaup spp., swans, and coot. There were, however, some noteworthy departures from the expected values for other dabbling and diving duck species, total geese, and Canada geese. Observed mallard-use days in the CS were 33%, 5.5 times the expected BUDs to be equivalent to the SONEC. Cinnamon/ Blue-winged teal use-days were 41%, more than 6.8 times greater than expected. It can be assumed that the CS provides the resources needed by these species at densities greater than SONEC. Three dabbling duck species, American green-winged teal, northern shoveler, and gadwall use-days were considerably below the expected 6% difference based on area, indicating that habitat important to these species may be either lacking or unavailable during the timing of their northern migration. Diving ducks with greater than expected use-days in the CS included ring-necked ducks, goldeneyes, and redheads. The canvasback and ruddy duck both exhibited use-days much lower than expected at 1% or less. We mentioned earlier that the ruddy ducks were under sampled in the CS survey; evidence of this was that they arrived later, and their numbers were still increasing at the end of the CS spring migration surveys. Although total goose use-days were nearly half what was expected because of the almost complete absence of snow/Ross and white-fronted geese in the CS, Canada geese use days were much greater than expected at 48% (8 times greater than expected).

Explaining differences between observed and expected values of the three waterfowl population metrics (average birds per day, peak populations and waterfowl use-days) requires a more detailed understanding of the availability and composition of spring migration habitat beyond the obvious difference in size. Fleskes and Gregory (2010) analyzed the availability of waterfowl habitats in the SONEC region during the 2002 and 2003 waterfowl survey years using a combination of the National Land Cover Database (NLCD) and analysis of LandSat imagery to determine area of waterfowl habitat having surface water present during their spring surveys. The five land cover categories Fleskes and Gregory (2010) considered to be potential waterfowl habitat included open water, marsh (woody and emergent herbaceous wetlands), grassland/herbaceous, pasture/hay, and cultivated crops. Determining the area of these land cover types that were flooded during their surveys using LandSat image analysis was critical to understanding waterfowl response to habitat availability. They found that 12% of the potential waterfowl habitat cover types were flooded during their study. Unfortunately, this spatial data is not yet available for the CS. A project being conducted by the WDFW and the IWJV will provide similar spatial data allowing estimation of available flooded waterfowl habitat during the timeframe of our study. Until this data set becomes available, comparisons can still be made using the 5 NLCD categories. Area and percent cover of the 5 land cover types were determined for the CS survey strata and transects for comparison to SONEC (Table 9).

Table 9. Comparison of the area (square kilometers) and proportion of the Channeled Scablands survey strata and transects and the SONEC Region in 5 National Land Cover types identified as potential spring waterfowl habitat by Fleskes and Gregory (2010).

Potential Waterfowl Habitat	Survey Strata	Survey Transects	SONEC

NLCD Type	% Strata	Area	% Transect	Area	%SONEC	Area
Open Wetland	1%	50	1%	3	3%	2,170
Marsh	4%	279	4%	11	2%	1,617
Grassland/Herbaceous	35%	2,416	36%	101	7%	5,040
Pasture/Hay	1%	40	<1%	1	5%	3,360
Cultivated Crops	33%	2,266	30%	85	2%	1,470
TOTAL	70%	4,883	71%	201	20%	13,657
Total Area (sq km)		6,960		283		70,000

There are several key differences in the availability of the potential waterfowl habitat cover types between the SONEC Region and our survey strata and transects that partially explain observed deviations of observed waterfowl metrics from expected values. Without consideration of the areas flooded, the CS study survey strata, and transects are over 70% potential waterfowl habitat while the SONEC sub-regions were only 20% potential waterfowl habitat. This difference is primarily the result of substantially greater proportion of cultivated crop cover, primarily dryland farming, and the herbaceous grasslands in the CS. These areas experience significant sheetwater flooding of topographic depressions and along drainages following snowmelt that would provide considerable early spring habitat for both mallards and pintails. The dryland crops of the region are dominated by winter wheat which provides abundant green browse throughout the winter and spring. The SONEC region has a much greater proportion of hay and pasture because of extensive flood-irrigated habitat associated with broad flat valleys and river floodplains. These habitats are very important to most of the dabblers which could explain in part observed ratios lower than expected in the CS for American green–winged teal, gadwalls, and northern shovelers. The hay and pasture in CS are primarily associated with center pivot irrigation and partially- drained, large depressional basins. The latter are frequently flooded in spring and receive high use by dabblers, especially northern pintails, mallards and American wigeon, and explain their near expected or higher observed ratios. At all scales including SONEC the wetland land cover types constituted about 5% of the landscape. Wetlands in the scablands are at their highest density in the ice age flood tracts. The survey strata we selected included a greater density of these depressional wetlands consisting of larger permanent sloughs and numerous small, shallow, pothole wetlands that rival the densities in the Prairie Pothole Region. This high density of smaller isolated wetlands likely supports the larger observed ratios of cinnamon/blue winged teal. Besides the numerous depressional wetlands in the CS, the major difference in aquatic land cover between SONEC and the CS and survey strata is the greater proportion of the open water category in SONEC. Although several deep lakes and reservoirs are found in both regions, the SONEC region is host to a much greater number of large, alkali lakes such as Upper Klamath, Goose, Summer, Albert, Harney, Malheur and Walker Lakes. The prevalence of these large, open water habitats that are open early in the migration period may explain the higher densities of canvasbacks, an early migrant, and ruddy ducks. The higher-than-expected observed values for several divers observed in the scablands is likely a result of large wintering populations in eastern Washington on the large rivers in the area that quickly move to more productive habitats in deeper wetlands of the

CS as they thaw in late March and April. Data on flooding of the different potential waterfowl habitat types in spring may also find that surface water is present on a considerably greater percentage than that reported by Fleskes and Gregory (2010) in the SONEC. In addition, the ground survey work discussed later in this report will allow greater exploration of the use of different habitat types by waterfowl and further highlight the varying use of both regions by individual waterfowl species during spring migration.

Spring Waterfowl Population in the Channeled Scablands Survey Strata in Comparison to Winter Abundance

At the flyway level, the CS survey strata supported spring waterfowl populations of several species that represented a significant proportion of the winter population, especially those species that may winter as far south as Central and South America such as redheads, cinnamon and blue-winged teal (Table 10). The percentages in Table 10 are lower than the true percentage would be, as well, because the total number of each species in the survey strata in the CS is not known, and we can only use proxies such as the peak number which represents the highest value during one survey week, or the average birds per day. The actual total number of birds per species or group would be higher. However, notable species whose spring population proxies constitute a relatively higher proportion (>5%) of the flyway winter populations are northern pintail, mallards, scaup, bufflehead, ring-necked ducks, redhead, and cinnamon/blue-winged teal. The CS also supported a good proportion of the goose and swan winter populations during migration.

Table 10. Comparison of the Average Birds per Day (BPD) and Peak Waterfowl Abundance of spring migrating waterfowl in the Channeled Scablands Survey Strata from 2017-2019 to the average estimated mid-winter populations in the Pacific Flyway from 2011-2015. Species and groups in bold had average BPD and Peak Abundance values greater than 5% of the estimated mid-winter population in the Pacific Flyway.

Species or Group	Flyway Average (2011-2015)	CS Av BPD	% of Flyway	CS Peak	% of Flyway
Dabblers	4,269,821	48,117	1.13%	147,869	3.50%
Northern Pintail	1,745,575	22,965	1.32%	**98,246**	**5.60%**
Mallard	708,339	16,045	2.27%	35,675	5.00%
American Wigeon	536,331	6,679	1.25%	18,739	3.50%
American GW Teal	429,914	1,508	0.35%	6,470	1.50%
Northern Shoveler	657,177	188	0.03%	876	0.10%
Gadwall	184,772	178	0.10%	614	0.30%
Cinnamon/BW Teal	4,095	134	3.27%	**688**	**16.80%**
Wood Duck	3,619	5	0.14%	24	0.70%
Divers	392,465	11,261	2.87%	26,322	6.70%
Scaup spp.	78,007	**4,244**	**5.44%**	**19,811**	**25.40%**
Bufflehead	34,116	**3,167**	**9.28%**	**7,838**	**23.00%**
Ring-necked Duck	48,948	**2,633**	**5.38%**	**6,126**	**12.50%**
Goldeneyes	38,524	490	1.27%	1,327	3.40%
Redhead	12,523	351	2.80%	**1,269**	**10.10%**

Canvasbacks	74,076	207	0.28%	1,368	1.80%
Ruddy Ducks	106,272	84	0.08%	672	0.60%
All Geese	367,312	17,152	4.67%	**62,751**	**17.10%**
Canada Geese	367,312	13,903	3.79%	**62,538**	**17.00%**
Swans	81,397	1,913	2.35%	**11,163**	**13.70%**
Mergansers	15,959	420	2.63%	**1,056**	**6.60%**
American Coot	754,920	5,816	0.77%	24,234	3.20%
Total Waterfowl	5,881,875	81,856	1.39%	217,507	3.70%

Survey Area Relative to Eastern Washington Waterfowl Habitats

The two discrete survey areas chosen for this project represent only a small portion (approximately 27%) of the entire Channeled Scablands, and therefore our estimates do not reflect the total use of the CS in spring by waterfowl. Though we chose these areas as a good representation of the CS, it is not statistically acceptable to assume that birds were distributed equally in the areas we did not sample. Land cover comparisons indicate that there are notable differences in the proportion of potential waterfowl habitat in each area. As previously mentioned, the CS as a whole had a lower proportion of aquatic land cover types than the survey strata: namely the marsh category, comprised of woody or herbaceous emergent wetlands. However, for the purpose of discussion, we did rough calculations of what some of the bird numbers would be if the rest of the CS mirrored our study area. Total average birds per day would increase 3.7-fold to nearly 303,000 BPD for all waterfowl combined (average of all years 2017-2019), and to nearly 85,100 for northern pintail alone. As a comparison, the SONEC, an area nearly three times the size of the entire Channeled Scablands, reported pintail average BPD as 269,500 (Fleskes and Yee 2007). Total waterfowl use-days would increase to 19.4 million for all waterfowl combined, to over 5.3 million for northern pintail, and to more than 3.9 million for mallard.

Moreover, the Channeled Scablands do not contain the only wetland habitats available to migratory birds passing through eastern Washington. We cannot underestimate the value of the Yakima River basin, the Columbia Basin Irrigation Project, large rivers such as the Columbia, Snake, and Walla Walla, and the waterways, lakes, and wetlands of northeastern Washington (including the Pend Oreille River, Colville River and Spokane River), which include many wetlands, rivers, lakes, reservoirs and other habitats, including vast agricultural fields. Many more waterfowl are known to utilize these areas during the spring.

Potential Factors Affecting Waterfowl Use of the Channeled Scablands

Weather played a significant role in the temporal pattern of spring migration in the Channeled Scablands. Hydrologic inputs in the form of total precipitation, especially snow in the winter prior to migration, and the onset of warmer temperatures during late winter and early spring that initiates run-off, ultimately provide open water wetland habitats of varying depths to migrating waterfowl. Cooler than normal conditions can delay runoff and maintain frozen conditions in the landscape longer into the migration period. The three years of the survey occurred in what would be classified as a wet period in the wet/dry cycle in this semi-arid region. The initiation, peak and duration of the migration period was similar between years except for 2019, which started out colder and snowier than the previous two years and the long-term average. Migration onset was delayed in 2019, but waterfowl use-days were greater than in previous years. This is a result of the sudden arrival of high numbers of birds that had been held back by the weather, whereas in other years, birds arrived in smaller numbers over a longer period.

Individual species and groups exhibited expected temporal variations that reflect their differences in foraging ecology, breeding chronology and disparate nesting grounds. Species that nest early and farther north seek habitats during migration where they can meet their energy demands early. These species are typically dabblers that feed in shallow wetlands (northern pintail, mallard, American green-winged teal and American wigeon) and arrive in the CS almost 2-weeks earlier than other duck species. Geese and swans both exhibited a pattern of earlier arrival as they nest earlier, and in the case of tundra swans, much farther north. Both species frequently use shallow wetland habitats or open field foraging habitats.

Birds that use deeper water habitats and/or nest later in the season arrived later in the project area when their preferred foraging habitats were more available. Divers, coots and the mid- to late-season nesting northern shovelers, blue –winged and cinnamon teal, and gadwalls are in this group. Thus, we may not have surveyed through the end of those species' migration. For example, ruddy duck and blue-winged teal numbers were still increasing the last week of the surveys and therefore their true numbers are likely greater than what are reported here.

This region may be disproportionately important to certain species, such as the cinnamon teal. Cinnamon teal are thought to be the least abundant of the North American dabbling ducks, though population estimates are uncertain (Baldassarre 2014). They are a relatively understudied species, but it is known that they breed in high densities in the western United States, particularly the Intermountain West. They have the narrowest distribution and the most southerly breeding range of all teal species native to North America, and the CS of eastern WA is known as an important area for breeding (Connelly and Ball 1984). The USGS Western Ecological Research Center has begun a Western States Cinnamon Teal Initiative to better understand their ecology. As stated on their website: "Given the species reliance on some of the more arid regions of the western U.S., resource selection patterns (particularly habitat availability during migration) may strongly affect survival and reproductive success (USGS 2018)." Our study did not differentiate between cinnamon and blue-wing teal, but comparisons of cinnamon/blue-wing numbers from SONEC and the Pacific flyway wintering populations showed that the CS hosts a significant number of those species. Moreover, a recent study of cinnamon teal fall stopover locations derived from 61 satellite tagged individuals suggests that cinnamon teal selected increasingly smaller and more isolated wetlands as aridity increased on their migratory pathway (Patrick Donnelly, pers comm). Cinnamon teal are known for using alkaline wetlands during migration and breeding. During breeding, they require tall vegetation that provides nest concealment on all sides, with the females entering the nests through tunnels in the vegetation. The CS of Washington contains tens of thousands of pothole wetlands, along with larger lakes, vernal pools, and other types of wetland habitats. In comparison, the SONEC habitats are largely vast tracts of flooded agricultural fields, which may lack the alkalinity or vegetation structure required by cinnamon teal during migration and breeding. These specific habitats may be available in higher proportions in the CS versus the SONEC. Thus, conservation of the wetlands in eastern Washington may be particularly important to cinnamon teal, whose range and population are small, and who utilize the CS for breeding as well as migration.

Correcting Bird Counts due to Detection Bias

Observers do not detect all animals during aerial surveys (Caughley 1974), making the estimates of waterfowl abundance provided here almost certainly lower than the true number of waterfowl using the CS during spring migration. Many factors can affect detectability of birds during surveys, such as weather, angle of the sun (i.e., light levels, glare), obstructing vegetation or landforms, bird behavior, bird size and coloration, habitat types, observer experience, and type of aircraft. Ignoring imperfect detectability (visibility bias) causes estimates of abundance to be biased negatively. Therefore, ideally, surveys should include one or more methods for determining the probability of detecting individuals and adjust estimates accordingly. There are multiple ways to do this, including but not limited to the double-counter method, having both air and ground survey crews, and statistical modeling methods (Smith 1995, BC Ministry of Environment, Land and Parks 1999, Pearse et al. 2008, Adams 2014). However, not all are appropriate for a particular survey, and these methods are generally time-consuming, expensive, and require additional effort and staff. Our survey design and analyses did not include techniques for estimating detectability due to staffing and budget constraints. For discussion purposes, we searched scientific literature for migration or wintering waterfowl surveys that used a correction factor for detectability to apply to our data post-hoc, but found few relevant papers (Smith 1995, Prenzlow and Lovvorn 1996, Pearse et al. 2008, Koneff et al. 2008, Adams 2014, Masto 2019). We cannot apply correction factors from breeding bird surveys, as bird behavior and distribution are different during the breeding season than during migration or wintering. For example, birds are less dense, more secretive, and remain longer on breeding grounds during breeding season (a “closed” population), versus during migration where birds may be more densely congregated, less secretive, and animals are continually entering and leaving (an “open” population).

Based on our literature search, Pearse et al. (2008) appeared to be the most comparable because the time of year, habitats, and species present were most similar to ours. He conducted an experiment to estimate and correct for visibility bias related to detecting waterfowl during aerial surveys during winter from fixed-wing aircraft. He used decoys in different types of wetlands (emergent and forested/scrub shrub), varying the group sizes, to test the influence of wetland type and group size on detectability. He then used a model-based approach to correct for visibility bias based on group detection and counts of individuals within each group. His correction factors were: Mallard = 1.42x, other dabbling ducks = 1.37x, diving ducks = 1.39x and total ducks 1.39x. It would not be unreasonable to assume the bird numbers from our surveys could be similarly adjusted upwards approximately 37-42% to account for imperfect detection.

Ground Surveys:

Although the aerial waterfowl observations were georeferenced, the coarseness of these locations and the lack of accurate wetland-cover GIS data in this region limits their utility in habitat use assessments. Therefore, ground surveys were conducted to quantify the number and types of habitats that were available each week for waterfowl use, and the number and species composition of birds observed on each habitat type.

Survey Routes

Eight ground survey routes were delineated to cover a sub-sample of the entire survey area and to include the variety of habitat types that waterfowl were expected to use. In combination, the ground routes covered approximately 370 driving miles (Figure 13). Some routes contained stopping points requiring observers to hike to view a waterbody or other habitat from a high vantage point, but most of the routes were surveyed from a vehicle. The routes were selected specifically for this project, except for the Turnbull Refuge Points route, which consisted of a series of points within TNWR that are part of their long-term monitoring program.

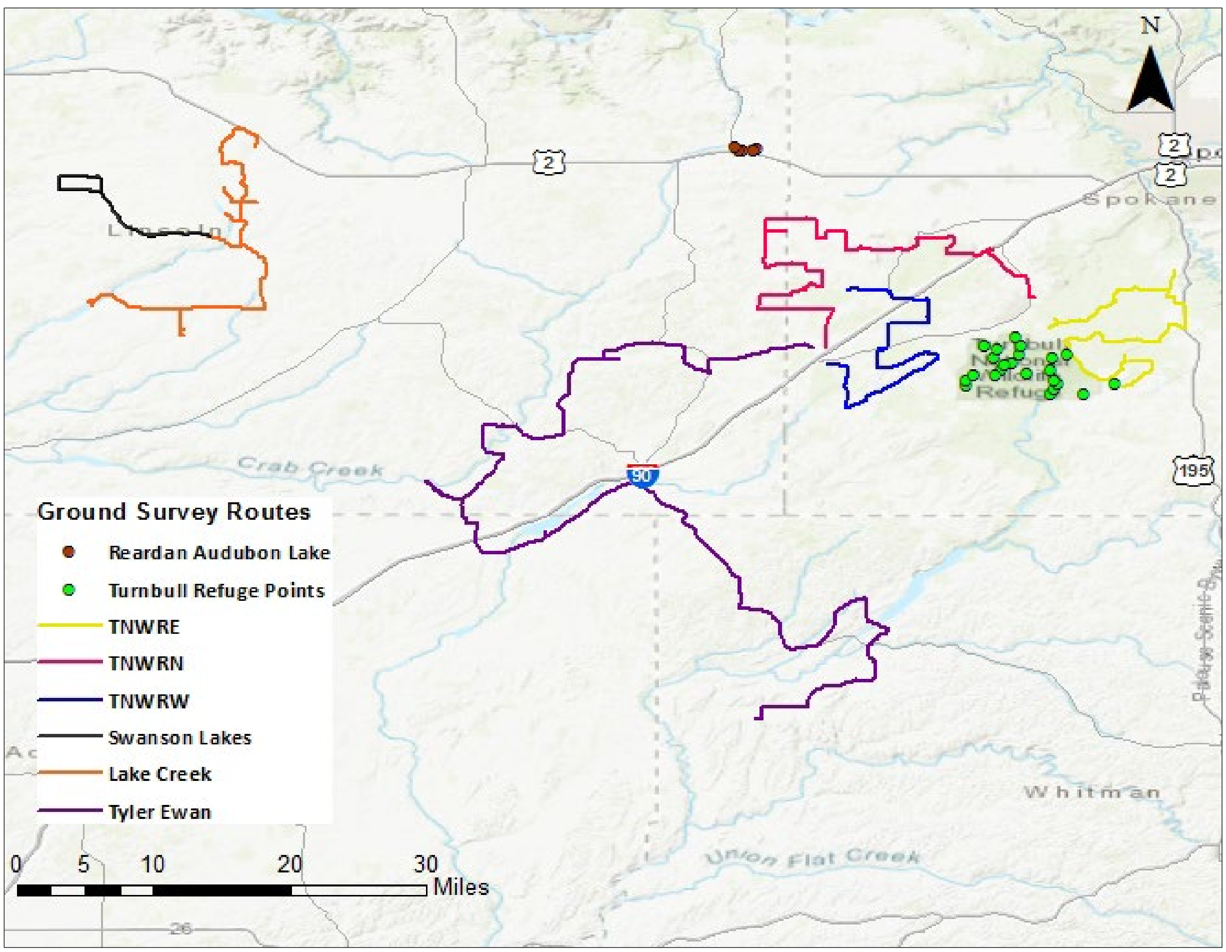


Figure 13: Eight ground survey routes used for the spring waterfowl surveys. TNWR = Turnbull National Wildlife Refuge. Routes were created W (west), E (east), and N (north) of the Refuge to supplement the Refuge Points route.

Routes were designed so a single surveyor could complete the route in a single day. Each route was divided into several shorter segments as data collection units; if the entire route could not be completed in a day because of weather or other factors, the segments allowed surveyors to return to complete unfinished portions of the route within that same week. Maps, digital tracks in handheld GPS units, and annual surveyor briefings ensured that all surveyors followed the same routes and protocol each year.

Methods

Each route was run weekly starting the first full calendar week (Sunday-Saturday) in February through the fourth full week in April, resulting in a survey season that was 12 weeks long. Surveys of the same route were run a minimum of three days apart, and five to seven days apart if possible (e.g., for a route surveyed on Friday the next potential survey date was the following Monday, but ideally would be run Wednesday-Friday). There were no set start or end times for surveys, but they were not started before, or continued past, good light conditions. Most often this was sun rise/set, however depending on area topography and route orientation, the survey may have been started later or ended earlier to avoid glare. There were also no set weather criteria; surveys were run on the best weather day of the week when possible and were not run during conditions that limited visibility (e.g., low lying fog) or were not safe for observers.

Information collected on each survey included: observer name(s), weather conditions (temperature, wind speed measured on the Beaufort scale, cloud cover, and precipitation), counts of habitat in each category that were "available," i.e. contained water, and waterfowl counts by species (in 2016), or waterfowl count by species and associated habitat type for 2017-2019 (e.g., a pintail in a flooded agricultural field would be recorded in a different column than a pintail seen on a creek). If species could not be determined, the next lowest identifiable classification was used (e.g., greater scaup, scaup spp., diving duck, unknown duck). When waterfowl were seen, the observer stopped to count and classify the birds and record the associated habitat type. If it was unsafe to do so (e.g., no road shoulder), the best estimate of number and species was noted while continuing to drive. Only waterfowl seen on or flushing from waterbodies or fields were recorded; flocks migrating overhead were noted in a separate Notes field. The Notes field was also used to record events that may have impacted bird or habitat counts, such as numerous fishing boats on a lake. See Appendix 1 for an example of the ground survey protocol and data form used in 2018 and 2019.

Habitat Categories

To investigate the relative availability and use of wetland habitats by waterfowl during spring migration, we divided habitat into various categories that could be easily identified in the field consistently by observers. To be counted during a survey as available, there had to be visible water present in the wetland or other habitat. It was also noted whether the water was unfrozen or frozen, and an overall percent frozen was estimated for each segment of each route. We did not have a way of determining water depth for any category, thus wetlands were not differentiated from ponds and lakes.

Table 11. Habitat categories used in Channeled Scabland surveys from 2016 – 2019.

<table>
<tr><th>Year</th><th colspan="7">Categories</th></tr>
<tr><td>2016</td><td>Creeks</td><td>Waterbodies
< ½ acre</td><td>Waterbodies
<5ac</td><td>Waterbodies
>5ac</td><td colspan="3">Sheetwater</td></tr>
<tr><td>2017</td><td>Creeks</td><td>Waterbodies
< ½ acre</td><td>Waterbodies
<5ac</td><td>Waterbodies
>5ac</td><td colspan="2">Sheetwater
Agricultural</td><td>Sheetwater
Native/
Vernal
Pools</td></tr>
<tr><td>2018
and
2019</td><td>Creeks</td><td>Waterbodies
< ½ acre</td><td colspan="2">Waterbodies > ½ acre</td><td>Sheetwater
Annual Ag</td><td>Sheetwater
Pasture/
Perennial
Ag</td><td>Sheetwater
Native/
Vernal
Pools</td></tr>
</table>

Habitat categories changed slightly between years, with some categories splitting and some merging (Table 11). Creeks and waterbodies <½ acre were consistent categories throughout the survey effort. In 2017 we split the sheetwater category into native/vernal pools and agriculture, to assess potential differences in use by waterfowl between natural habitats and lands altered by agriculture. We merged the small waterbodies (<5 acres) and large waterbodies (>5 acres) categories in 2018, due to concerns over accurate visual estimation of acreage in the field. In 2018 we also split the sheetwater agricultural category into annual (e.g., wheat or other crop that is disked or tilled and replanted annually) and perennial (e.g., hayfield or other field that is not disked or tilled and replanted annually) to account for vegetative distinctions between agricultural types and potential differences in use by waterfowl (Figure 14; see Appendix 2 for additional photo examples of habitat categories).


A)

B)

C)
Figure 14: Examples of sheetwater habitat categories. A) perennial agricultural sheetwater, B) annual agricultural sheetwater, C) native sheetwater (camas meadow). Photos by T. Blewett, DU.

Data Records and Archive

Data sheets from each field visit were scanned and transferred into Excel spreadsheet format by the observer. In 2016 the scanned datasheets and Excel files were submitted via email to WDFW and DU. In 2017 a SharePoint site was developed, and scanned datasheets and Excel files were uploaded to the site directly by observers. The SharePoint site currently houses all files: Excel spreadsheets, PDF scans of data sheets, additional files such as email correspondence related to the surveys, GPS data, and photos.

Data were compiled in a Microsoft Access database, including all waterfowl count data from both aerial and ground surveys, survey condition information for ground surveys, and habitat data from the ground surveys. The Access database, all raw data, hard copies of data forms, and all other survey related materials are housed at WDFW Region 1 Headquarters in Spokane Valley, WA, and are available by contacting the District Biologists or the WDFW Statewide Waterfowl Specialist.

Results

We limited the data presented in this report to 2017 – 2019 due to significant differences in how data was collected in 2016 that make comparisons between it and the other years impractical. Data were summarized using the following habitat categories: Creeks, Waterbodies < ½ acre, Waterbodies > ½ acre, and Sheetwater (all types combined) for easier comparison across years. The individual sheetwater categories were used when an analysis focused on sheetwater only.

Habitat Availability

Counts of habitats are only a coarse index of habitat availability, as surface area was not estimated for the habitats we counted. However, given the size of the project area and limited time, staff, and budget, it was the only feasible index available; as such, we limit our discussion of habitat availability to general patterns observed. If additional and more accurate GIS layers of wetlands and other land covers become available for eastern WA, we can use the geo-referenced aerial waterfowl data to make additional detailed analyses of habitat availability compared to usage.

Habitat availability varied seasonally and between years (Figure 15). In general, there were fewer of all habitats earlier in the season and more available later in the season. However, the magnitude of this shift across the season varied year to year and was highly dependent on temperature. For example, in 2019 an unusually long cold period from mid-February to late March suppressed the availability of all categories for the first six weeks of the survey. In general, there were also more habitats available in later years. We looked at annual temperature and precipitation for each year of the surveys, and 2017 had 50% higher precipitation than the 20-year average, and 2018 and 2019 were also on the high end of average (see section on Annual Weather Conditions and Appendix 4).

The distribution of sheetwater habitat availability followed similar patterns as the other categories (Figure 16). However, while other categories tended to increase more quickly and then plateau, sheetwater showed a pattern of slower but steady increase. This appears to be driven mostly by the perennial agriculture category, with annual agriculture being sporadic, and native sheetwater following the same pattern of rapid increase and plateau as other habitat categories.

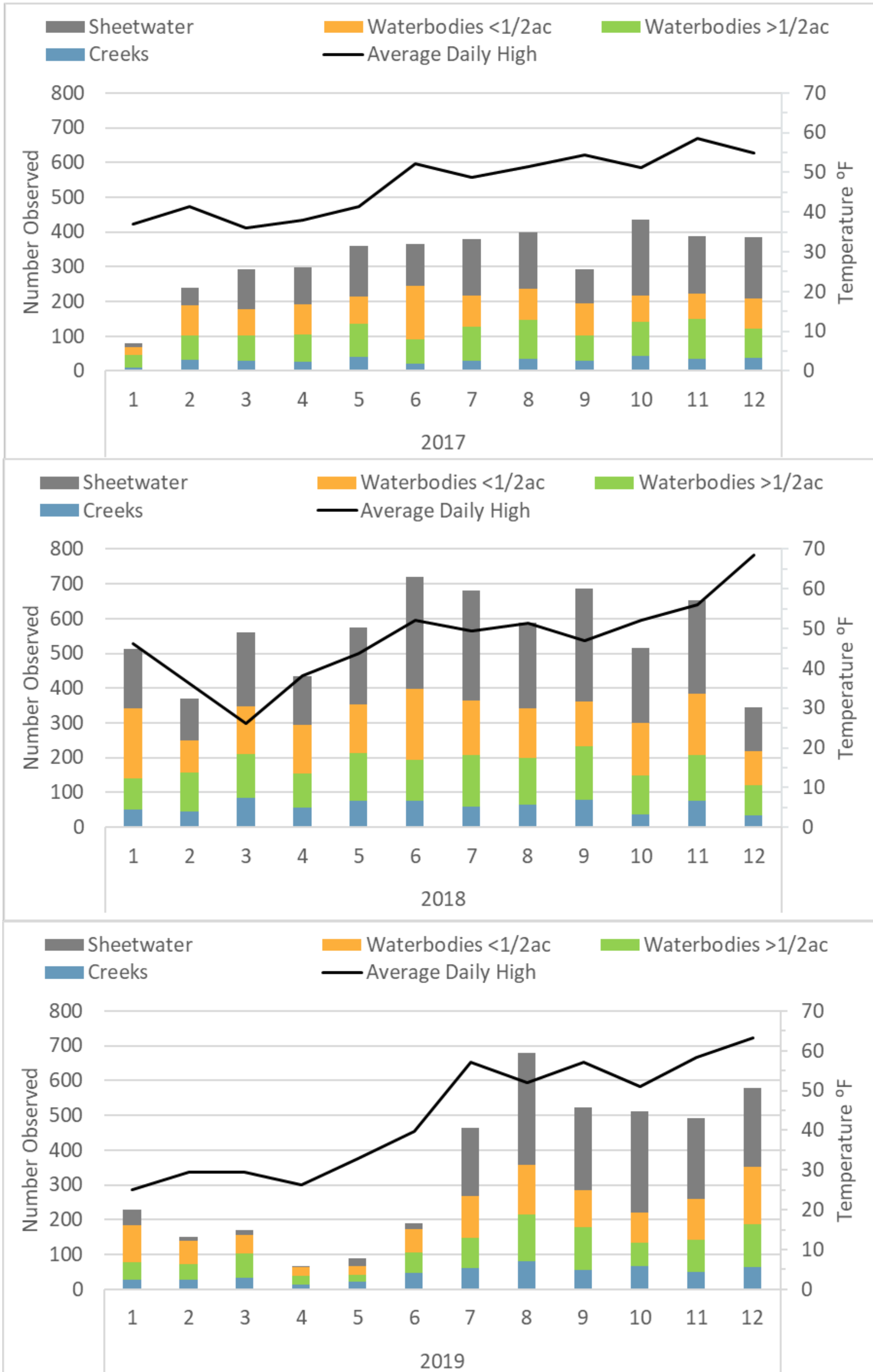


Figure 15: Counts of habitats shown with average daily high temperature by survey week for the Channeled Scablands spring waterfowl migration surveys (2017-2019).

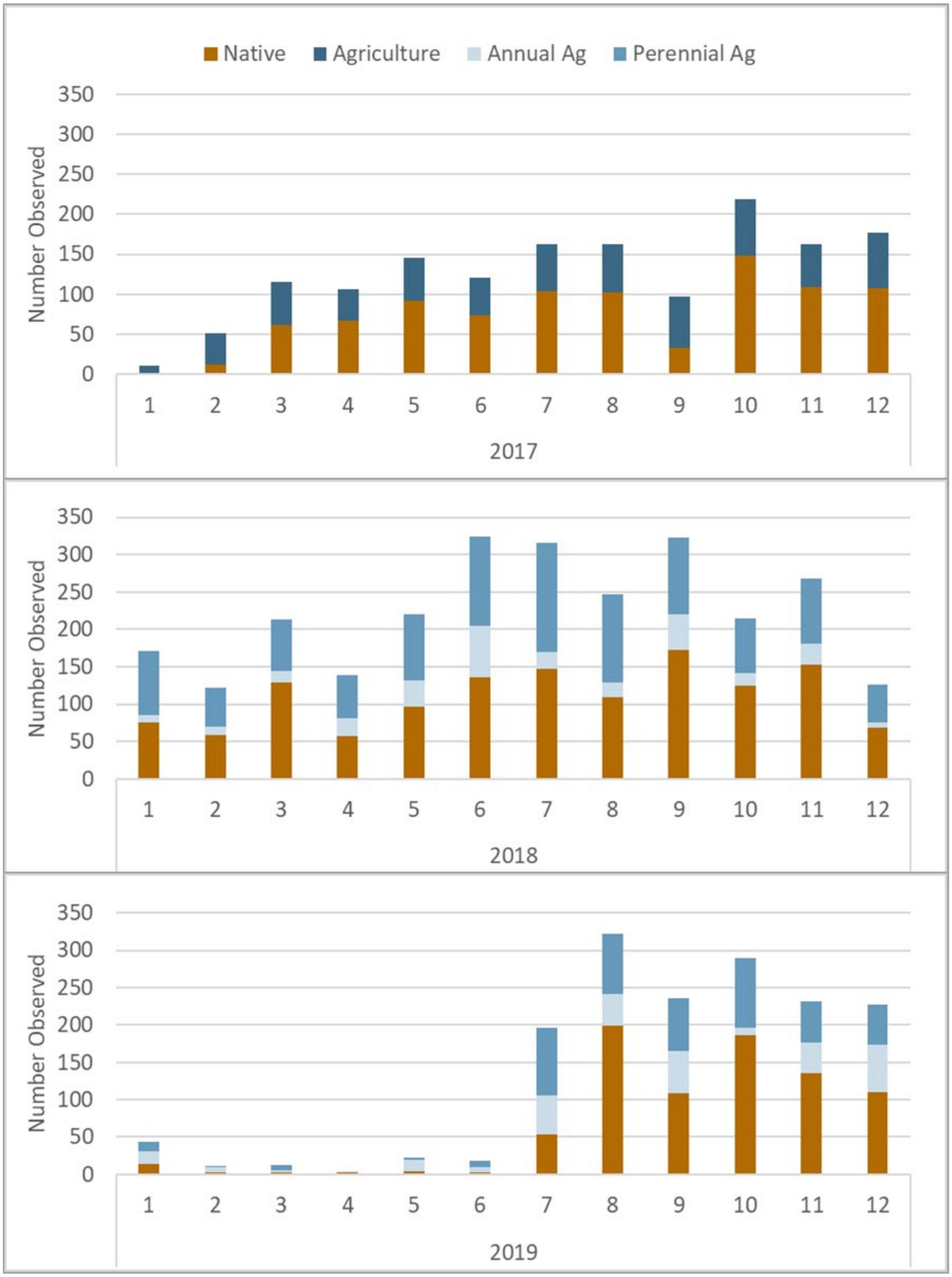


Figure 16: Counts of sheetwater habitats by category (native vs agriculture) and survey week for the Channeled Scablands spring waterfowl migration ground surveys (2017-2019).

Habitat Occupation

Overall, species of waterfowl were consistent in their occupation of the different habitats across years, though there was seasonal variation in use. As mallards, pintails, and wigeon were the most abundant dabblers encountered in the CS, we show the habitat occupation of these species separately, and group the remaining dabblers (predominantly gadwall, green-winged teal, and northern shoveler) into “other dabblers,” and show diving ducks, geese and coots separately (Figure 17). We combined all years (2017-2019) in our assessments of habitat use because when analyzed, there was little difference in overall habitat occupation between years for any species/group (Appendix 3), except for rare weather events, e.g., the long cold period early in 2019.

Waterbodies > ½ acre was the primary habitat category observed for all waterfowl use in the CS, except for mallards, pintails, and wigeon who were observed in sheetwater habitat more often than any other habitat category (Figure 17, Table 12). Though the majority (~56%) of “other dabbler” observations were in waterbodies > ½ acre, sheetwater use is significant with ~34% of observations. Use of waterbodies < ½ acre and creeks was relatively insignificant by all species and groups, except for mallards and “other dabblers” where 14% and 9%, respectively, of observations occurred in these habitats combined.

Table 12: Percent of observations on sheetwater by species or group from the Channeled Scablands spring waterfowl migration ground surveys (2017-2019).

SPECIES/GROUP	2017	2018	2019	2017-2019 AVERAGE
MALLARD	49%	47%	55%	50%
N. PINTAIL	76%	61%	74%	69%
A. WIGEON	65%	45%	59%	55%
OTHER DABBLERS	44%	31%	33%	34%
DIVING DUCKS	7%	2%	3%	4%
COOTS	14%	5%	4%	7%
GEESE	53%	19%	15%	24%

When looking only at the sheetwater habitat categories, approximately 90% of all bird observations (all species and groups) were on agricultural (ag) sheetwater habitats (versus native sheetwater) (Figure 18). However, coots, other dabblers, and mallards did occupy native sheetwater occasionally, with 15%, 14%, and 12% of observations, respectively. Perennial ag sheetwater was used more than annual ag with ~39% of observations on average across all species in perennial ag compared to only ~15% in annual ag. However, geese were counted in the perennial and annual ag categories in essentially equal amounts, with 25% and 28% of observations, respectively.

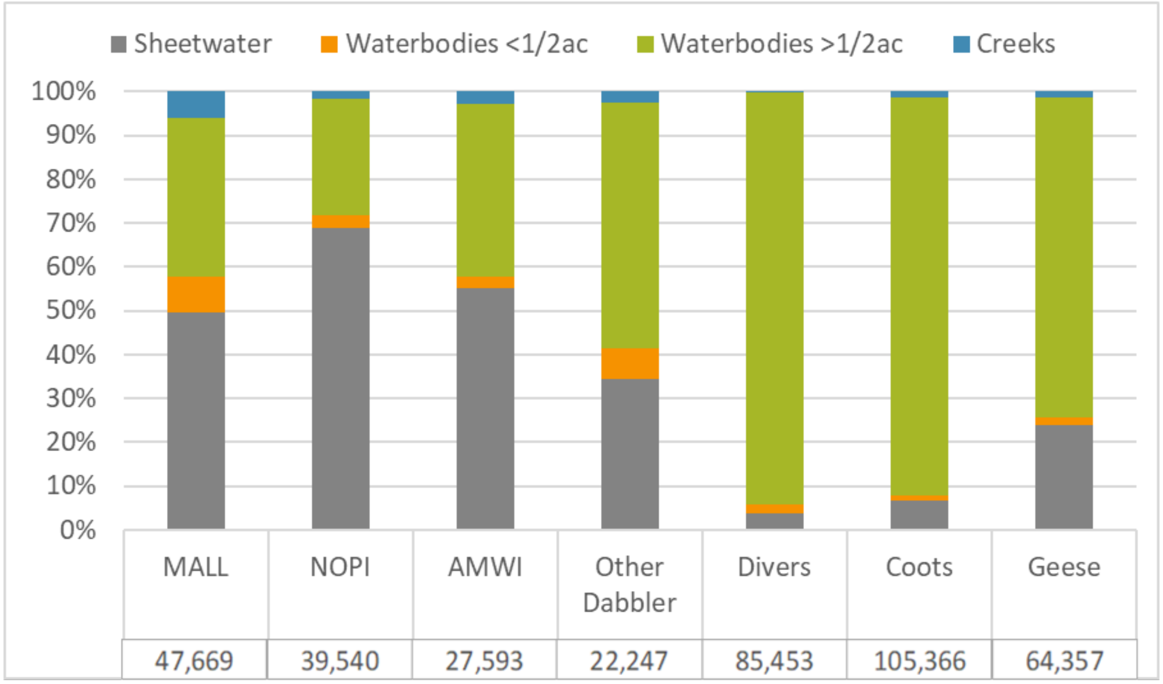


Figure 17: Proportion of observations across four different habitat categories by species or group, all years combined. Channeled Scablands spring waterfowl migration ground surveys (2017-2019). Numbers below columns are the total numbers of birds counted.

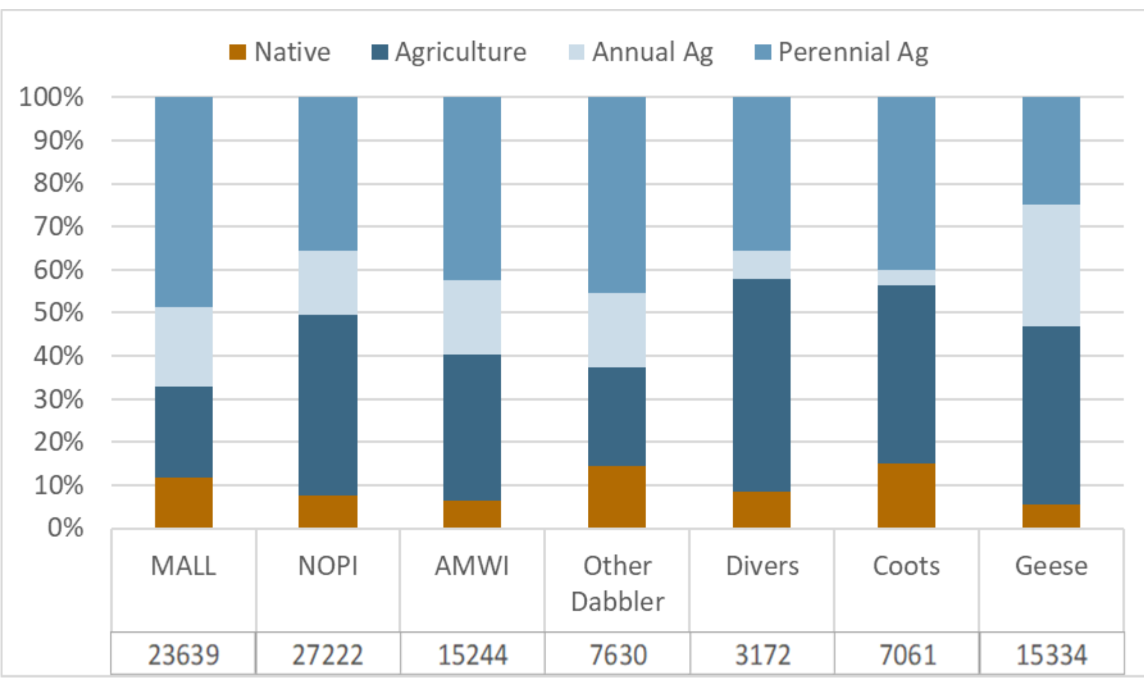


Figure 18: Proportion of observations within the sheetwater categories by species or group, all years combined. Channeled Scablands spring waterfowl migration ground surveys (2017-2019). Numbers below columns are the total numbers of birds counted.

Discussion:

The amount of wetland habitat and timing of its availability is driven by winter precipitation and early spring temperatures in the CS. This, along with conditions elsewhere in the Flyway, drives the timing of waterfowl arrival, with species arriving as the availability of their preferred habitats increases. For divers, coots, and many of our dabblers this is the larger lakes and wetlands (i.e., waterbodies > ½ acre category). However, pintails, wigeon, mallards, and other dabblers are targeting the ephemeral sheetwater category, particularly shallow flooded agricultural fields. The data from the ground surveys show that flooded perennial agricultural fields represent a significant proportion of the sheetwater habitats used by waterfowl. Native sheetwater (rangeland and vernal pools) appears to out-number the perennial ag fields during migration, but they are generally much smaller in size and may have poorer productivity during the spring migration timeframe (i.e., aquatic plant and invertebrate production), and thus, why we saw less usage by waterfowl overall in these habitats.

Exploration of the abundance and timing of availability of the different categories of sheetwater in the region and their use by waterfowl was of particular interest because we suspected that waterfowl use would vary significantly between the various sheetwater categories. This was true, as stated above, perennial agriculture was clearly important to dabblers, and used by divers to some degree. This can direct conservation and management actions on-the-ground, as sheetwater (especially agricultural) has a greater potential for conservation actions (restoration, enhancement, protection, and management) than any of the other habitat categories. Though waterbodies larger than ½ acre are of great importance to the waterfowl in the CS as well, these waterbodies tend to be large lakes and wetlands that have had limited ag development of the lake or wetland itself (i.e., have not been drained), or they have been protected from development formally or by their sheer size. Upland practices around all the habitat categories have the potential for serious implications for habitat and water quality, which in turn will eventually impact waterfowl and other wildlife, if indeed it has not already. We strongly urge analysis of and modification of upland practices that may be detrimental to the water quality in these habitats.

Agricultural sheetwater habitats in the CS, particularly perennial ag, tend to be hay meadows; many were once wetlands that have been ditched, drained, and converted to hay production. They have deep soil and good connectivity to ground and surface water sources, resulting in good productivity and longer duration of surface water. When seasonally flooded, they are highly attractive to waterfowl. Where willing landowners can be found, these should be targets for future conservation activities such as protection from development or conversion, hydrological restoration, and management that includes spring flooding for waterfowl migration. In many cases, all that may be needed is the installation of a water control structure in the original drainage ditch to restore and manipulate hydrology. Having the ability to manage and store water longer would benefit the landowners, especially in dry/drought years which severely reduce hay yields. Climate change models predict this region will experience an earlier freshet, and longer, hotter, drier summers. These meadows rely on spring snowmelt and precipitation to recharge groundwater for sub-irrigation. If the spring freshet occurs earlier in the year, water control infrastructure can retain the waters within those meadows through spring to benefit both spring migration and sub-irrigation of the hay crop.

During the study years, there was an apparent increase in diver numbers in 2018, both in aerial surveys and ground surveys. This increase in divers was largely driven by counts of scaup. For example, in the aerial survey, the estimated bird use-days for scaup increased from nearly 139,000 in 2017, to over 766,000 in 2018, and back to 118,000 in 2019. One possible reason could be the survey methods. Aerial counts are only within the transect, therefore a large group of scaup could be present on a large waterbody, but not counted during the survey if it did not fall within the transect. Therefore, scaup numbers could be larger in 2017 and 2019 than the estimates show, if we missed large groups that fell outside the transects. The ground surveys also counted more scaup in 2018 than in other years (raw counts of scaup from all surveys: 2016 = 6328, 2017 = 7665, 2018 = 11,823, and 2019 = 6145 scaup). On ground routes, the observers record all birds seen from their vantage point on any waterbody, therefore making it less likely to miss a large group of scaup, though that is still possible on large lakes where the entire lake cannot be seen during the survey (e.g., Sprague Lake, Rock Lake, Coffeepot Lake, and Cormana Lake). The magnitude of the increase in 2018 ground counts is not as great as the magnitude of the increase from the aerial counts, however it is present. The reason for the increase in scaup that year is unknown, however it is worth noting, and suggesting that future studies target surveying large lakes by drone to census diving ducks present during migration, with the goal of counting all birds on those habitats. The surveys could also have under-represented large lakes as well. Large lakes represented 16.3% of the habitats within the survey strata, however 12.7% of the habitats on the transects were large lakes. We only sampled 6.6% of all the large lakes within the strata. Scaup are a species of concern in the Intermountain West, as their populations have declined from the long-term average. The population estimate of scaup from 2018 (greater and lesser combined) was 4.0 ± 0.2 million, similar to the 2017 estimate, and was 20% below the long-term average of 5.0±0.04 million (USFWS 2018).

Other limitations:

There were a few other factors that could have impacted our ability to detect individuals during these ground surveys that should be mentioned. During the early portion of spring migration, there was not a strong vegetation limitation, but in April when the grasses and other vegetation started to emerge from the water, it often became more difficult to detect birds from the ground. As well, the landscape contains waterbodies that are partially obstructed by basalt outcroppings and other landscape features.

Conclusions:

Our overall objective was to perform the first large-scale waterfowl spring migration surveys to better understand waterfowl spring migration ecology in an area long identified as a continental priority in the North American Waterfowl Management Plan for non-breeding waterfowl (migration and wintering), to better inform conservation planning, fundraising, and project implementation in this unique area. Partner staff time and funding are in limited supply with all partner agencies, and it is critical to utilize resources in a manner that will provide maximum long-term benefits to the habitats. We collected data to fill critical data gaps, such as: the total estimate of waterfowl using this landscape for migration; species composition; timing of migration (initiation, peak, and duration); and the types and timing of habitats used by different species throughout the migration season. A concurrent study by WDFW used trapping and banding to investigate residence time and behavior of individual pintail hens during their stopover time in this landscape, with satellite tags on some birds to track their entire migration. Those data will help to further our understanding of waterfowl use in this area.

This study achieved our objectives and more. First, the CS is indeed a significant spring migratory stopover location. In an average year (2018), the estimated number of waterfowl in terms of bird use-days within our survey strata was over 5.83 million, representing 27 species of migratory waterfowl and coot, and ten of these species are NAWMP or IWJV priority species (IWJV 2019, U.S. Department of the Interior et al. 2018). Dabbling ducks represented the largest component of those bird use-days at 54%, and 41% of those 5.83 million bird use-days were mallard and pintail alone, both priority species.

Though divers represented a smaller overall number of birds, their numbers were also significant, with over 822,000 use-days in 2018 in our survey strata. This represents 14% of the overall numbers of bird use-days in that year. More work needs to be done to investigate their use of this area, as this region contains many large lakes, and some are undoubtedly more important than others. Sprague Lake for example, at 1,800 acres, was not included in the aerial surveys, but was on a ground-survey route. During peak migration, we counted thousands of birds using this lake per survey, mainly diving ducks such as scaup, ruddy duck, canvasback, redhead, bufflehead, and others. Redhead were once more common throughout this area, and it was concern for the redhead duck that spurred formation of the Turnbull National Wildlife Refuge, and small but potentially significant numbers of redhead still persist through the area.

We found that 27 species of waterfowl utilize this area during spring migration, and timing, duration, and peaks of these species differed over the three comparable years of the study, which can inform managers as to which habitats need to be protected and available during those times of the spring migration when they are needed. For example, generally pintail, mallard and geese are the most abundant birds in the early season, with a wave of diving ducks arriving next, along with other dabblers such as American wigeon, gadwall, cinnamon, and green-winged teal. Swans and coots arrive a bit later, and birds such as ruddy ducks and blue-wing teal are late-arrivals and are still not at their peak by end of April.

A significant finding was that for 2018 and 2019, the total number of bird use-days did not greatly differ between those years, though there was a difference in the timing of bird-use days, largely due to when habitats were available between years. This was especially apparent in 2019, due to the unusual long cold spell well into March. Huge numbers of birds were counted suddenly in 2019 after the long cold spell ended, which illustrates the importance of this region to spring migrating waterfowl. The birds were likely staging nearby on deeper lakes and riverine wetlands. When habitats in the CS rapidly thawed, large numbers of birds rushed to utilize those habitats within a shorter timeframe, rather than avoiding the CS entirely for areas farther north.

There was an apparent increase in waterfowl use between 2017 and 2018-2019, which could be explained by the increase in precipitation each year, and therefore wetted / available habitats. Waterfowl can adjust their migration patterns due to the ephemeral nature of their desired habitats. Areas wet in some years may be dry in other years. The CS region indeed appears to host much higher numbers of waterfowl when the area contains more available habitat during a series of wet years.

Third, we learned a great deal about various habitats in the CS and their use by waterfowl over the duration of spring migration, across the three years, all of which were different water years and weather patterns. Overall, perennial agricultural fields, when flooded, provided a very important habitat resource for many species of waterfowl, especially dabbling ducks, swans, and geese. This type of habitat should be prioritized for land protection activities, and landowners should be supported to continue or adopt land use practices to preserve and maintain the valuable contribution of flooded perennial agricultural fields in this landscape.

Across the west, flood irrigation practices are being converted to pivot irrigation, in the name of water conservation. (Sketch et. al. 2020). In reality, pivot irrigation can have a larger detrimental impact on groundwater supplies than flood irrigation and does not provide the spring migratory habitat for water birds, waterfowl, and shorebirds (Ochoa et. al. 2013 and Peck and Lovvorn 2001). To-date, most of the flood-irrigated habitats in the CS are passively flooded during spring snow melt, rains, and over-bank flooding rather than being primarily flooded through active diversion as is common in the SONEC. As a result, pivot conversion has been relatively rare in the CS. If flood irrigated habitat becomes scarcer in traditional migration stopover locations in the arid west, the spring migration habitats available in the CS may become more important to waterfowl in the Pacific Flyway.

Large waterbodies (>½ acre) were important to all the species/groups, but were critically important to diving ducks, and should be prioritized for protection of water supplies and water quality. More than 94% of the time, divers were found on waterbodies > ½ acre in size. Habitats within this category included wetlands larger than ½ acre as well as large lakes, such as Cormana, Coffeepot, Rock, Sprague, and other lakes. Threats to these habitats include diminishing water supplies due to climate change and groundwater extraction, as well as water quality issues such as temperature, eutrophication, excess nutrients, pesticides, and other toxins. For example, Sprague Lake, which hosted thousands of migrating waterfowl consistently each year, has two Category 5 water quality listings, two Category 3 listings, and 15 Category 1 listings, and is included in the Palouse River Watershed Temperature TMDL (DOE 2020). Across Washington and other western states, more lakes are having periods of eutrophication. Eutrophication is excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen. Eutrophic lakes also can harbor HABs, harmful algal blooms, that contain toxins which make the fish unsafe to eat and even make the waters unsafe to swim in. Human activities in the CS have a large impact on the water quality and quantity of lakes and large wetlands, include cattle grazing, agricultural activities, shoreline development, roads, recreational activities, and groundwater extraction. Lakes and other water bodies important to migrating waterfowl should be monitored for water quality, and human activities mitigated on the shore of the lakes by using best management practices such as buffers to protect the water quality of the lakes and the value they provide for waterfowl, other wildlife, humans who enjoy those lakes, and downstream water users.

Protection and maintenance of high-quality habitats is critical as the landscape alters due to climate change. Climate models predict that the region will have less snowpack overall, earlier thaw dates and spring freshet which results in earlier run-off, and longer, hotter, and drier summers. Waterbodies will have less water inputs, and higher outputs through evapotranspiration. Water bodies are predicted to shift in size, duration, and type due to these potential changes (Halabisky et al. 2017).

Management implications and Next Steps:

It will be important to continue refining our approaches to habitat conservation in the CS and across the arid West, particularly in the face of climate change and the myriad impacts expected, and already being felt. Chambers and Pellant (2008) discuss the impacts of climate change on rangelands in the arid west. Their points could be applied to spring flood-irrigated agricultural lands as well, as both types of lands depend on local surface water supplies and precipitation. Changes are already occurring, and more are to be expected, in water resources – quantity, flow regimes, and quality, shifts in plant and animal species' ranges, loss of biodiversity, increases in exotic species invasions, altered fire regimes, and more. They state that higher temperatures and increasing variability in precipitation will increase the difficulty of managing for sustainable lands, resulting in the potential for more litigation and political intervention. Natural population dynamics of many native and even introduced species are unlikely to respond quickly enough to changing climatic conditions to avoid widespread changes in plant communities. This may be especially true for wetland communities which are largely dependent upon winter precipitation in the form of snowpack. Rangelands and flood-irrigated agriculture fields are major land uses across much of the region, and, without highly flexible management options, land degradation could accelerate, especially during drought.

Given the uncertainties of future climate and its impacts on wetland communities and agriculture across the arid west and in eastern Washington, it is critical to use the best available science for developing concepts and practices for dealing with change. A variety of policies and programs are needed to provide the necessary funds, mechanisms, and flexibility to implement large-scale adaptive management approaches. Private landowners also require more options and the flexibility to make decisions that have sound economic benefits in the short and long-term. Successful adaptive management will require engaging the local stakeholders, especially landowners, and letting their concerns guide the development of the programs and management activities. Lastly, but perhaps most importantly, conservation partners should explain to stakeholders the changes that are likely to occur and the reality of responding to a changing climate.

One of the important actions we have identified is the conservation of sheet flooded agricultural lands in the CS. We have documented the importance of these habitats to waterfowl in the CS, but this has also been identified in the SONEC, southwestern Montana, Utah, and Colorado. The IWJV (www.iwjv.org) states that wet meadows on irrigated agricultural lands comprise 62 percent of the wetland habitat in snowpack-driven systems of the Intermountain West. These lands provide vital habitat for migratory birds, sustain floodplain function, and recharge aquifers, but are at risk of fragmentation from rural subdivision, competing water demands, and the ongoing impacts of climate change. The role of the IWJV is to support diverse public-private partnerships for the delivery of coordinated habitat conservation that also benefits birds and other wildlife, ranching, industry, and economic livelihoods of western communities. Their "Water 4 Initiative" and their work in the SONEC to protect working wet meadows has helped local partners and landowners determine their needs and develop strategies for maintaining flood irrigation on working lands to benefit agricultural production, profitability, and habitats for waterfowl and other migratory birds. The CS already has a strong collaborative group of conservation partners, including the IWJV, and together we intend to use the results of this effort to develop outreach products for stakeholders, to educate them, and develop a variety of tools that can be used to enact meaningful on-the-ground conservation activities in the CS, and perhaps scaled-up throughout eastern Washington.

Over the past several decades, partners in the CS have accomplished tens of thousands of acres of habitat work on wetlands and associated uplands, yet vast opportunities remain in this landscape. Wetland acres in the two survey strata used in our study equal over 72,500 acres (source: USFWS National Wetlands Inventory). Those acres might not include all the flooded agricultural lands, depending on when those lands were flooded and when the NWI layer was developed. One benefit of working in the CS is that historically, real estate development has not been as much of a threat to wetlands as in other parts of the country. However, the pace of land subdivision seems to be accelerating in the last few years, and we have seen the subdivision of large wetland basins into multiple 20-acre lots in places, which significantly complicates and can limit the management and restoration efforts in those large basins. The major threats facing the remaining large, intact wetland and riparian complexes and large sheet flooded agricultural lands (which were mostly former wetlands or floodplain habitats) include conversion from native habitats to agriculture, or conversion from sheet flooded agriculture to other land uses, invasive species, changing climate, and dwindling or uncertain water supplies. A second benefit to working in this landscape is the cost-effective nature of hydrological restoration in ditched and drained wetlands: a simple water control structure in the ditch to manage water is relatively inexpensive and can benefit hundreds or thousands of acres.

However, funding remains a challenge in this region. One important source of funding historically has been the North American Wetlands Conservation Act Program (NAWCA). Administered by the USFWS Division of Migratory Birds, funding is available for protection, enhancement, and restoration of wetlands and associated habitats. The coalition of partners in the CS has already accomplished significant habitat work in the CS using NAWCA funding. Three standard grants of $1,000,000 each were secured, impacting 15,915 acres of wetlands and associated uplands. For the Phase 3 grant alone, 17 partners provided over $4,095,000 in non-Federal matching funds and over $1,315,000 in Federal contributions to secure those grant dollars. However, the last standard grant was secured in 2014; shifting priorities within the program have made securing the standard grants more difficult in our area. This effort to document the importance of the CS to waterfowl spring migration may elevate the priority of this region by the IWJV, the NAWCA program, and other funding partners. Local partners have benefitted thousands of additional acres through their individual or other group efforts as well. Other important past and potential future sources of funding include the Bureau of Land Management, WA State Migratory Waterfowl and Wetlands Conservation Program (aka “Duck Stamp Program”), USFWS Partners for Fish and Wildlife Program, grants from the WA State Water Quality Program, and the USDA NRCS funding through Farm Bill programs.

The research documented here was an immense effort across four years, led by six local partner groups and multiple other public and private landowners, and illustrates the importance of this region to waterfowl during spring migration. It also contributes significantly to the paucity of information on waterfowl spring migration in the Intermountain West, and highlights areas where further research is needed. Given the uncertainties of future habitat conditions due to a changing climate, we urge partners across the Intermountain West to perform similar spring migration surveys. Collaborating across administrative boundaries will be necessary in the future to provide adequate resources to waterfowl during spring migration throughout the Pacific Flyway for decades to come.

References:

Adams, E. M. 2014. Using migration monitoring data to assess bird population status and behavior in a changing environment. Dissertation, The University of Maine, Orono, USA. http://digitalcommons.library.umaine.edu/etd/2238

Baldassarre, G. 2014. Ducks, geese, and swans of North America. Johns Hopkins University Press, Baltimore, Maryland, USA.

BC Ministry of Environment, Land and Parks. 1999. Inventory methods for waterfowl and allied species: loons, grebes, swans, geese, ducks, American coot and sandhill crane. Standards for components of British Columbia's biodiversity no. 18. Province of British Columbia, Resources Inventory Committee. https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/waterfowl.pdf

Bonsignore, C., T. Blewett, and B. Heck. 2013. Monitoring report and management recommendations for restored wetlands on the Bureau of Land Management Border Resource Area, eastern Washington. Ducks Unlimited, Inc. Spokane, Washington, USA.

Caughley, G. 1974. Bias in aerial survey. Journal of Wildlife Management 38:921–933.

Chambers, J. C., and M. Pellant. 2008. Climate change impacts on northwestern and intermountain United States rangelands. Rangelands 30:29–33.

Connelly, J. W., and I. J. Ball. 1984. Comparisons of aspects of breeding blue-winged and cinnamon teal in eastern Washington. Wilson Bulletin 96:626–633.

Fleskes, J. P., and C. J. Gregory. 2010. Distribution and dynamics of waterbird habitat during spring in southern Oregon—northeastern California. Western North American Naturalist 70:26–38.

Fleskes, J. P., and J. L. Yee. 2007. Waterfowl distribution and abundance during spring migration in southern Oregon and northeastern California. Western North American Naturalist 67:409–428.

Halabisky, M., S. Y. Lee, S. A. Hall, and M. Rule. 2017. Can we conserve wetlands under a changing climate? Mapping wetland hydrology across an ecoregion and developing climate adaptation recommendations. USGS Technical Report, Reston, Virginia, USA. https://www.sciencebase.gov/catalog/item/55e07c5fe4b0f42e3d040f3e

Heusmann, H. W. 1999. Let's get rid of the Midwinter Waterfowl Inventory in the Atlantic Flyway. Wildlife Society Bulletin 27:559–565.

Intermountain West Joint Venture [IWJV]. Priority species list. www.iwjv.org Accessed 4 November 2019

Koneff, M. D., J. A. Royle, M. C. Otto, J. S. Wortham, and J. K. Bidwell. 2008. A double-observer method to estimate detection rate during aerial waterfowl surveys. Journal of Wildlife Management 72:1641–1649.

Masto, N. M. 2019. Evaluation of aerial surveys to monitor fall-winter waterbird populations in South Carolina. Thesis, Clemson University, Clemson, South Carolina, USA.

Ochoa, C. G., A. G. Fernald, S. J. Guldan, V. C. Tidwell, and M. K. Shukla. 2013. Shallow aquifer recharge from irrigation in a semiarid agricultural valley in New Mexico. Journal of Hydrologic Engineering 18:1219–1230.

Pearse, A. T., P. D. Gerard, S. J. Dinsmore, R. M. Kaminski, and K. J. Reinecke. 2008. Estimation and correction of visibility bias in aerial surveys of wintering ducks. Journal of Wildlife Management 72:808–813.

Peck, D. E., and J. R Lovvorn. 2001. The importance of flood irrigation in water supply to wetlands in the Laramie Basin, Wyoming, USA. Wetlands 21:370–378.

Prenzlow, D. M., and J.R. Lovvorn. 1996. Evaluation of visibility correction factors for waterfowl surveys in Wyoming. Journal of Wildlife Management 60:286–297.

Sketch, M., A. A. Dayer, and A. L. Metcalf. 2020. Western ranchers' perspectives on enablers and constraints to flood irrigation. Rangeland Ecology and Management 73:285–296. https://doi.org/10.1016/j.rama.2019.12.003.

Smith, G.W. 1995. A critical review of the aerial and ground surveys of breeding waterfowl in North America. Biological Science Report 5. National Biological Service, Washington, D.C., USA.

U.S. Department of the Interior, Environment Canada, and Environment and Natural Resources Mexico. 2012. North American waterfowl management plan: people conserving waterfowl and wetlands. U.S. Department of the Interior, Washington, D.C., USA. https://nawmp.org. Accessed 20 December 2019.

U.S. Department of the Interior, Environment Canada, and Environment and Natural Resources Mexico. 2018. North American waterfowl management plan update. U.S. Department of the Interior, Washington, D.C., USA. https://nawmp.org. Accessed 20 December 2019.

U.S. Fish and Wildlife Service [USFWS]. 2007. Turnbull National Wildlife Refuge comprehensive conservation plan. U.S. Fish and Wildlife Service, Portland, Oregon, USA. https://www.fws.gov/sites/default/files/documents/turnbull_nwr_comprehensive_conservation_plan_1.pdf.

U.S. Fish and Wildlife Service [USFWS]. 2014. Survey techniques and protocols. U.S. Department of the Interior, Washington, D.C., USA. https://www.fws.gov/waterfowlsurveys/forms/protocols.jsp? menu=protocols.

U.S. Fish and Wildlife Service [USFWS]. 2018. Waterfowl population status. U.S. Department of the Interior, Washington, D.C., USA.

U.S. Fish and Wildlife Service [USFWS]. 2021. Division of Migratory Bird Management, mid-winter waterfowl survey. https://migbirdapps.fws.gov/mbdc/index.html. Accessed 10 January 2021.

U.S. Geological Survey [USGS]. 2018. Western Ecological Research Center. Western states cinnamon teal initiative. https://www.usgs.gov/centers/werc/science/western-states-cinnamon-teal-initiative. Accessed 19 July 2021.

Appendices:

Appendix 1

CHANNELED SCABLAND SPRING WATERFOWL GROUND SURVEY PROTOCOL

- Run surveys weekly starting the first full week in February through the third full week in April.
- Try to keep consecutive runs of a route 5-7 days apart and at a minimum 3 days apart (e.g. a survey was run on Friday the next potential date is the following Monday, but ideally would be run Wednesday-Friday). Better to get the survey done though then wait for ideal day or perfect weather conditions.
- Email the group of folks that are surveying the route to let them know the day you completed the survey and any important tips/notes (e.g. bridge at Cherry Creek is out).
- Individual observer should enter their data into Excel datasheet and upload to Sharepoint site to the appropriate year folder in the "ground_surveys" folder in the "data" folder under documents.
- No set start or end times for surveys but should not begin before or continue past good light conditions. Most often this is sun rise/set, however depending on area topography and route orientation it might be best to start later or end earlier due to glare.
- No set weather standards, but again should not be run in conditions that limit visibility or are not safe for observers.
- **Survey Routes** are broken into <u>segments</u> and potentially walk in points.
- **Survey Areas** (e.g. Reardan Audubon Lake, Deep Creek Preserve, Swanson Lakes, etc.) will be composed of multiple observation <u>points</u> that give a good representative of the waterfowl present.
- Record the number of Creeks, Potholes (≤ ½ acre), Lakes, Sheetwater Annual Ag (e.g. flooded wheat fields), Sheetwater Pasture/Perennial Ag (e.g. hay field, bunch grass fields, etc.) and Sheetwater Native/Vernal Pools (flooded shrubsteppe or biscuit and swale) available at each point or along each segment of route. Only record those that contain water on the day of the survey. See the data form for more information.
- Record the number of each species seen on or flushing from waterbodies, fields, etc. at each Point or along each Segment of a route (see data form). DO NOT include migrating flocks in the Point/Segment fields, record these (species, number, etc.) in the Notes field.
- If you cannot identify to species use the lowest identifiable classification (diving duck, dabbling duck, goose, etc.) and record number of individuals.
- The same equipment should be used for each survey at a particular Point/Segment. For example, if a spotting scope is used to perform surveys on a route, observers must always use a spotting scope at the same locations, otherwise counts may not be comparable.
- If you cannot complete a survey Route/Area, take detailed notes on what was the last Segment of a Route or Point at an Area you finished. This may prevent loss of data for an entire Route/Area for that week. Also contact survey coordinator so they can look into getting the route re-run that week if possible.

- If you cannot run a route contact the survey coordinator ASAP so they can look into getting the week covered.
- Record any potentially significant disturbances present at time of survey (i.e. crop duster in area, people and/or equipment activity in close proximity) in notes.
- A WDFW or DU truck may be available on occasion to volunteers. This requires filling out DMV record paperwork ahead of time. Please contact Tina Blewett or Michael Atamian for additional information.

WEEKLY CHANNELED SCABLAND WATERFOWL SURVEY FORM

DATE:____________________ OBSERVER:____________________ ROUTE & SEG:________________________

START TIME:______________ TEMP (F°): ______ WIND: ______ CLOUD: ________ PRECIP: _______

END TIME:_________________ TEMP (F°): ______ WIND: ______ CLOUD:________ PRECIP: _______

Wetland Type	Creeks	Potholes (≤1/2acre)	Lake	Sheetwater Annual Ag	Sheetwater Pasture/ Perennial Ag	Sheetwater Native/Vernal Pools
Count						
Percent Frozen						
Species:						
MALLARD						
GADWALL						
AMERICAN COOT						
CANADA GOOSE						

UNKNOWN DUCK						

NOTES:

TEMP	**Temperature within a 5-10 degree range**
WIND SPEED CODES:	
0	**less than 1 km/h; calm; smoke rises vertically.**
1	**1-5 km/h (1-3 m/h); smoke drift shows wind direction.**
2	**6-11 km/h (4-7 m/h); leaves rustle, wind is felt on face.**
3	**12-19 km/h (8-12 m/h); leaves, small twigs in constant motion; light flag extended.**
4	**20-28 km/h (13-18 m/h); raises dust, leaves, loose paper; small branches in motion.**
5	**29-38 km/h (19-24 m/h); small trees fully leafed sway**
6	**39-49 km/h (25-31 m/h); larger branches in motion; whistling heard in wires.**
7	**50-61 km/h (32-38 m/h); whole trees in motion; resistance felt walking against the wind.**
8	**62-74 km/h (39-45 m/h); twigs, small branches broken off trees; walking generally impeded.**
9	**Greater than 74 km/h (47 m/h).**
CLOUD	**Cloud cover: Clear, Partly (16-50%), Mostly (51-75%), Overcast**
PRECIP	**None, Fog/Mist, Drizzle, Rain, Snow**
SECTION or OBS-POINT	**Name/number of the Transect or Observation Point**
CREEK, POTHOLES, etc.	**Count of waterbody by type with water for that transect or point. Size of waterbody is estimated based on amount of water at time of observation. Meaning even if the waterbody at full capacity would be considered a "Small Lake" if it only has ½ acre of water it is a recorded as a "Pothole". With regards to counting sheetwater bodies, if they are discrete (more than 100 yards apart) should be counted separately. Two properties with one large expanse of water crossing a fence should be counted as a single occurrence regardless if there is a fence dividing it.**
PERCENT FROZEN	**On average what percentage of the waterbodies in the transect/point were frozen (Open, 5%, 25%, 50%, 75%, 100%)**

SCABLAND SPECIES	
MALLARD	CANADA GOOSE
GADWALL	SNOW GOOSE
AMERICAN WIGEON	TUNDRA SWAN
GREEN-WINGED TEAL	TRUMPETER SWAN
CINNAMON TEAL	
BLUE-WINGED TEAL	
NORTHERN SHOVELER	
NORTHERN PINTAIL	
WOOD DUCK	
REDHEAD	
CANVASBACK	

LESSER SCAUP	
GREATER SCAUP	
RING-NECK DUCK	
RUDDY DUCK	
BUFFLEHEAD	
AMERICAN COOT	
COMMON GOLDENEYE	
BARROWS GOLDENEYE	

Appendix 2

Photo Examples of Habitat Categories

Photo 1: Example of a creek assigned to the creek habitat category for spring waterfowl migration surveys in the Channeled Scablands. Photo by V. Kaufman.

Photo 2: Crab Creek, assigned to the creek habitat category. Photo by T. Blewett, DU, on 04/10/2019. Lincoln County, WA.

Photo 3: Example of a small wetland in the "waterbody < ½ acre" habitat category. Photo by V. Kaufman.


Photo 4: Example of a feature that would be classified in the "waterbody < ½ acre" habitat category. Photo by V. Kaufman.


Photo 5. Example of a small wetland assigned to the "waterbody < ½ acre" habitat category. This is one of the restored wetland cells at the Swanson Lakes Wildlife Area, Z-Lake Unit, along the Lake Creek system in Lincoln County, WA. Photo by T. Blewett, DU, on 03/16/16.

Photo 6: Example of a large wetland assigned to the “waterbody > ½ acre” habitat category. This restored wetland is part of the BLM Lone Pine property along Lake Creek, in Lincoln County, WA. Photo by T. Blewett, DU on 02/23/2016.

Photo 7: Cormana Lake (aka Duck Lake) near Harrington, Lincoln County, WA. Example of a lake assigned to the “waterbody > ½ acre” habitat category. Photo by T. Blewett, DU, on 02/23/2016.

Photo 8: Example of perennial agricultural sheetwater category. South of the town of Sprague, WA and alongside Highway 23. Photo on 03/18/2018 by T. Blewett, DU.

Photo 9: Example of a feature classified as in the perennial agricultural sheetwater habitat category. Photo by T. Blewett, DU.

Photo 10: Example of an annual agricultural sheetwater habitat category from spring waterfowl migration monitoring in the Channeled Scablands. Photo made available through Ducks Unlimited.org.

Photo 11: Example of an annual agricultural sheetwater habitat category. Photo by T. Blewett, 02/22/2017, near Coffeepot Lake, Lincoln County, WA.

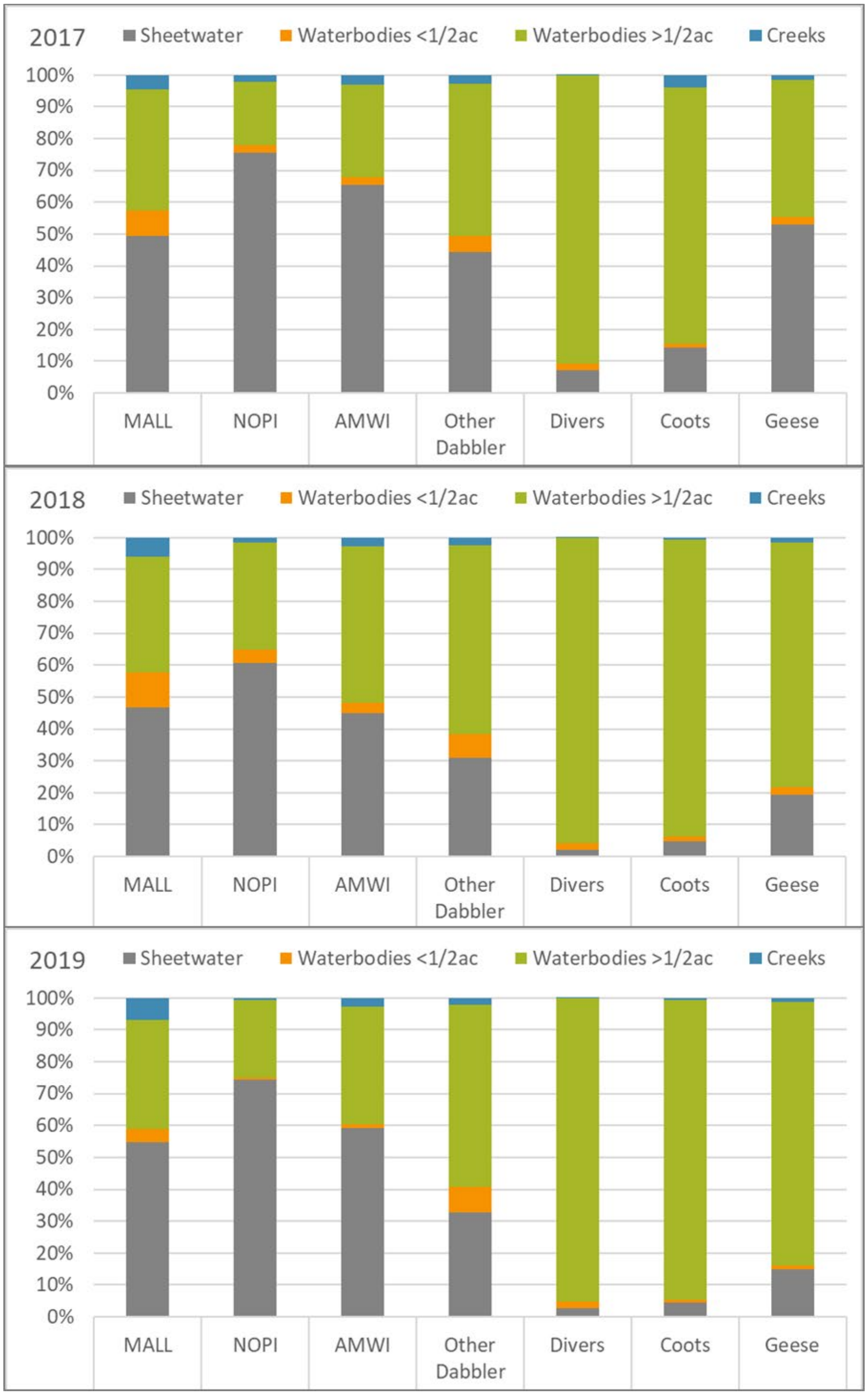
Photo 12: Example of flooded native grass in the sheetwater habitat category. Photo by T. Blewett, DU on 04/21/2016. Located at the south end of Rock Lake, Whitman County, WA. Comprised of native grasses and camas (*Camassia quamash*).

Photo 13: Example of a flooded native grass in the sheetwater habitat category, along Telford Road south of Highway 2, west of Davenport WA. Vernal pools fell into this category. Photo by T. Blewett, DU, on 04/13/2016.

Photo 14: Example of flooded native grass in the sheetwater habitat category. Native grass areas are commonly used as rangelands in the Channeled Scablands. South of Rock Lake, Whitman County, WA. Photo by T. Blewett, DU, on 04/21/2016.

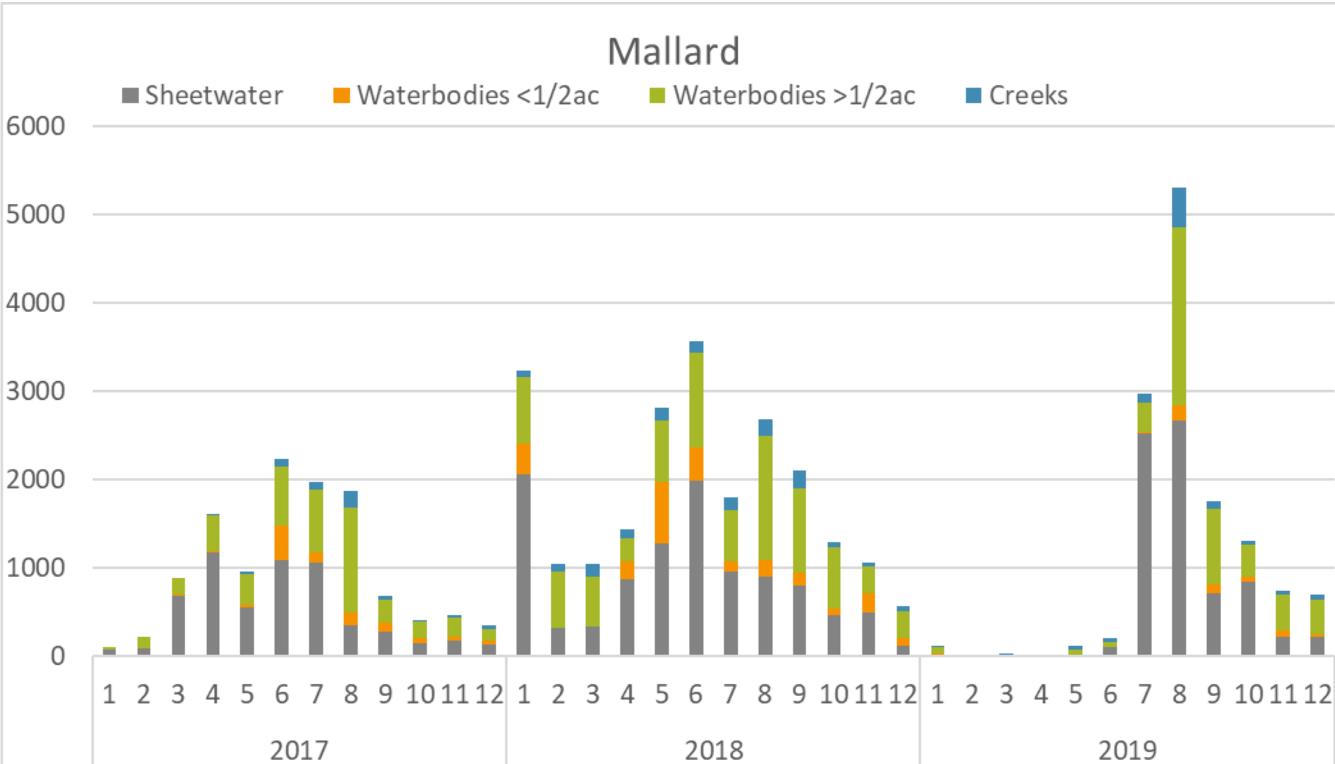
Appendix 3.

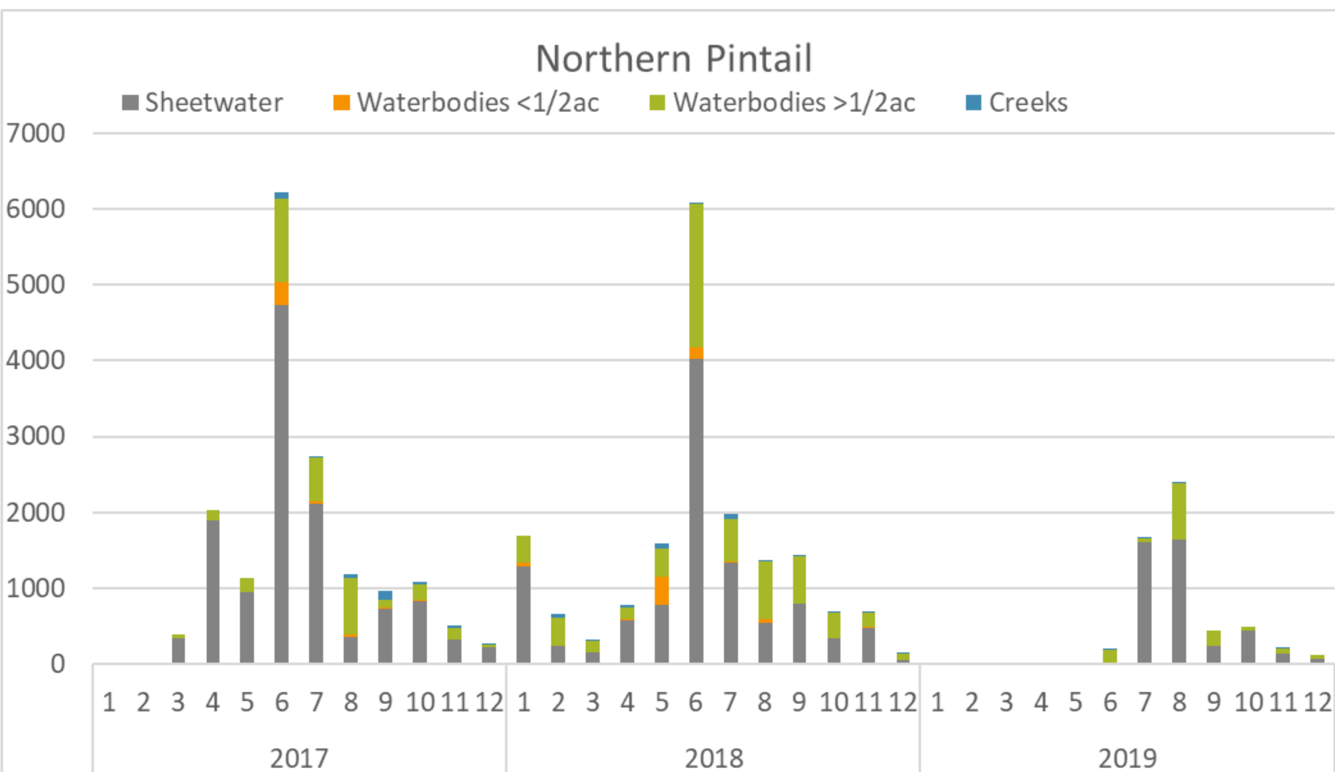
Additional waterfowl - habitat graphs.

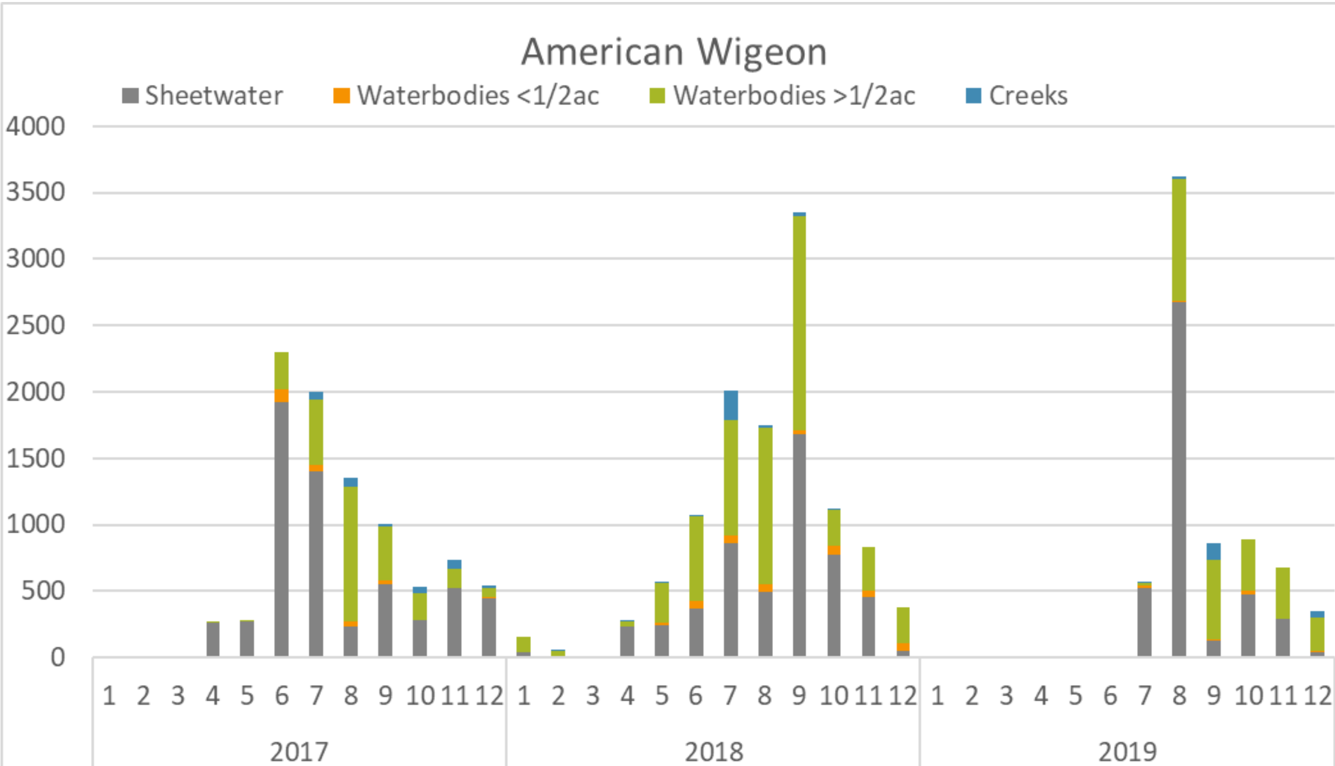


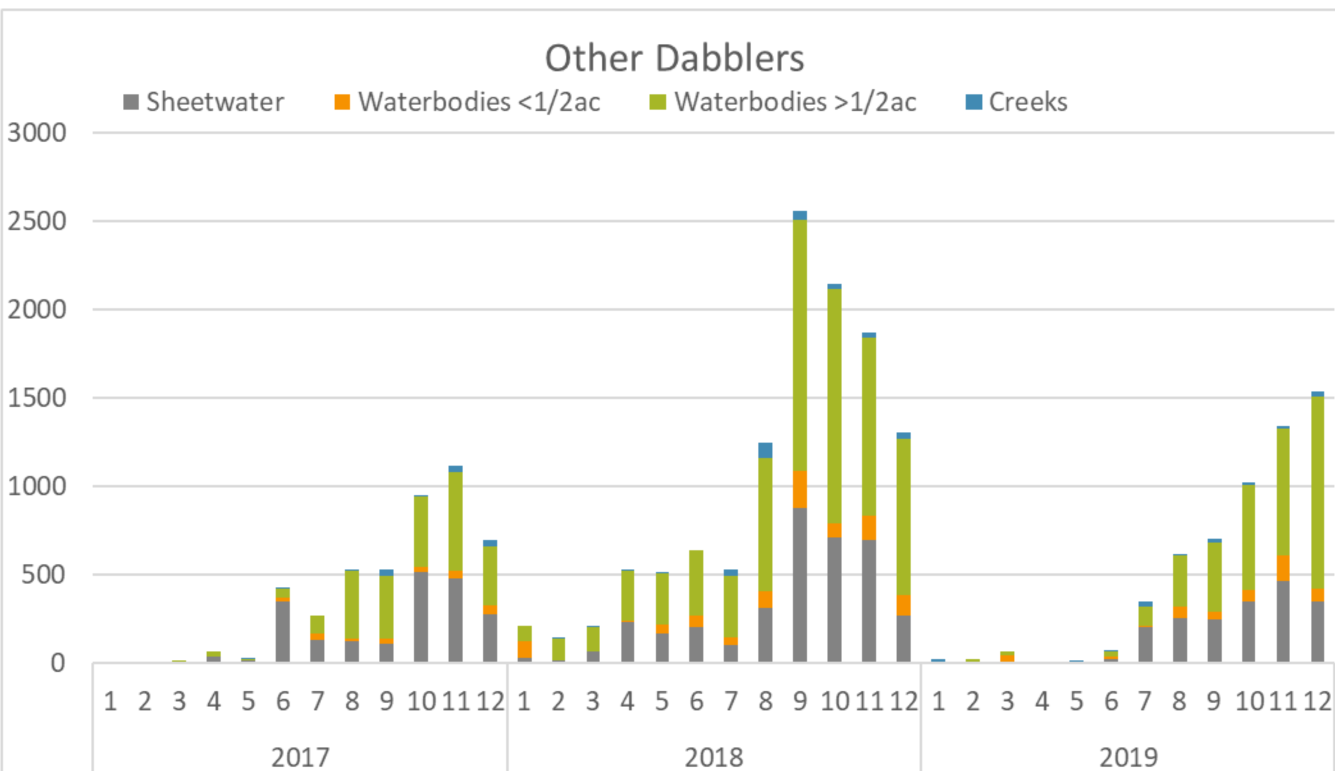
Proportion of observations across four different habitat categories by year and by species or group from the Channeled Scablands spring waterfowl migration ground surveys (2017-2019).

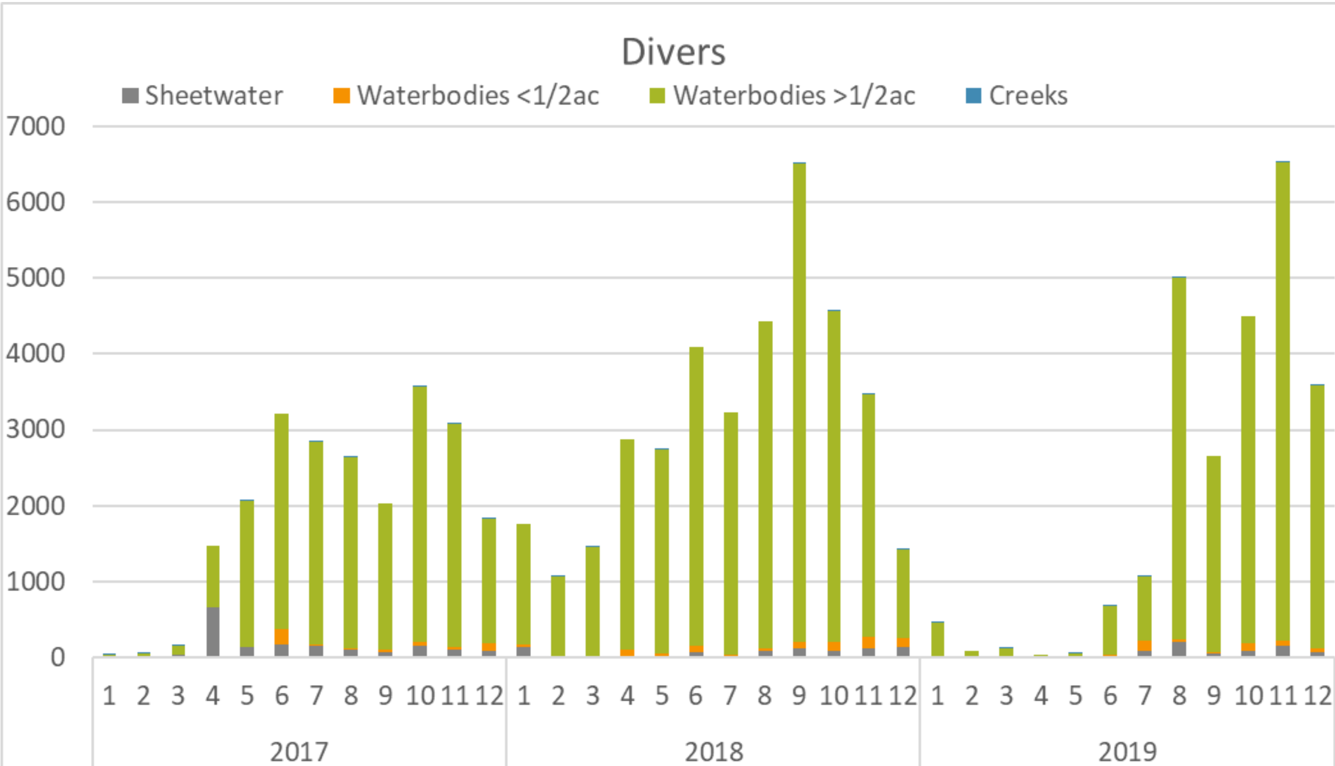
Each of the following figures show use of four different habitat categories by survey week and by year for an individual species or group.

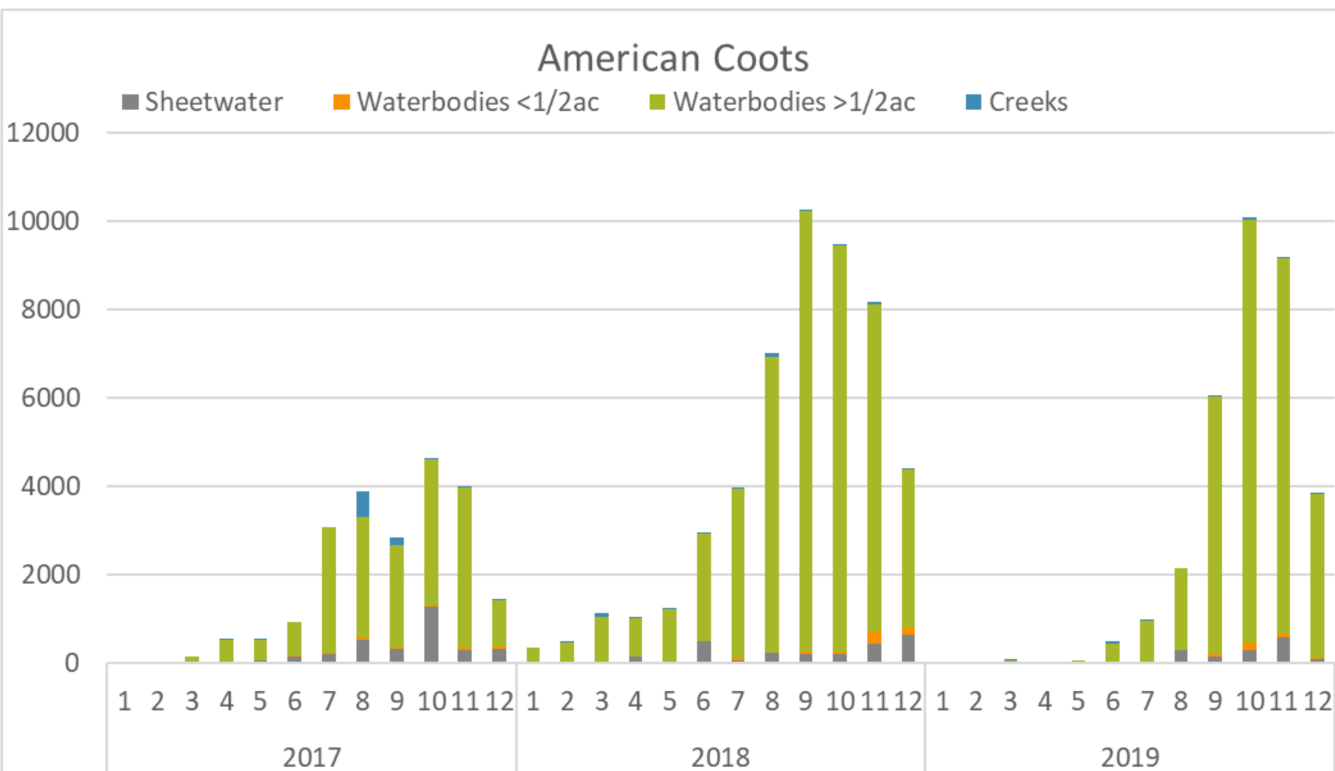


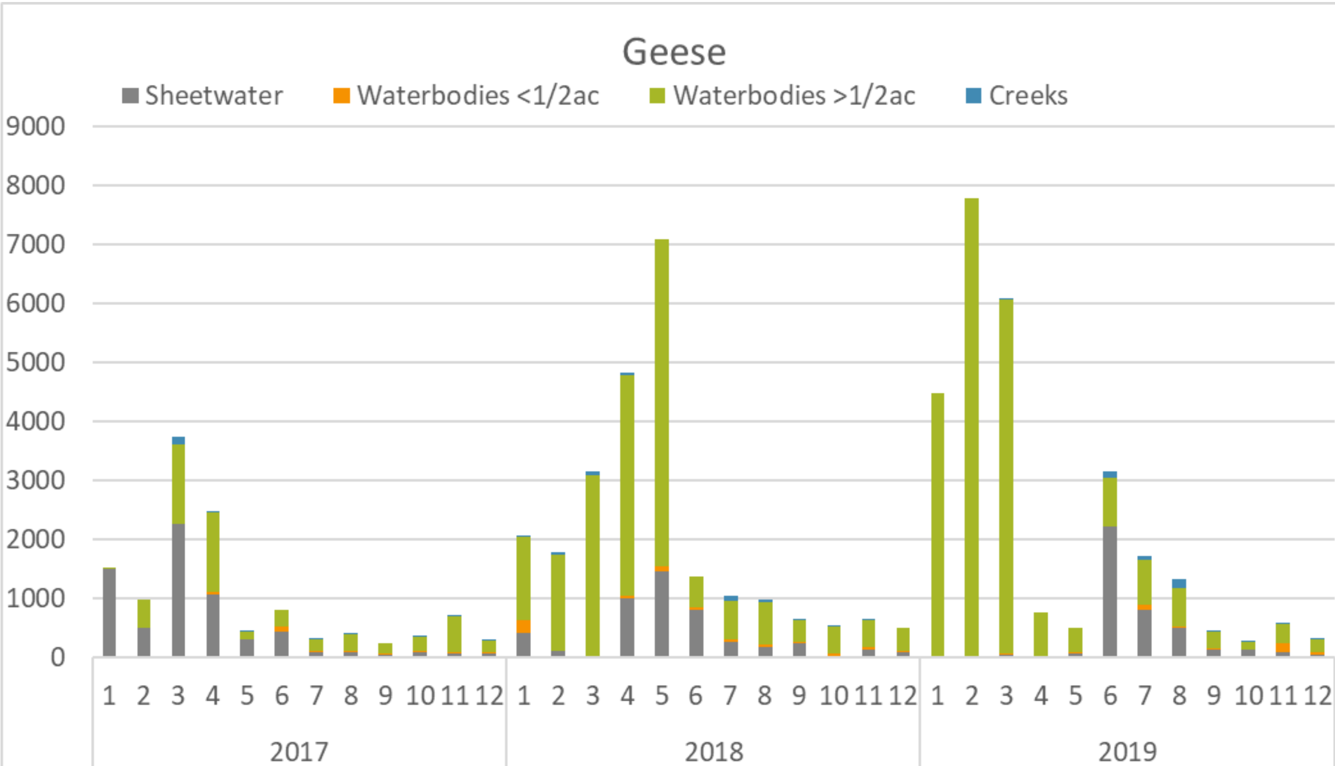



American Wigeon
Sheetwater
Waterbodies <1/2ac
Waterbodies >1/2ac
Creeks
4000
3500
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2017
2018
2019


Other Dabblers
Sheetwater
Waterbodies <1/2ac
Waterbodies >1/2ac
Creeks
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2017
2018
2019

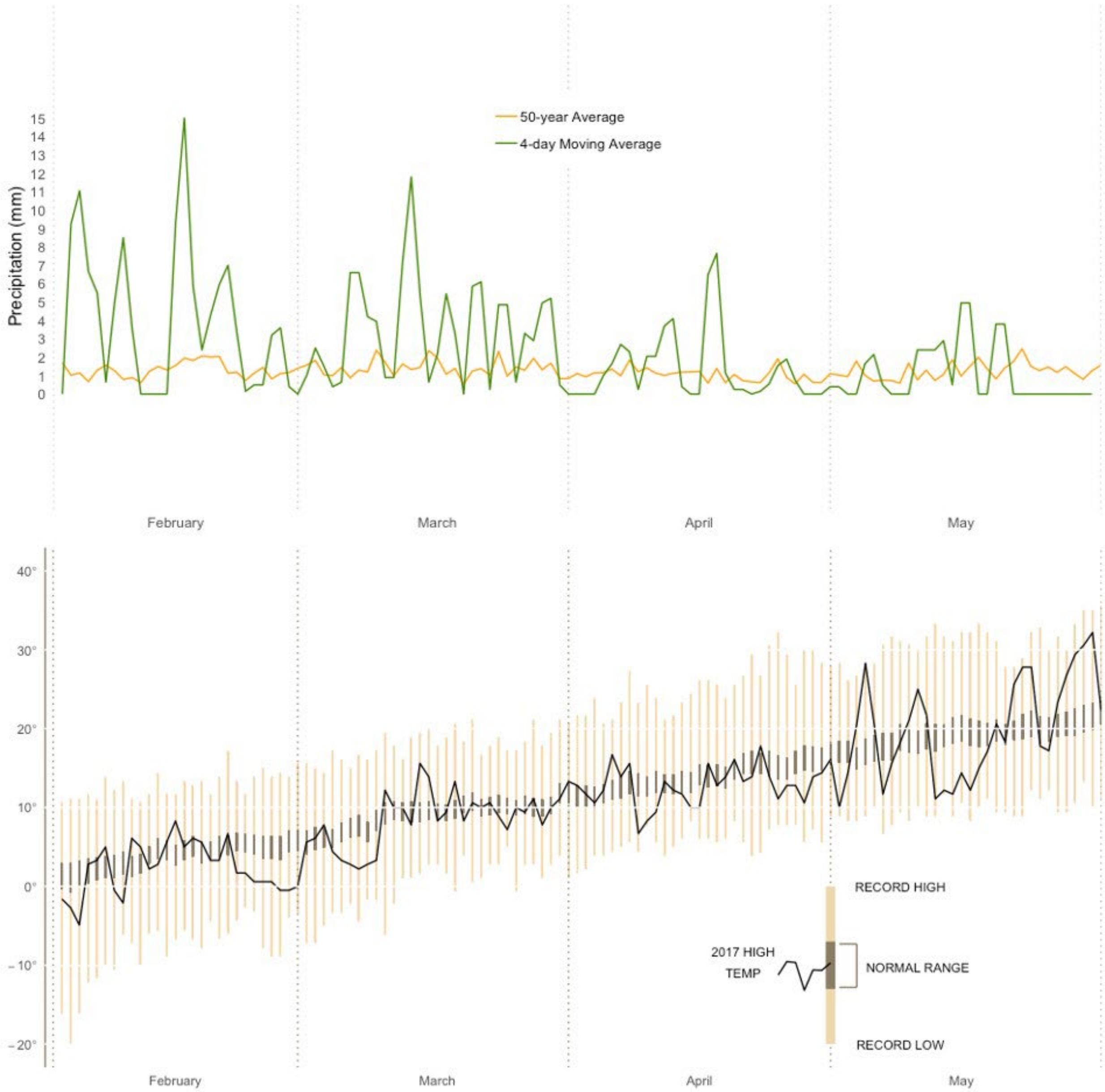

Divers
Sheetwater
Waterbodies <1/2ac
Waterbodies >1/2ac
Creeks
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2017
2018
2019


American Coots
Sheetwater
Waterbodies <1/2ac
Waterbodies >1/2ac
Creeks
12000
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2017
2018
2019

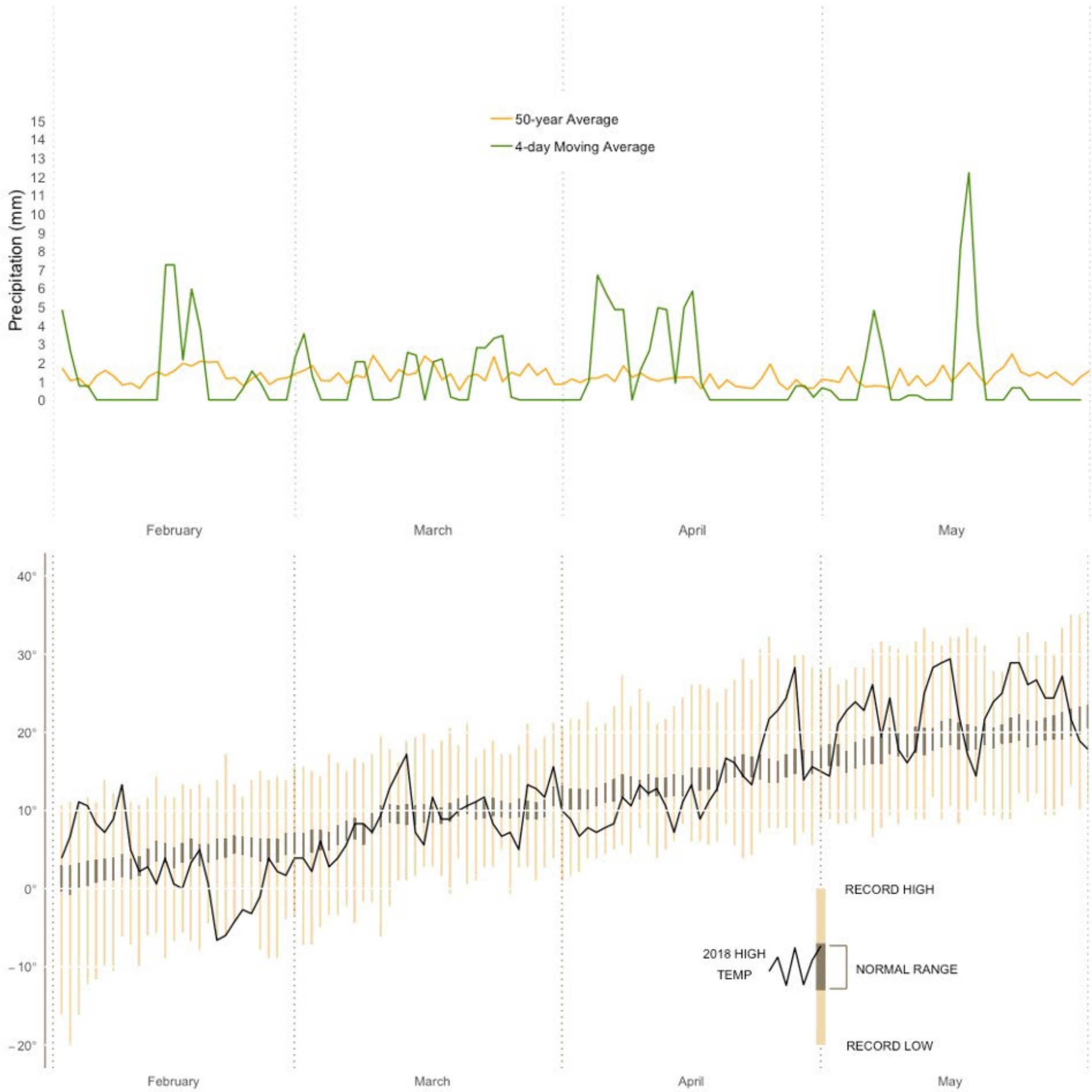

Geese
Sheetwater
Waterbodies <1/2ac
Waterbodies >1/2ac
Creeks
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2017
2018
2019

Appendix 4

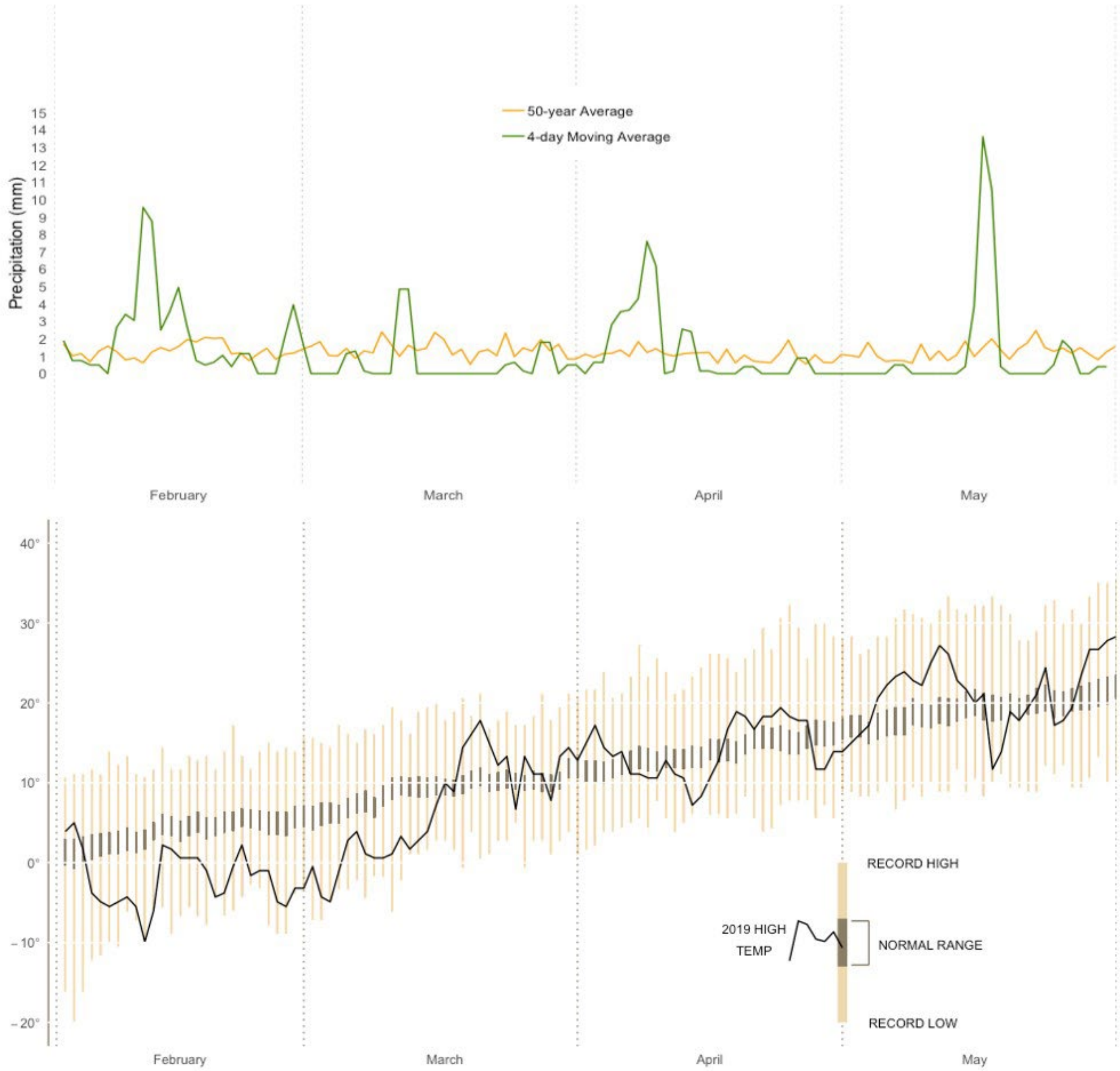
Precipitation and Temperature Data modeled using data from the NOAA weather archives for the Spokane International Airport.



Spring 2017 daily precipitation (top graph) and daily high temperature (˚C) (bottom graph) compared to the 50-year averages.



Spring 2018 daily precipitation (top graph) and daily high temperature (˚C) (bottom graph) compared to the 50-year averages.



Spring 2019 daily precipitation (top graph) and daily high temperature (˚C) (bottom graph) compared to the 50-year averages.

Appendix 5

Tables of survey weeks for the ground and aerial surveys.

	YEARS			
WEEK	2016	2017	2018	2019
1	2/7 - 2/13	2/5 - 2/11	2/4 - 2/10	2/3 - 2/9
2	2/14 - 2/20	2/12 - 2/18	2/11 - 2/17	2/10 - 2/16
3	2/21 - 2/27	2/19 - 2/25	2/18 - 2/24	2/17 - 2/23
4	2/28 - 3/5	2/26 - 3/4	2/25 - 3/3	2/24 - 3/2
5	3/6 - 3/12	3/5 - 3/11	3/4 - 3/10	3/3 - 3/9
6	3/13 - 3/19	3/12 - 3/18	3/11 - 3/17	3/10 - 3/16
7	3/20 - 3/26	3/19 - 3/25	3/18 - 3/24	3/17 - 3/23
8	3/27 - 4/2	3/26 - 4/1	3/25 - 3/31	3/24 - 3/30
9	4/3 - 4/9	4/2 - 4/8	4/1 - 4/7	3/31 - 4/6
10	4/10 - 4/16	4/9 - 4/15	4/8 - 4/14	4/7 - 4/13
11	4/17 - 4/23	4/16 - 4/22	4/15 - 4/21	4/14 - 4/20
12	4/24 - 4/30	4/23 - 4/29	4/22 - 4/28	4/21 - 4/27

Table of the dates the aerial surveys were flown, by survey week and year.
* In 2019, circumstances prevented flying in week 6 (between 3/10 and 3/16) and therefore, the closest flight on 3/18/19 was assigned to week 6.

Aerial Surveys ONLY		
Year	Date	Week
2016	3/8/2016	5
2016	3/25/2016	7
2016	4/5/2016	9
2016	4/19/2016	11
2017	2/24/2017	3
2017	3/3/2017	4
2017	3/10/2017	5
2017	3/16/2017	6
2017	3/23/2017	7
2017	3/28/2017	8
2017	4/11/2017	10
2017	4/21/2017	11
2018	2/13/2018	2
2018	2/22/2018	3

2018	3/6/2018	5
2018	3/12/2018	6
2018	3/19/2018	7
2018	3/29/2018	8
2018	4/9/2018	10
2018	4/18/2018	11
2019	2/21/2019	3
2019	3/5/2019	5
2019	*3/18/2019*	*6**
2019	3/22/2019	7
2019	3/27/2019	8
2019	4/16/2019	11
2019	4/24/2019	12