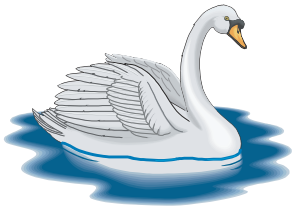

APPENDIX E:

Waterfowl Analysis

HOME

NEXT

An Analysis of Stillwater NWR Waterfowl Use Data

1970-1998

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January 1, 2002

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Introduction

As a guild, waterfowl have been one of the primary target species for which Stillwater NWR habitat management has been focused. The original refuge establishing authority (Tripartite Agreement 1948), lists provision of a public shooting ground (predominately for waterfowl hunting) as a coequal purpose with livestock grazing and the conservation of fish, wildlife, and their habitats. This 50 year agreement dissolved in November 1998, leaving the refuge with a new set of purposes (Title II of Public Law 101-618) where waterfowl management is now one component of management for natural biological diversity and waterfowl hunting is now coequal with five other priority public uses outlined in the National Wildlife Refuge System Improvement Act (1997). To ensure that potential adverse impacts to waterfowl populations and the hunting public through changes in management authority are adequately addressed, it is necessary to examine long-term waterfowl population/habitat information.

While the refuge has accumulated considerable habitat information from several different sources, the Nevada Division of Wildlife (NDOW) was consulted to acquire seasonal waterfowl population data. These data were collected using the same observer (Nevada State Waterfowl Biologist Norm Saake) and survey routes over a 22 year period. Funding and time limitations led to some inconsistency in data collection schedules but most months were sampled between 1977-present. The following are the results of a preliminary analysis of this information, as it applies to Stillwater NWR.

Methods and Materials

Data were organized into spreadsheet format with waterfowl species numbers by month, year, and wetland acreage recorded for years where this information was available. Values in the final spreadsheet were compared with raw data, to check for data entry errors and/or sample periods where complete surveys were not conducted. In some cases, observation limitations allowed for only a subsampling of refuge wetland habitats and these observations were subsequently truncated from the data set. Only complete observations were used in the following analyses, resulting in a data set which roughly covered 1977-1998, inclusive.

The 14 refuge wetland units were pooled into sanctuary and open area blocks, to facilitate analyses comparing species specific, seasonal distribution effects and to decrease variability in the data set. It was assumed that data collection procedures were consistent among sample sessions and that the strength of these procedures allowed for some descriptive analysis of patterns and trends. Descriptive analyses were used to examine seasonal waterfowl population trends and wetland acreage. To examine waterfowl distribution among pooled, open and sanctuary units, waterfowl density was calculated and median, monthly values among years were used. The following section explains statistical procedures used in the analysis.

A set of two-factor (sanctuary [hunted and non-hunted wetlands] and month) analyses of variance (ANOVAs) were used to compare densities of aquatic migratory bird. ANOVA's were run only for those species where >50% of the surveys had values for them. Because heterogeneity of treatment variances could not be reduced by transformations, raw values were replaced with ranks to run ANOVA's (Iman 1982). If month-by-sanctuary interactions were found for these two-ANOVA's, we ran ANOVA's on smaller data sets, so results would not be confounded by them. For example, because the month-by-sanctuary interaction and sanctuary terms were significant from the two-factor ANOVA for green-winged teal, densities between sanctuary and non-sanctuary wetlands were compared separately for each month with one-factor ANOVA's. If no interaction was found, values were calculated as the median of cell (month or sanctuary and non-sanctuary wetlands) medians. Bonferroni simultaneous confidence interval and Tukey's tests were used to separate medians where differences were found for two-factor ANOVA's with and without interactions, respectively. For species with a month-by-sanctuary interaction and months where >50% of surveys had zero values (e.g., canvasbacks in August [Table 1]), Fisher's exact test was used to compare frequencies of surveys with birds recorded (>0) between sanctuary and non-sanctuary wetlands. SAS (SAS Institute Incorporated 1989) was used to run statistical tests and compute test statistics. All statistical tests were run at ? = 0.050.

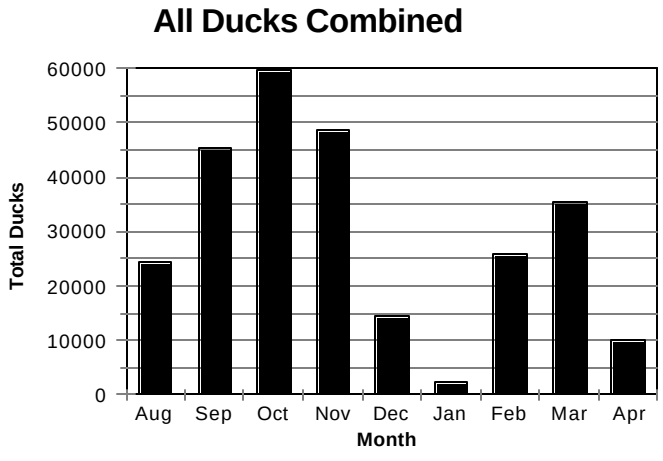
Results

Waterfowl Population Chronology

Duck populations were censused on Stillwater NWR at varying intervals from the onset of fall migration (mid-late August) through spring migration (April). Peak populations have ranged between 210,260 (15 Sept. 1995) and 0 total ducks, which occurred during a mid January freeze in 1988. Average populations by month were variable with the highest total counts occurring through the fall. Figure 1 displays the median, monthly duck population, from the 22 year observation period. The number of counts used to calculate these averages are as follows:

Aug - 17	Jan - 17
Sep - 17	Feb - 9
Oct - 16	Mar - 11
Nov - 21	Apr - 10
Dec - 20	

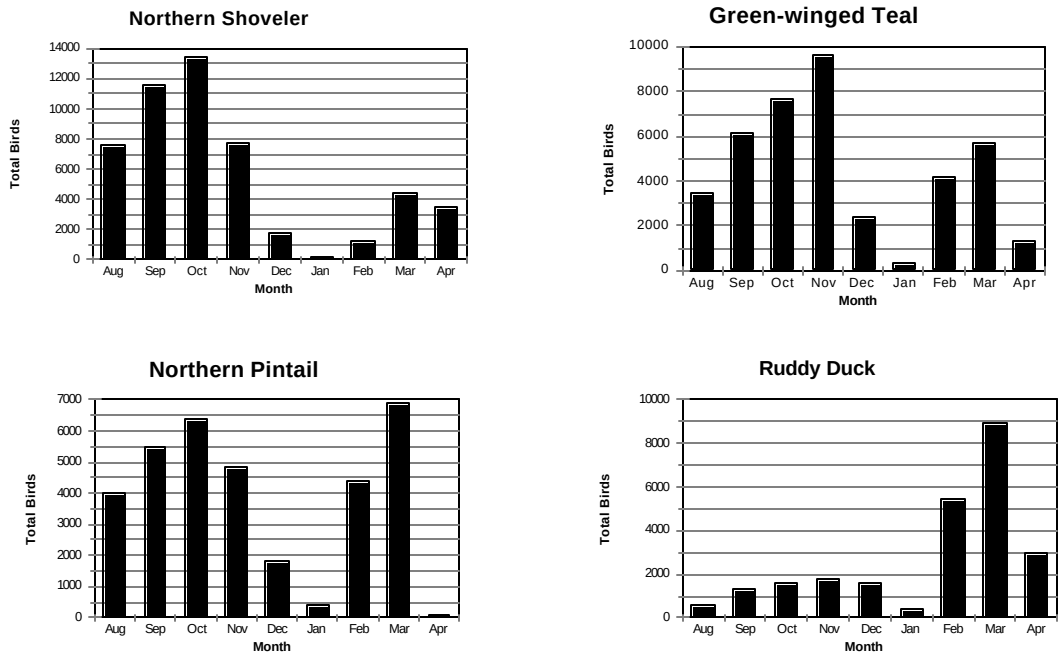
Figure 1: Median total duck population by month for Stillwater NWR, 1977-1998.



Monthly median populations range from 2,170 (January) to 59,707 (October), with the highest average counts recorded during the fall. Of 14 counts where peak population exceeded 100,000 total ducks, 13 were recorded between August and December.

As would be expected, most individual species also experience peak populations during fall including northern shoveler (*Anas clypeata*; 13,472 - October), green-winged teal (*Anas crecca*; 9,627 - October), and all other ducks except ruddy ducks (*Oxyura jamaicensis*) and northern pintail (*Anas acuta*; 8,920 and 6,885, in March, respectively). While ruddy ducks are clearly a spring migrant, northern pintails experience similar population levels in October (6,400) and March. Graphs for each

Figure 2: Median monthly population for the most common duck species using Stillwater NWR wetland habitats, 1970-98.

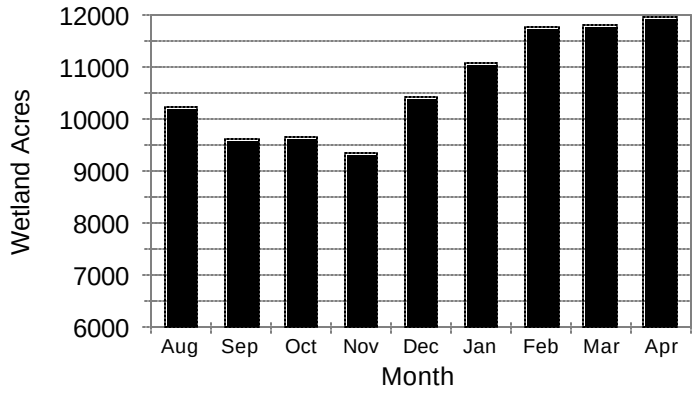


of these species are presented in figure 2.

When examining these numbers, it is important to remember that over the last five years, we have experienced large wetland acreage associated with above average snowpack in the Sierra Nevada's. These average population statistics include drought periods as well with average wetland acreage ranging from 9,341 (November) to 11,971 (April), for years where water information was available (figure 3). Duck numbers observed during the past 5 high water years are not indicative of historic waterfowl use (the last thirty years) but, could be a glimpse at population trends to be expected at completion of the water rights acquisition program.

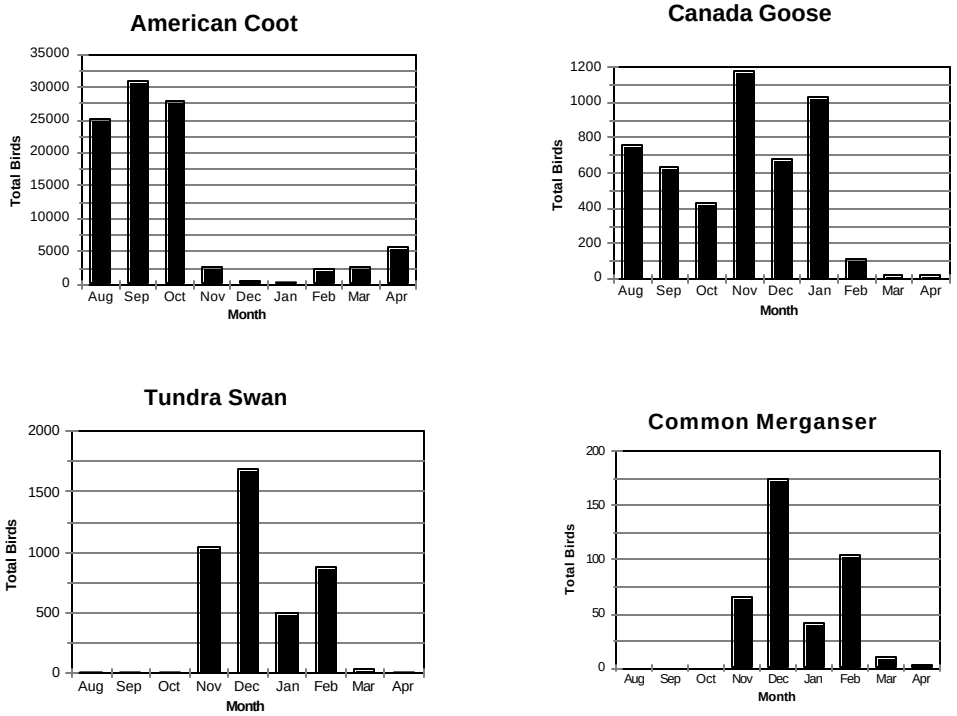
When averaging the past five years, wetland acreage ranged from 8,727 (November) to 14,048 (April) which includes seasonally flooded habitats in the Big Water Unit and at the Carson river delta in Fallon NWR. Wetland acreage estimates were inconsistently recorded; therefore, only a subset of wetland acreage estimates were used in this analysis covering roughly 14 years within the 22 year period.

Figure 3: Average monthly wetland acreage at Stillwater NWR, 1977-98.



While duck species were the primary focus of these surveys, other waterfowl species

Figure 4: Median population of other waterfowl species censused on Stillwater NWR wetland habitats, 1977-98.

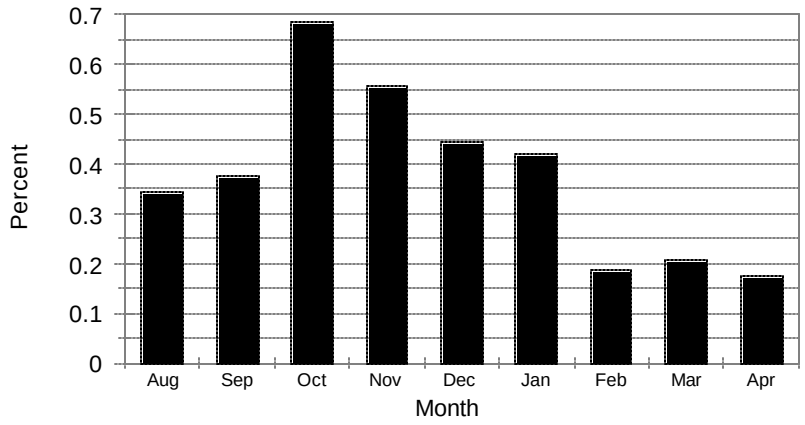


including geese, mergansers (*Mergus merganser*), coots (*Fulica americana*), and swans *(Cygnus columbianus*) were censused (figure 4). Similar to most other duck species, the peak coot population was recorded during fall (30,910 - September). Canada geese (*Branta canadensis* var. *moffiti* and var. *parvipes*) and tundra swans were primarily winter residents, both experiencing population peaks in November and December (1,175 and 1,038, respectively). Common mergansers (*Mergus merganser*) were similar in winter representation, but appear to stay for longer periods, eventually building to a median peak population of 175 in December. Mergansers were not surveyed outside of September - April.

Seasonal Distribution of Duck Species

To provide some initial information on seasonal distribution of waterfowl using sanctuary and non-sanctuary wetland units, an analysis of total waterfowl using each area by month was performed (figure 5). Percent duck use in sanctuary units ranged from 0.175 (April) to 0.687 (October) with hunting season apparently having an effect on distribution. Over 61% of the total waterfowl population was surveyed on sanctuary wetland units during hunting season compared to 28% during non-hunted months.

Figure 5: Median monthly percentage of duck species using sanctuary habitats at Stillwater NWR, 1977-98.

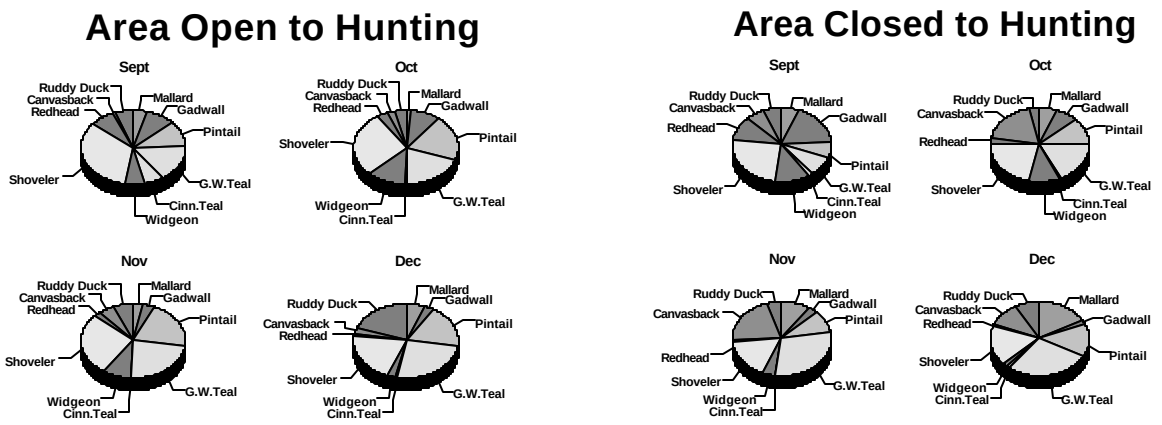


During fall migration, species composition within sanctuary and non-sanctuary units is fairly similar with a few notable exceptions (figure 6). First, although composition is similar, all species display higher sanctuary populations in October with northern pintail and American wigeon increasing in non-sanctuary units during November and December. All other species increase proportionally throughout hunting season, in sanctuary habitats, with Canvasback showing a strong preference for sanctuary habitats during October - December.

It should be understood that these percentages are associated with total waterfowl numbers and do not consider acreage provided between the compared habitat blocks (sanctuary and non-sanctuary). On average, sanctuary wetlands comprise roughly 1/3 of total wetland acreage, thus, the 35% frequency in

August (figure 5) would represent equal proportions of waterfowl species using sanctuary and non-sanctuary units. Conversely, approximately 69% of waterfowl species frequent sanctuary habitats during October with similar distribution occurring until February.

Figure 6: Proportional use of sanctuary and open public use wetland units by species at Stillwater NWR, 1970-98.



Unit	month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Widgeon	Shoveler	Redhead	Canvasba	Ruddy Du
Open	Sept	1246	3023	3636	5103	1860	1864	10744	2319	165	1925
Open	Oct	363	2707	5515	5486	114	3449	7981	828	764	979
Open	Nov	460	610	3307	3839	7	1401	4443	289	743	1051
Open	Dec	452	220	1466	2001	6	223	1623	126	188	1498
Sanctuary	Sept	1251	3724	1593	1770	399	2346	5278	2299	1265	1391
Sanctuary	Oct	2996	3802	6022	9809	177	5090	11603	1386	9485	1969
Sanctuary	Nov	2558	1071	2749	8332	6	1262	4764	274	5889	1381
Sanctuary	Dec	2061	320	1690	3598	68	274	2144	90	1264	1097

Figure 7 illustrates the seasonal acreage provided in both sanctuary and non-sanctuary units. Average monthly wetland acreage ranges from 9,341 acres in November to 11,972 acres in April while median values range from 7,793 in March to 15,724 acres in April. Wetland acreage was calculated from a subset of years in which total acreage was estimated, and the set of years recorded vary by month. For example, March estimates were calculated from a set of seven years where low water availability was more frequently the case. Conversely, February and March acreage was calculated from a set of years where higher flows into the refuge were recorded. This factor has likely skewed wetland acreage distribution but should have less effect on waterfowl density estimates. Therefore, acreage estimates presented in this paper should not be used as an indicator of wetland coverage over the 30 year period, but instead, should be used as an index of wetland habitat acreage to be compared with known waterfowl populations.

Total waterfowl density varied by month and unit with a low of 0.35 birds/ha (0.14 birds/ac) recorded on open habitats in January, and a high of 36.33 birds/ha (14.71 birds/ac) in sanctuary habitats during October (figure 8). American coots account for roughly 25% of this total with waterfowl species peaking at 20.67 birds/ha (8.37 birds/ac), also in October sanctuary units. When duck totals are examined, all months except March have experienced higher waterfowl densities on sanctuary habitats. Other species displayed mixed seasonal responses with all species exhibiting an increased preference

Figure 7: Median and average monthly wetland acreage recorded by total, open, and sanctuary habitats, Stillwater NWR, 1977-1998.

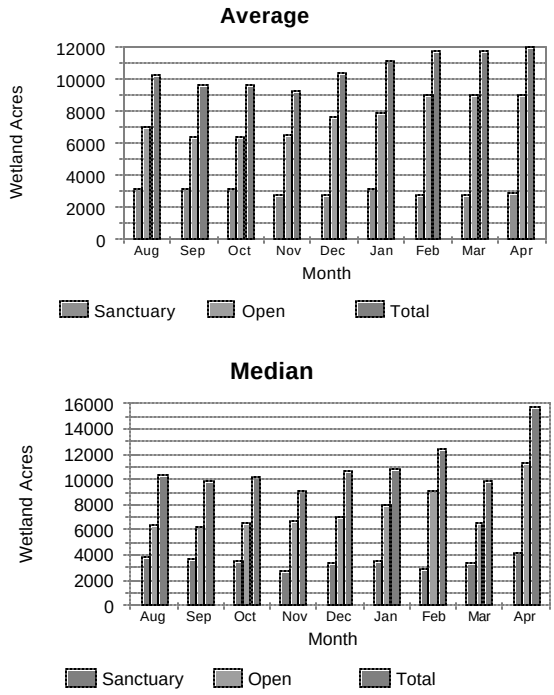


Figure 8: Median, monthly total waterfowl and coot density on open and closed public use habitats at Stillwater NWR, 1977-98.

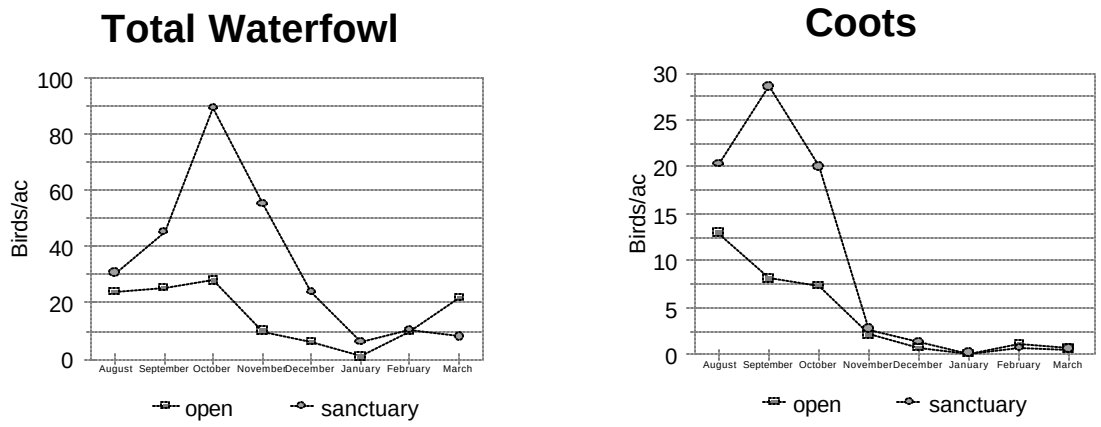
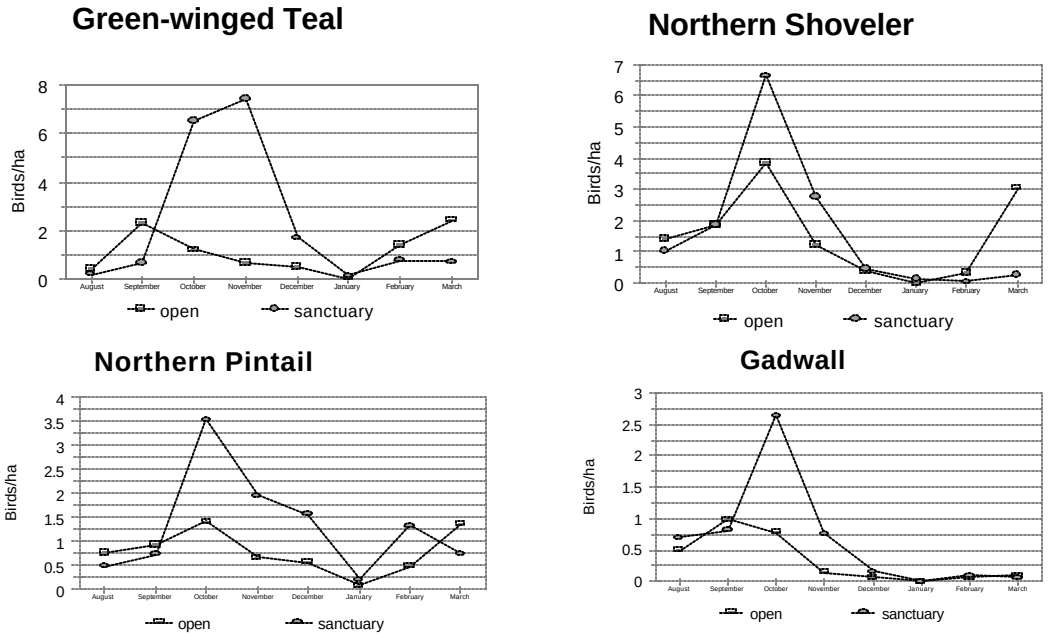
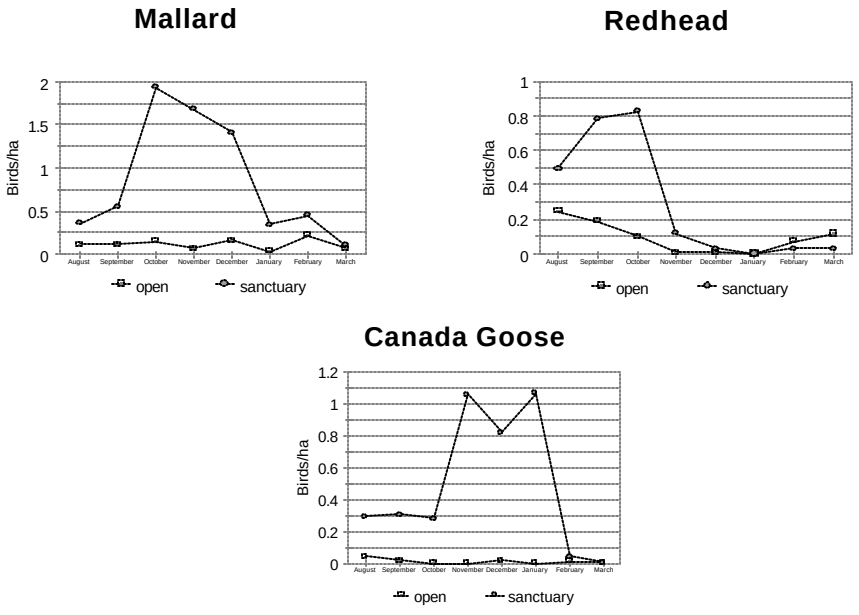


Figure 9: Density (birds/ha) estimates for species showing no apparent preference for sanctuary or open habitats prior to hunting season at Stillwater NWR, 1977-98.



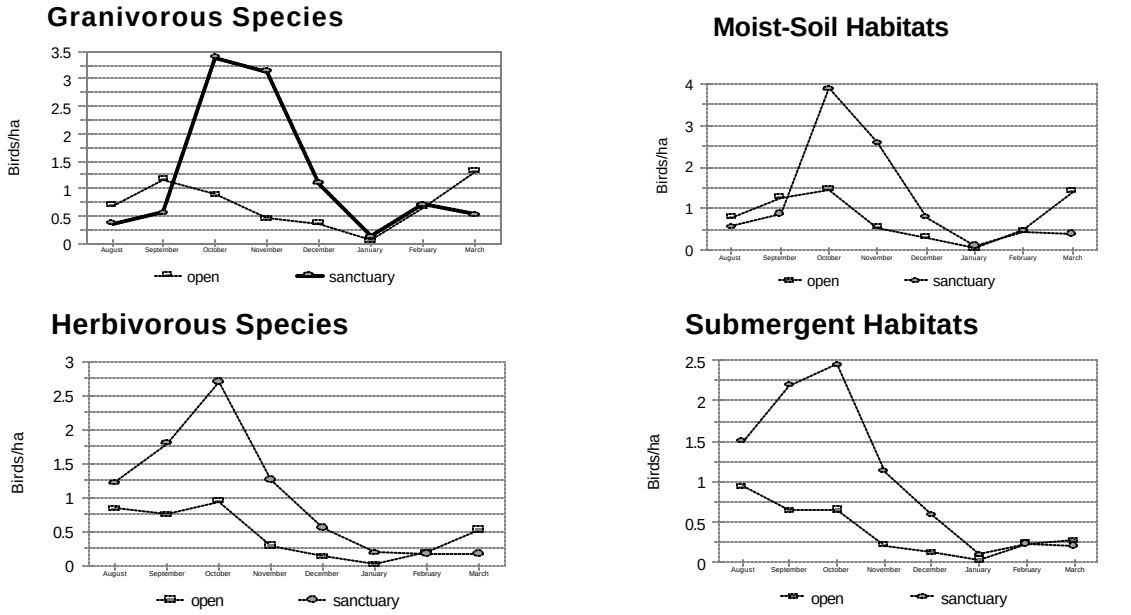
for sanctuary habitats during hunting season (Table 1). Green-winged teal, northern shoveler, northern pintail, and gadwall (*Anas strepera*) appear to utilize sanctuary and non-sanctuary units with equal frequency prior to hunting season (figure 9). However,

Figure 10: Density (birds/ha) estimates for species showing an apparent preference for sanctuary habitats prior to hunting season at Stillwater NWR, 1977-1998.



mallards *(Anas platyrhynchos*), redheads (*Aythya americana*), and Canada geese exhibit higher densities within sanctuary habitats across all seasons (figure 10). For all species, sanctuary density increases during hunting season months, but it would appear that sanctuary units are preferred throughout the year by at least the herbivorous waterfowl species (figure 11).

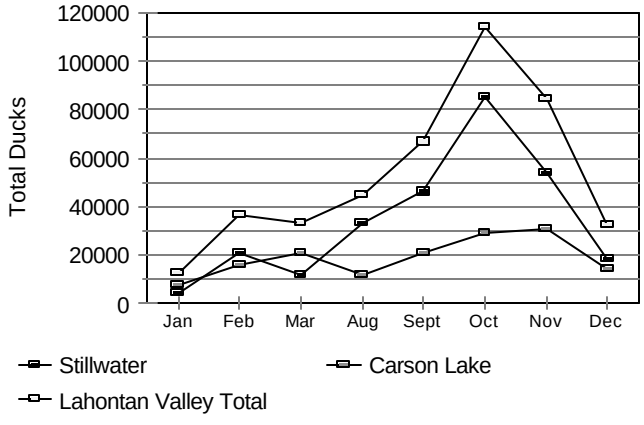
Figure 11: Density (birds/ha) of waterfowl using sanctuary and open public use units, by foraging guild and habitat type preference at Stillwater NWR, 1977-98.



Carson Lake and Stillwater Marsh

The Lahontan Valley is comprised of three primary wetland areas: Stillwater NWR, Carson Lake, and the Fallon Paiute-Shoshone tribal wetlands, along with scattered irrigation reservoirs, canals, drains, and playas. Of these areas, Stillwater NWR and Carson Lake are the most important for waterfowl. These two areas differ somewhat in management purposes; however, the combined efforts lead to provision of a

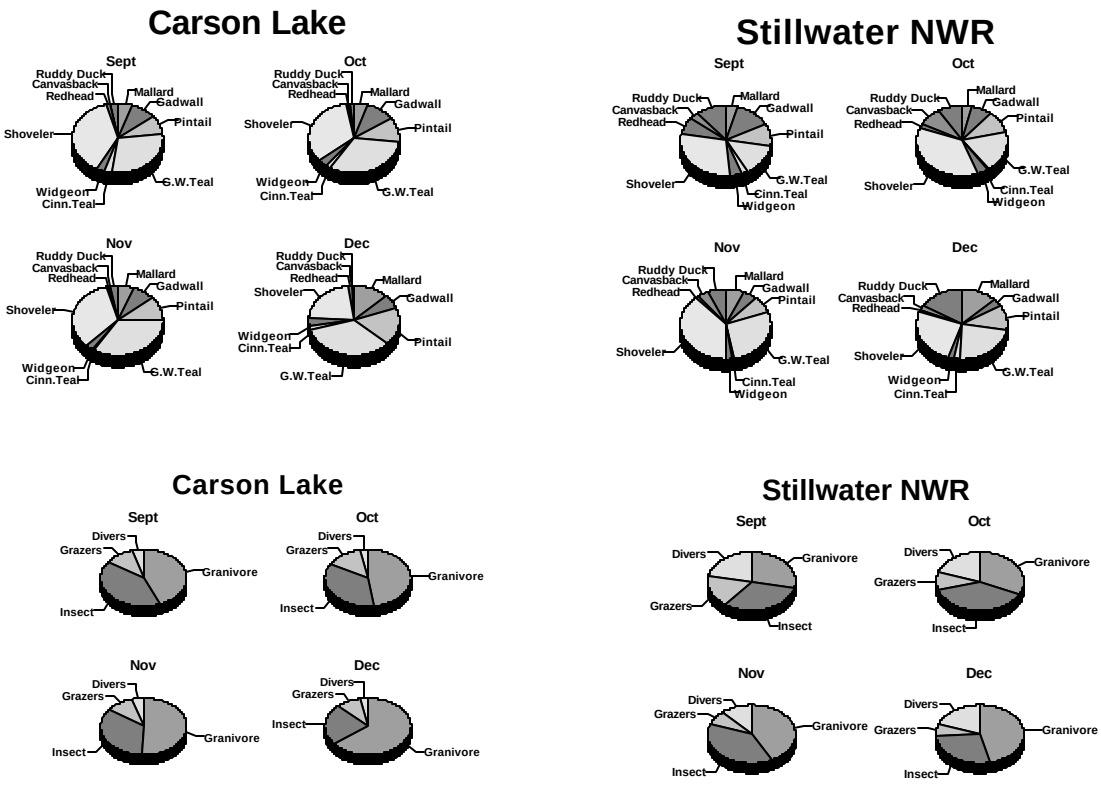
Figure 12: Lahontan Valley, Stillwater NWR, and Carson Lake average duck counts for the period August - March, 1970-98.



Lahontan Valley wetland habitat complex which provides for the seasonal requirements of a variety of waterbirds.

Totals for each area and combined Lahontan Valley totals tend to mirror previously described trends, with peak duck counts occurring in October, and then dropping through the remainder of fall and winter months (Fig. 12). The average peak for Stillwater NWR and Carson Lake combined is 114,380 (October) with Stillwater NWR holding approximately 75% (85,179) of this total. Carson Lake does, however, maintain similar to slightly higher spring populations which results in higher duck densities when considering that Stillwater typically has more wetland acres during spring. Species composition is somewhat different between the two areas, with Carson Lake populated by proportionally more dabbling ducks and Stillwater Marsh receiving the higher proportion of diving duck use. These trends are further displayed by observing waterfowl foraging guild preferences during the fall months (September - December; Fig. 13).

Figure 13: A comparison of species specific and foraging guild composition between Carson Lake and Stillwater NWR during fall (Sept.-Dec., 1970-98).



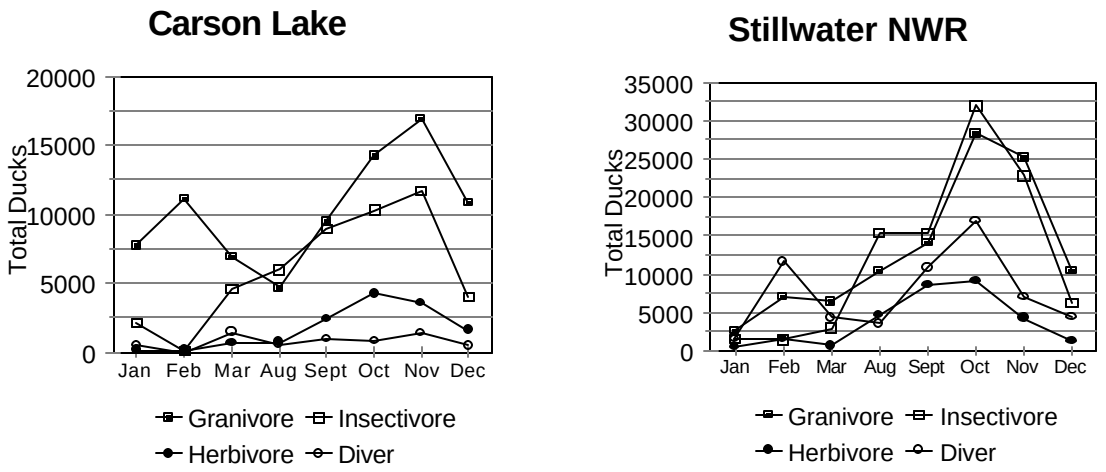
Dabbling ducks comprise 95-98% of the Carson Lake total while diving ducks range from 12-22% of the Stillwater total. Primary species at each site are similar with northern shoveler, green-winged teal, and northern pintail dominant in fall counts; however a more equal percentage of the various dabbling

duck species appears to occur at Stillwater NWR. When species composition is considered relative to seasonal requirements and forage/habitat type preferences, this difference becomes even more apparent.

To examine forage preferences, species were placed into four specific foraging guilds based on feeding ecology research for the species present in the Lahontan Valley. While this research was not conducted in the Lahontan Valley, and many of the species considered are opportunistic and can easily adapt to a variety of habitats, four guilds were subjectively selected to represent the preferred habitat and forage items for the species during migration periods (Bellrose 1982). Selected guilds are granivores (mallard, northern pintail, green-winged teal), insectivores (northern shoveler, cinnamon teal), herbivores (American wigeon, gadwall), and diving ducks (redhead, canvasback, and ruddy ducks). Cinnamon teal appear to be more granivorous throughout their life history cycle; however, it is believed that aquatic invertebrates comprise a large percentage of their diet during the August - September peak use period in Lahontan Valley and they are often observed foraging in similar habitats as northern shoveler during early fall. Piscivorous species such as the common merganser display a strong preference for Stillwater NWR habitats; however, peak counts only average near 1,000 total birds (December and January) and, therefore, are not considered in this analysis.

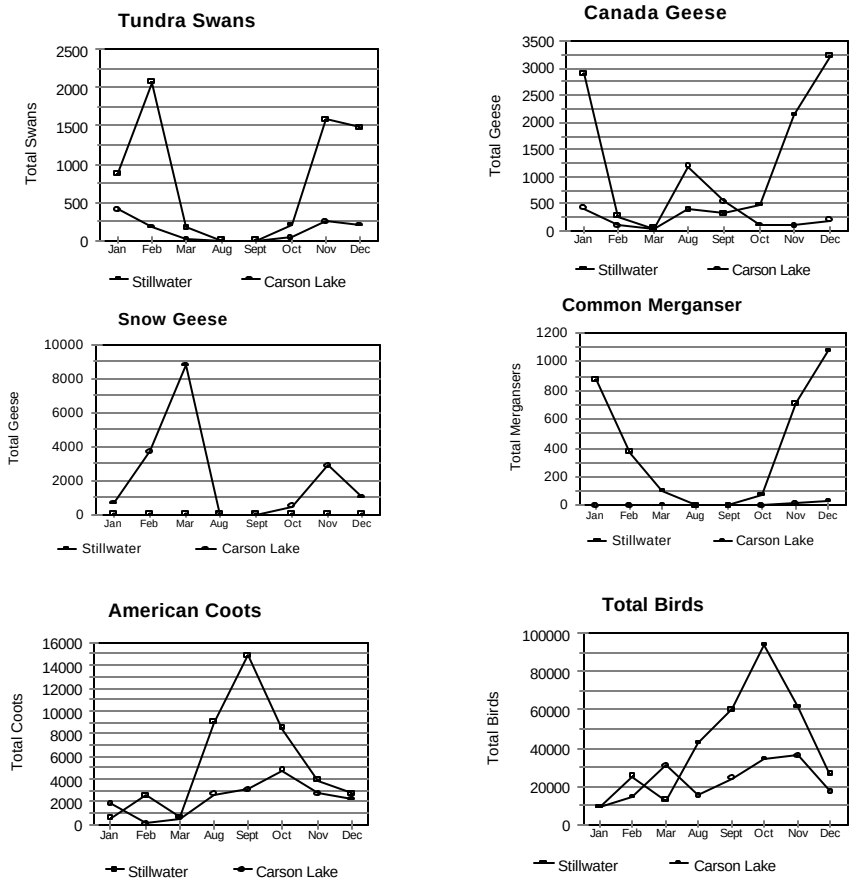
Granivorous species comprised 43-64% of the Carson Lake total (compared to 29-47% of the Stillwater NWR total) with insectivores (24-41%), herbivores (9-14%), and divers (3-4%), rounding out the Carson Lake duck population during fall. Conversely, a more even distribution among foraging guilds is apparent for Stillwater NWR with granivores (29-47%), insectivores 28-38%), divers (12-22%), and grazers (6-18%) nearly equal during September. Grazers tend to drop off from October through December at Stillwater NWR, possibly shifting to Carson Lake habitats where grazers are well represented throughout fall months.

Figure 14: Monthly average duck population by foraging guild for Carson lake and Stillwater NWR (Aug. - Mar., 1970-98).



Fewer data are available for a spring analysis; however, Carson Lake population totals appear to be similar to slightly higher than Stillwater NWR. Carson Lake is strongly dominated by dabbling ducks (nearly 99%) during February, with March numbers depicting a more proportional mix among foraging guilds (Fig. 14). As will be considered in the discussion section, these differences are likely related to the different habitats provided at Stillwater NWR and Carson Lake during spring.

Figure 15: Monthly average, non-duck species population for Carson Lake and Stillwater NWR (Aug - Mar, 1970-98)



Tundra swans, common mergansers, and American coots, all experience higher populations at Stillwater NWR throughout the year, with mergansers almost exclusively found at the Stillwater marsh (figure 15). Geese display a differential response with snow geese inhabiting Carson Lake in much higher numbers while the distribution of Canada geese appears to change seasonally. The Carson Lake Canada goose population rises to nearly 1,200 birds in August; however, Stillwater populations remain disproportionately higher during fall and winter months. In all cases, these differences would seem closely related to differences in habitats provided at the two areas.

Stillwater NWR Wetland Unit Analysis

Individual wetland units within the Stillwater NWR experience waterfowl use patterns likely related to habitat availability, disturbance, and hydration. Certain species tend to concentrate in specific units which is related to species specific, seasonal and diurnal life history requirements each unit can fulfill. These unit characteristics are a function of unit size, amount of unit hydrated, hydration timing, and related vegetative response which appears to vary both annually and seasonally within units. Rather than cover each year individually, table 2 examines the average monthly wetland acreage for available years between 1977 - 98, for seven sanctuary and seven non-sanctuary units.

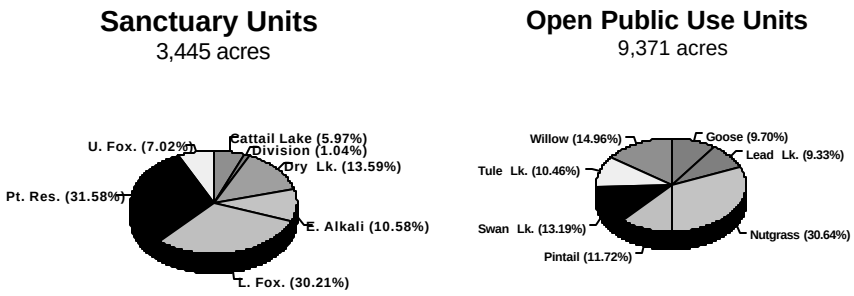
The full pool acreage is included at the top of each column followed by the monthly average for each wetland unit. Total wetland acreage by sanctuary designation is provided in the final column allowing for an analysis of the percentage of each area a specific wetland unit occupies (figure 16). For

Table 2: Average monthly acreage among 14 wetland units at Stillwater NWR, 1977-98.

Sanctuary Units	Cattail Lake	Division Pond	Dry Lake	East Alkali Lake	Lower Foxtail	Stillwater Point	Upper Foxtail Lake	Total
	270	100	565	585	1,190	1,840	370	4,920
Jan	213	53	539	424	1121	985	296	**3631**
Feb	208	33	459	361	883	1196	170	**3309**
Mar	194	25	400	333	904	1104	192	**3153**
Apr	180	39	352	251	799	941	241	**2802**
Aug	227	24	517	345	1170	1119	296	**3698**
Sept	195	37	464	340	1090	1123	263	**3512**
Oct	226	38	489	406	1139	1069	259	**3626**
Nov	210	45	472	427	1135	980	249	**3517**
Dec	199	27	521	394	1127	1275	213	**3755**
Average	**206**	**36**	**468**	**365**	**1041**	**1088**	**242**	**3445**
Non-sanctuary Units	**Goose Lake**	**Lead**	**Nutgrass**	**Pintail Bay**	**Swan Lake**	**Tule Lake**	**West Marsh**	**Total**
	1,006	1,025	3,495	1,520	1,880	1,245	2,830	13,001
Jan	902	930	3175	1241	1776	1152	1868	**11043**
Feb	834	827	3146	1463	1451	1195	2123	**11038**
Mar	936	943	2936	1444	1340	1198	566	**9362**
Apr	855	849	2427	1127	1316	898	1238	**8711**
Aug	917	844	2609	1025	940	956	1421	**8713**
Sept	895	871	2651	979	940	930	1505	**8771**
Oct	942	829	2903	853	918	771	1236	**8453**
Nov	926	868	2894	845	1135	795	1403	**8867**
Dec	971	905	3099	909	1310	926	1258	**9378**
Average	**909**	**874**	**2871**	**1098**	**1236**	**980**	**1402**	**9371**

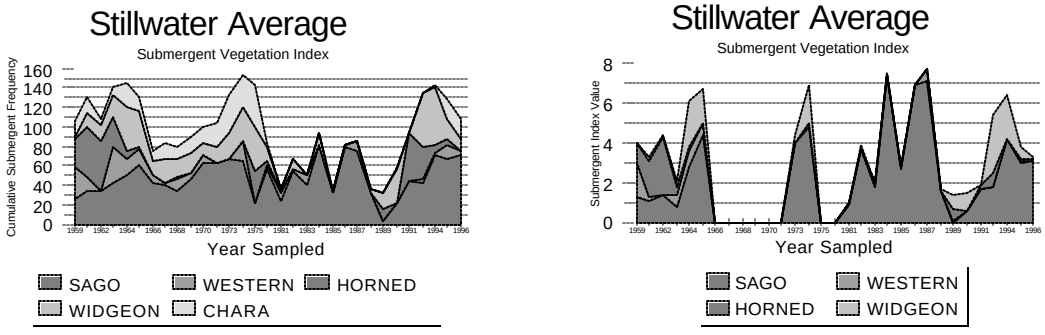
example, Cattail Lake has a full pool estimated at 270 acres. Across years where this unit was hydrated, seasonal acreage ranged from 180 ac. (April) to 227 ac. (August), comprising roughly 6% of the sanctuary wetland acreage base. Each unit was hydrated a different number of years and only those years where hydration occurred were used in this analysis. On average, 70% of sanctuary units and 72% of open public use units have been hydrated, with seasonal peaks typically occurring during winter (Dec. - Feb.). Unit specific peaks vary by refuge location, with most northern units (non-sanctuary) displaying winter peaks and southern units (sanctuary) experiencing peak acreage during different time periods.

Figure 16: Relative size of wetland units within sanctuary and open public use areas at Stillwater NWR, 1977-98.



Frequency of occurrence among submergent vegetation species common to Stillwater NWR wetland units were also analyzed to help elucidate waterfowl, species specific, seasonal use patterns (figure 17). The left figure encompasses the frequency at which each species was sampled while the right figure is

Figure 17: Frequency and density index for submergent vegetation species common to Stillwater NWR wetland units.



an index created to examine the combination of sampling frequency and density. Density values were not recorded for all years, but where available, the following calculation was used to create an index of submergent vegetation availability:

(Species frequency * Species density) / 1000 = Submergent vegetation index

As displayed, sago pondweed (*Potamogeton pectinatus*), is the primary species found throughout wetland units and years, with western pondweed (*Potamogeton latifolia*), horned pondweed (*Zanichellia pallustris*), wigeongrass (*Ruppia maritima*), and muskgrass (*Chara* sp.), together comprising more than 98% of the total. A general trend with sago pondweed strongly dominating southern wetland units and a more even species mix on northern wetland units was documented, with availability of the various submergent species likely contributing to the proportional mix of waterfowl species populating each unit. The following discussion, will examine vegetation response and waterfowl species use relative to the different hydration schedules calculated for all units on Stillwater NWR.

Sanctuary Wetland Units

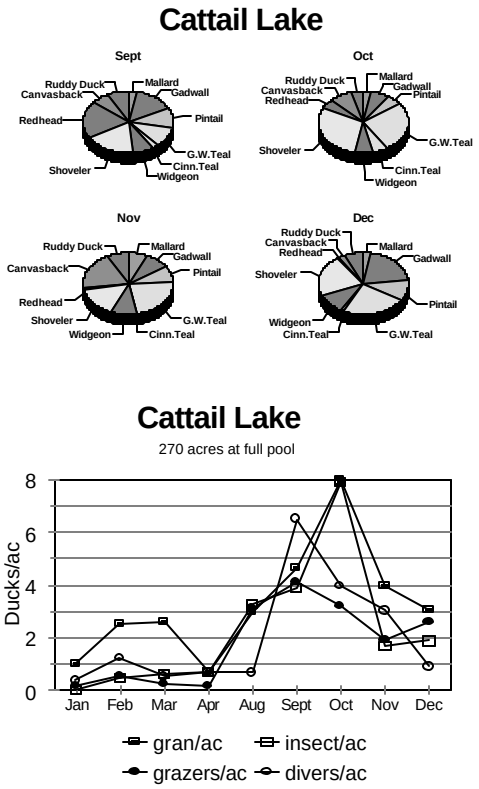
Cattail Lake

Table 3: Duck species numbers by month in Cattail Lake, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Wigeon	Shoveler	Redhead	Canvasback	Ruddy Duck	Total
Jan	15	5	114	90	0	30	0	20	27	30	331
Feb	34	20	169	320	30	100	75	25	145	90	1008
Mar	13	30	333	160	13	20	110	20	25	55	778
Apr	44	26	22	64	19	0	113	38	10	60	396
Aug	113	572	359	204	135	139	613	79	20	53	2286
Sept	123	537	384	399	92	270	670	748	233	293	3748
Oct	123	361	289	1388	250	369	1534	220	454	224	5211
Nov	144	208	175	518	0	194	353	25	416	180	2214
Dec	41	343	194	378	15	177	361	20	32	113	1675

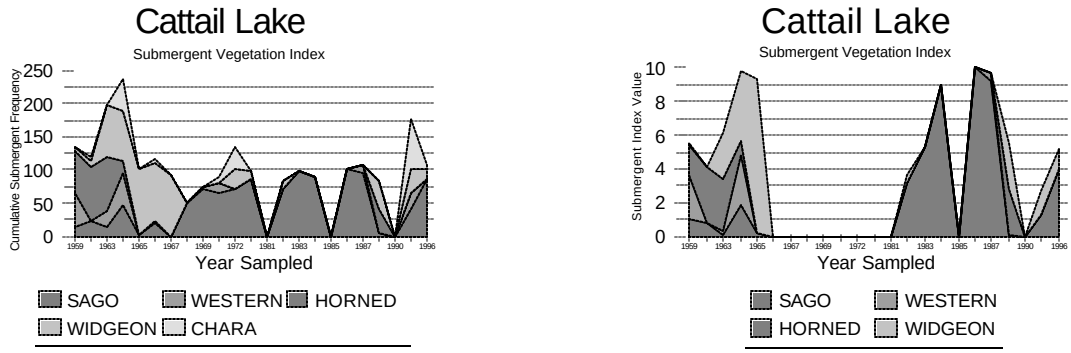
Cattail Lake is a small wetland unit (270 acres at full pool) located at the northern end of the Stillwater NWR sanctuary area (south of Division Rd.). Early during fall, duck species composition is fairly well split among the primary 10 species, with Northern shoveler, redhead, canvasback, and green-winged teal comprising the highest proportional use of the unit during later fall and winter months (table 3; figure 18). Herbivorous and granivorous species are strongly dominant during fall with granivorous species (primarily northern pintail and green-winged teal) having higher compositions during spring. Total duck density reaches a peak of 23.1 ducks/ac during October and averages greater than 10 ducks/ac. From August - November. Spring densities range from 2.3 to 4.8 ducks/ac.

Figure 18: Duck species composition and foraging guild density for Cattail Lake, 1970-98.



Wetland acreage ranged from 180 ac. (April) to a high of 227 ac. (August) providing a seasonal proportion of the unit flooded of 67% and 84%, respectively. This relatively consistent flooding provided perennial water conditions, suitable for sustaining submergent vegetation (figure 19). From 1959 to present, Cattail Lake had an average depth of 30 cm., a salinity range of 1371 to 3205 ppm (2033 average), and a turbidity average of 17 cm over the 23 years of submergent vegetation sampling. Sampling frequency for the five most common submergent vegetation species averaged 46% (sago pondweed), 8% (western pondweed), 12% (horned pondweed), 26% (wigeongrass), and 8% (muskgrass) with submergent index values of 2.00, 0.27, 0.52, and 0.94 for the first four species. Annual variation was significant, with index values ranging from 0 (1985) to 9.216 (1987) for sago pondweed which was the dominant submergent vegetative species in Cattail Lake throughout the 1980's and 90's.

Figure 19: Submergent vegetation availability by frequency and density in Cattail Lake, 1959-96.

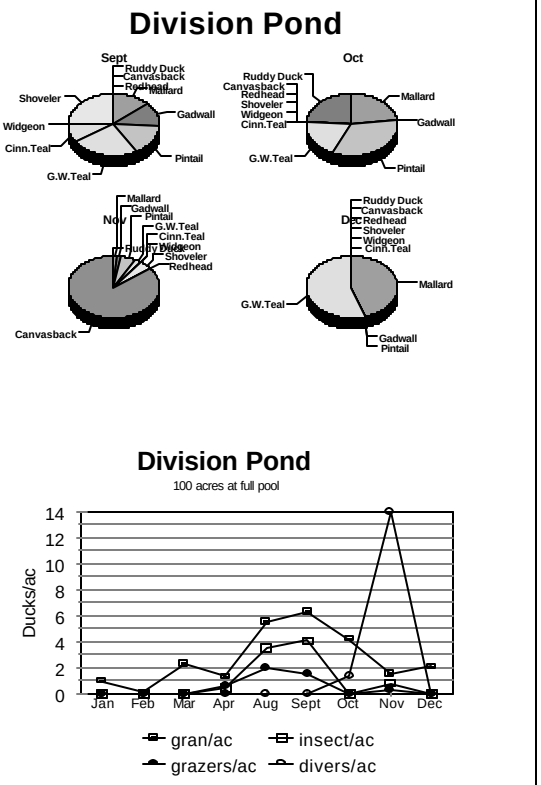


Division Pond

Table 4: Duck species numbers by month in Division Pond, 1970-98.

Month	Mallar	Gadwa	Pinta	G.W.Te	Cinn.Te	Wigeor	Shovel	Redhea	Canvasba	Ruddy Du	Tota
Jan	10	0	40	0	0	0	0	0	0	0	50
Feb	1	0	0	0	0	0	0	0	0	0	1
Mar	0	0	30	27	0	0	0	0	0	0	57
Apr	30	23	0	20	17	0	0	0	0	0	90
Aug	28	48	98	10	55	0	30	0	0	0	268
Sept	58	55	65	106	41	0	108	0	0	0	433
Oct	48	0	70	40	0	0	0	0	0	50	208
Nov	10	10	37	20	0	0	35	0	630	0	742
Dec	25	0	0	30	0	0	0	0	0	0	55

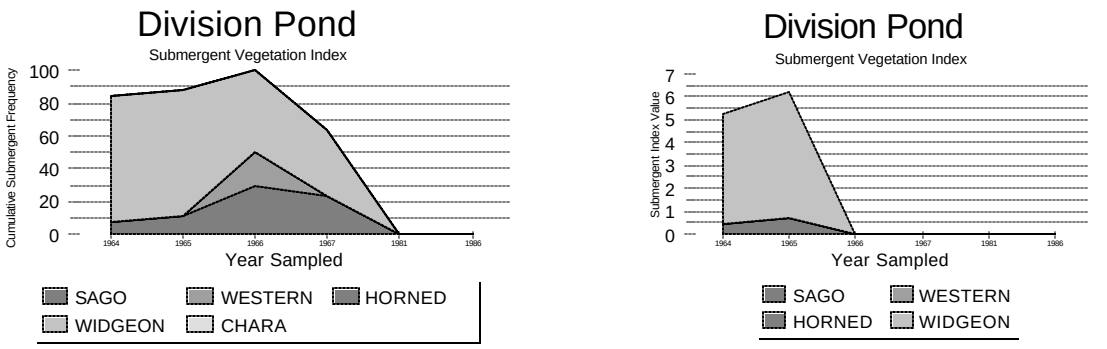
Figure 20: Duck species composition and foraging guild density for Division Pond, 1970-98.



Similar to Cattail Lake, Division Pond is also a small (100 ac), shallow wetland located at the north end of the Stillwater NWR sanctuary. This unit was infrequently hydrated during the 1970-98 survey period with samples collected sporadically over 16 years (46 of 325 survey sessions), typically September through January (table 4; figure 20). Duck use was inconsistent in this unit with a different species dominant during each month. The 630 canvasback sampled during November is a result of only one November observation collected during the sampling period. Therefore, insufficient samples prevented a more detailed analysis of duck use in Division Pond. Duck density ranged from <1 bird/ac (February) to 16.5 birds/acre relative to the single November count.

Few submergent vegetation samples were collected in Division Pond as well, with data available for only four years between 1959 - 1996 (figure 21). Water depth averaged 17 cm, with salinity ranging from 716 - 1600 ppm. Water turbidity measurements averaged clarity to the bottom of the unit. Submergent vegetation sampling frequency was low with wigeongrass dominant in all years. When sampled, wigeongrass had a high submergent vegetation index value; however,

Figure 21: Submergent vegetation availability by frequency and density in Division Pond, 1959-96.



submergent vegetation comprised a small percentage of this units overall vegetative composition as confirmed by the relatively low frequency values (figure 21, first inset)

Dry Lake

For the purposes of the waterfowl discussion, east and west dry lakes are considered as one unit. Together, they encompass 565 acres at full pool and have traditionally maintained high acreage throughout flood and drought periods (table 2; 352-539 ac). Proportional duck use is fairly even among the 10 most common species through September; however, dabbling ducks including mallards, green-winged teal, and northern shoveler become more abundant during hunting season months. Diving ducks are equally abundant during hunting season with high canvasback populations typically recorded through November (figure 22). Overall duck density ranged from 2.7 birds/ac (April) to 28.5 birds/ac (October) with September through December retaining the highest density. Diving ducks experience

Table 5: Duck species numbers by month in Dry Lake, 1970-98.

Month	Mallard	Gadwal	Pintail	G.W.Teal	Cinn.Tea	Wigeon	Shovele	Redhead	Canvasbac	Ruddy Duck	Total
Jan	359	15	258	297	0	112	270	15	207	476	2008
Feb	189	26	287	188	70	27	50	34	169	1131	2170
Mar	43	50	308	324	39	31	170	54	288	1633	2938
Apr	22	61	19	97	31	25	50	55	71	394	825
Aug	264	196	311	142	206	61	252	147	89	239	1907
Sept	264	680	418	416	132	911	602	464	412	611	4910
Oct	749	739	966	3487	130	1021	2609	208	2835	925	13668
Nov	426	317	513	1202	20	444	1279	50	1582	623	6455
Dec	615	133	305	718	50	74	537	124	472	356	3385

peak density during spring and again in fall, related to ruddy duck and canvasback numbers, respectively. All foraging guilds experienced peak density during October.

As stated, Dry Lake is a composite of two separate units (east and west) with the eastern unit dominated by emergent vegetation (providing thermal protection for wintering waterfowl), and the western unit dominated by thick submergent growth. While sago pondweed is the most common and productive among submergent species in the West Dry unit, western pondweed, horned pondweed, wigeongrass, and chara are all present during different years (figure 23). In general, West Dry Lake averaged 43 cm in depth, maintained salinity levels between 1022 and 4075 ppm (1781 ppm avg.), and typically remained clear to the unit bottom. Over 28 years where submergent vegetation was sampled, only 16% of the transect points monitored did not produce submergent vegetation. Sago pondweed produced an average index of 3.22 across all years with a high of 10 recorded in 1995.

Figure 22: Duck species composition and foraging guild density for Dry Lake, 1970-98.

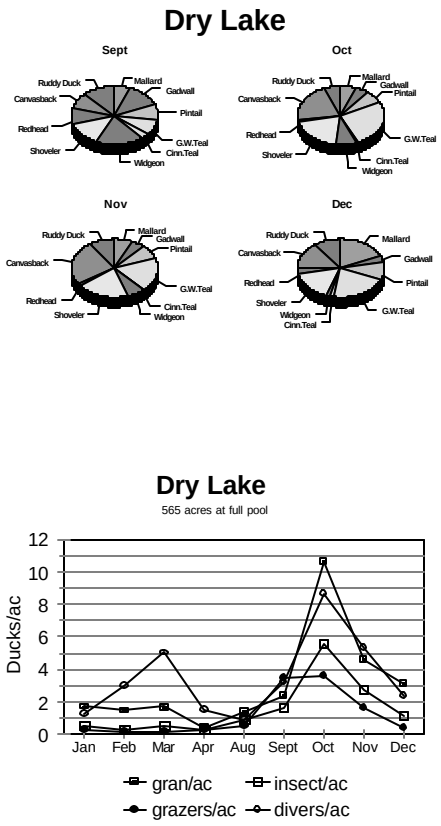
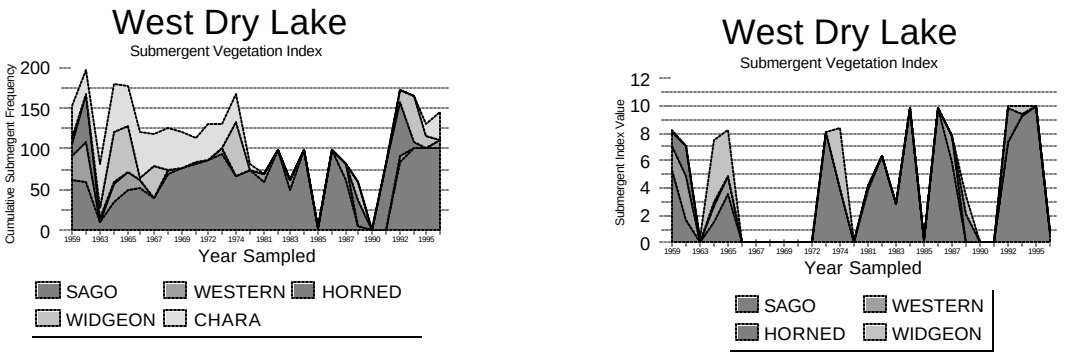


Figure 23: Submergent vegetation availability by frequency and density in Dry Lake, 1959-96.



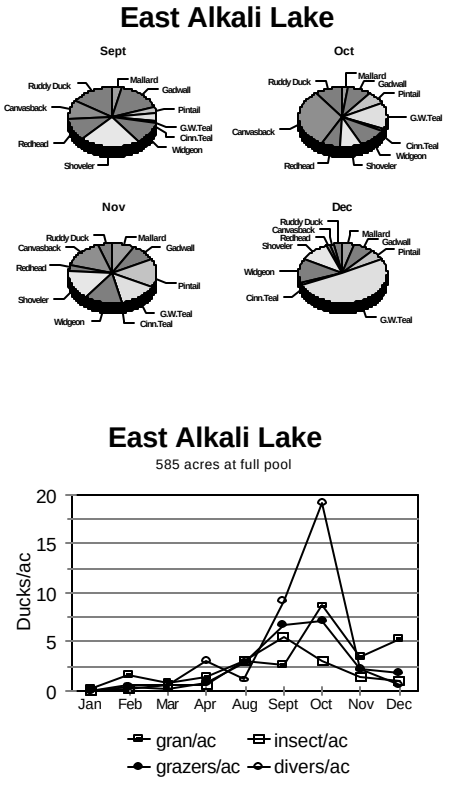
East Alkali Lake

Table 6: Duck species numbers by month in East Alkali Lake, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Tea	Wigeon	Shovele	Redhea	Canvasbac	Ruddy Duck	Total
Jan	50	0	25	0	0	0	0	0	0	0	75
Feb	69	25	380	108	0	90	40	65	50	40	867
Mar	26	25	82	174	37	8	170	28	58	100	708
Apr	29	114	50	283	27	75	148	71	10	660	1466
Aug	235	733	492	310	218	225	829	94	55	240	3431
Sept	270	1335	276	341	75	979	1825	974	763	1320	8158
Oct	303	1308	1078	2136	67	1610	1200	1078	4793	1575	15149
Nov	319	370	592	547	0	551	628	135	591	200	3932
Dec	130	270	193	1750	50	427	388	53	40	120	3419

East Alkali Lake is a 585 acre, shallow wetland, created in an historic alkali flat receiving water from precipitation or back fill from the Carson Sink. This unit has received freshwater input over the past 50 years which has led to considerable vegetative productivity and resulting waterfowl use (Table 6). All ten primary duck species are well represented on this unit; however, it appears to be particularly important during September and October for diving ducks and other herbivorous species. Green-winged teal tend to be the most abundant species during December, with respectable numbers from all other species recorded as well (figure 24).

Figure 24: Duck species composition and foraging guild density for East Alkali Lake, 1970-98.

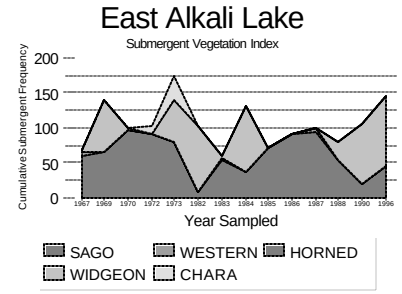


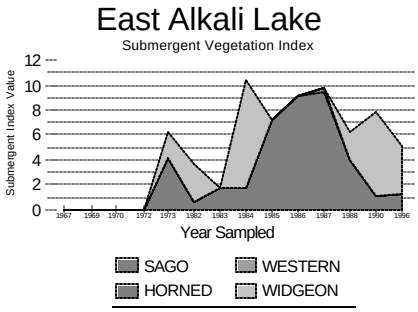
While all foraging guilds were observed at low density during spring, this unit experienced high diving duck use (19 divers/ac) during October, and then granivorous species use from October through December (3.4 - 8.6 granivores/ac). Insectivorous species increased up to a September/October peak, and then, similar to grazing species, dropped significantly from October - December. Considering density, East Alkali Lake has consistently been the preferred wetland unit for fall canvasback use.

One reason for this is that submergent vegetation production has been excellent over the 14 years samples have been collected; particularly for sago pondweed and wigeongrass (figure 25). Unit water

depth has averaged 41 cm, salinity ranged between 1246 and 8537 ppm (4972 ppm average), and turbidity has remained relatively low (clarity to 29 cm) producing ideal conditions for submergent vegetation growth. Additionally, this unit has maintained perennial water throughout the year averaging between 251 (April) and 427 ac (November), providing late spring drawdown for germination of sago pondweed. The sago pondweed index has remained high, compared to most units and years with a high of 9.405 recorded in 1987 and an average of 2.89 over the observation period. Wigeongrass has also been consistent with a high of 8.74 recorded in 1984 and an average of 1.9. While western pond weed has been sampled on this wetland unit, only chara was sampled with any frequency, and then, only from 1970-73. Among wetland units analyzed during this effort, acre for acre, East Alkali Lake would appear to be the most important unit on Stillwater NWR for fall migratory waterfowl.

Figure 25: Submergent vegetation availability by frequency and density in East Alkali Lake, 1959-96.





Lower Foxtail Lake

As far as total birds are concerned, Lower Foxtail Lake (1,190 ac at full pool) holds the largest percentage of birds among Stillwater NWR wetland units (table 7). Similar to East Alkali Lake, an equal composition of duck species has been maintained

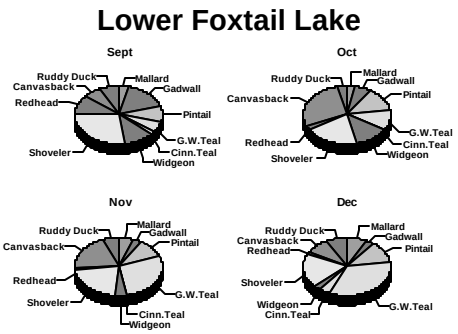
Table 7: Duck species numbers by month in Lower Foxtail Lake, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Wigeon	Shoveler	Redhead	Canvasback	Ruddy Duck	Total
Jan	623	47	366	945	0	77	292	20	368	142	2878
Feb	188	109	657	683	40	30	1257	23	319	1020	4325
Mar	97	31	416	362	29	20	183	40	592	1368	3137
Apr	35	139	37	215	74	30	189	46	138	845	1749
Aug	498	1185	886	384	154	231	1592	738	70	113	5852
Sept	409	1687	997	622	198	1205	2951	1060	739	773	10641
Oct	762	1858	3436	3143	131	3362	5631	524	7636	976	27458
Nov	944	644	2015	5338	25	841	4073	214	3783	1081	18958
Dec	735	230	1238	3252	403	248	1803	125	858	751	9642

during August and September; however, this unit became increasingly important for green-winged teal and canvasback as the hunting season progressed (figure 26). Diving ducks (canvasback in particular), were present in the highest density, but were closely followed by granivores, insectivores and grazers. Granivorous species increased through November and maintained their highest density from November through January. Total duck density on this unit ranged from 24.2, 16.8, and 8.6 ducks/ac for October - December, respectively.

Submergent vegetation production would be considered excellent, in Lower Foxtail Lake with sago pondweed and western pondweed both well represented throughout most of the 25 years this unit was sampled (figure 27). Production indices during the early to mid 1970's were the highest recorded for Stillwater NWR with a sago index of 8.0 and a western index of 3.75 recorded in 1973. Over the years, sago had an average index value of 3.04, maintained by a frequency and density of 63.7% and 44.8%, respectively. Horned pondweed, wigeongrass, and chara have also been well represented over the years with the former two species dominating submergent vegetation communities during early sampling periods.

Figure 26: Duck species composition and foraging guild density for Lower Foxtail Lake, 1970-98.



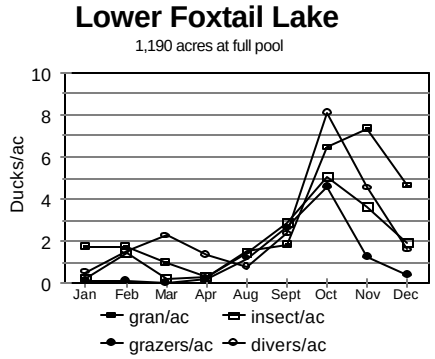
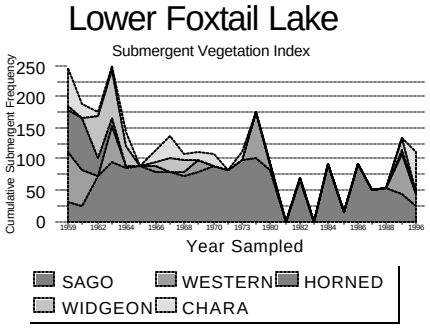
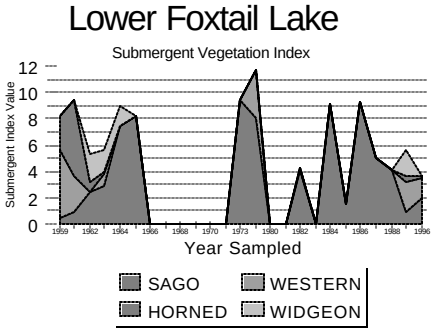


Figure 27: Submergent vegetation availability by frequency and density in Lower Foxtail Lake, 1959-96.





The quality of submergent vegetation produced, and resulting waterfowl use, is likely the result of water management strategies implemented on this unit over time. Lower Foxtail Lake has been consistently flooded from 67% (April, 800 ac) to 98% (August, 1170 ac) of full pool with an average depth of 47 cm occurring at high water in August. Salinity ranged from 943 ppm to 3920 ppm, while water remained clear to 26 cm. Overall, these are optimal conditions for the production of sago pondweed (Kantrud 1990), which is displayed in the preceding figures. While East Alkali Lake has likely been the most important wetland unit for fall migratory waterfowl on an acre for acre basis, Lower Foxtail Lake has hosted the largest population of ducks during fall migration (average of 24,552 and 15,269 in October and November, respectively).

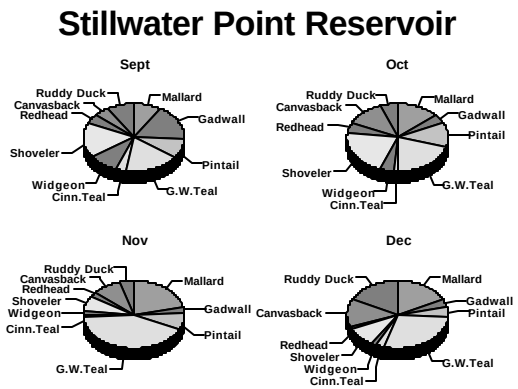
Stillwater Point Reservoir

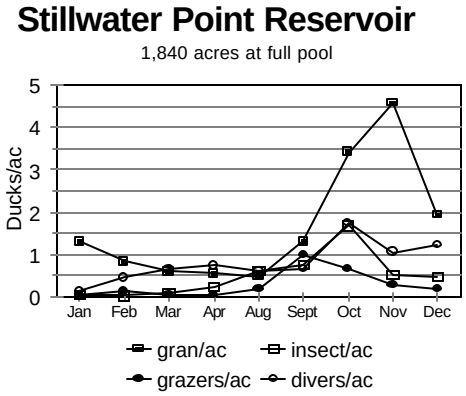
Table 8: Duck species numbers by month in Stillwater Point Reservoir, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Tea	Wigeon	Shovele	Redhea	Canvasbac	Ruddy Duck	Total
Jan	209	40	98	977	0	10	37	0	50	90	1510
Feb	106	20	622	273	30	125	13	80	13	440	1722
Mar	68	20	336	254	30	33	93	46	156	474	1509
Apr	34	48	56	424	59	13	153	35	73	555	1451
Aug	135	109	224	160	240	100	455	132	460	81	2095
Sept	359	705	403	705	141	399	698	171	226	345	4154
Oct	1058	351	981	1617	58	359	1739	393	976	456	7989
Nov	1345	159	533	2594	50	131	459	141	561	291	6263
Dec	861	177	250	1338	145	62	441	68	664	838	4845

Stillwater Point Reservoir, as the name implies, has primarily been used as a storage reservoir for hydration of lower units in the Stillwater marsh. As a result, this 1,840 ac wetland unit has ranged from 51% to 69% of full pool (940 to 1275 ac) with considerable variation occurring during the annual cycle. Duck use would be considered low as compared to other sanctuary wetland units, but similar to these other units, species composition was fairly equal during August and September. Mallard, and green-winged teal numbers steadily increased from October through November with a higher proportion of granivorous species occurring in this unit during October through December (table 8; figure 28). While water level fluctuation is optimal for annual seed production, which granivorous species rely on during late fall/winter months, it is uncertain whether this proportional increase was due to vegetation, or whether this unit was used as a staging point to access nearby agricultural fields for grain. An average of 1129, 928, and 706 Canada geese used this unit for the latter purpose from November through January. Canvasback use was highest from October through December with an average of 976 canvasback occupying Stillwater Point Reservoir during October. Maximum birds per acre (7.5) occurred in October, with granivorous species strongly dominant in this unit during October and November.

Figure 28: Duck species composition and foraging guild density for Stillwater Point Reservoir, 1970-98.

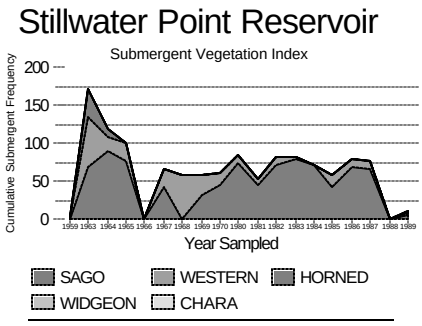


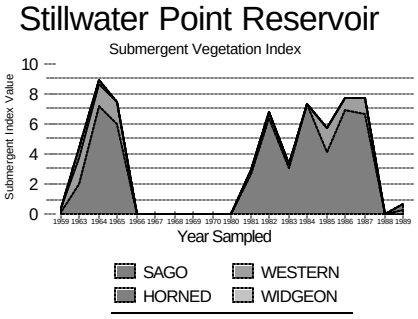


Submergent vegetation production was somewhat lower than comparable refuge units with low density and frequency recorded for sago pondweed, western pondweed, and horned pondweed (figure 29). As would be anticipated with fluctuating water levels, compounded by high flows through portions of the unit, submergent vegetation production was somewhat lower than other wetland units, with an average of 32% of transect points remaining unvegetated. Unit water depth averaged 52 cm over the 19 years this unit was sampled, while salinity ranged from 569ppm to 2063 ppm (1186 ppm average). Water clarity was good to 26 cm; however, clarity ranged from 8 cm to 1.1 m over the sampling period.

Even though sampling frequency was low, fair index values were recorded for both sago and western pondweeds where they occurred. Sago pondweed was sampled at an average index value of 2.77 (maximum of 6.42 in 1982) while western pondweed maintained an average index value of 0.49 (maximum of 1.73 in 1963).

Figure 29: Submergent vegetation availability by frequency and density in Stillwater Point Reservoir, 1959-96.





Upper Foxtail Lake

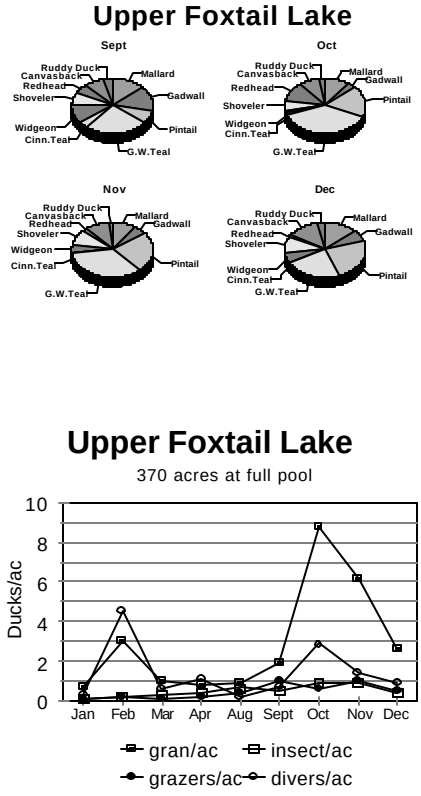
Table 9: Duck species numbers by month in Upper Foxtail Lake, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Wigeon	Shoveler	Redhead	Canvasback	Ruddy Duck	Total
Jan	120	0	35	43	0	10	20	10	47	25	310
Feb	70	10	73	368	30	20	5	100	70	600	1346
Mar	18	9	120	51	36	0	18	18	10	80	360
Apr	25	39	15	140	33	6	62	23	30	158	531
Aug	86	101	71	93	84	15	103	42	0	10	606
Sept	143	152	82	281	39	114	78	64	85	40	1078
Oct	344	89	621	1303	40	63	191	378	273	84	3385
Nov	205	129	534	784	10	115	216	36	207	40	2276
Dec	118	55	223	205	0	50	82	10	120	25	888

Similar to Stillwater Point Reservoir, Upper Foxtail Lake is subject to seasonally high flows and considerable fluctuation in water level. This 370 acre unit has ranged from 170 ac (February) to 296 ac (January and August) which equates to 46-80% of full pool on a monthly basis. Divided into two separate units (Duff's Pond and Upper Foxtail Lake), each provides different habitat types with Duff's Pond (80 ac) typically occupied by submergent vegetation and Upper Foxtail (290) comprised of an emergent, moist-soil, and submergent vegetation mix. Waterfowl use varied accordingly with a disproportionate percentage of dabbling ducks (primarily mallards, gadwall, northern pintail, and green-winged teal) surveyed through fall months (table 9;figure 30). A more even mix of diving ducks and granivores occurred during spring with insectivores and grazers poorly represented throughout the annual cycle.

Waterfowl density was relatively high through the hunting season with 13.1, 9.4, and 4.3 ducks/ac recorded from October through December. Within this total, 67%, 65%, and 60% consisted of granivorous species (mallard, green-winged teal or northern pintail.

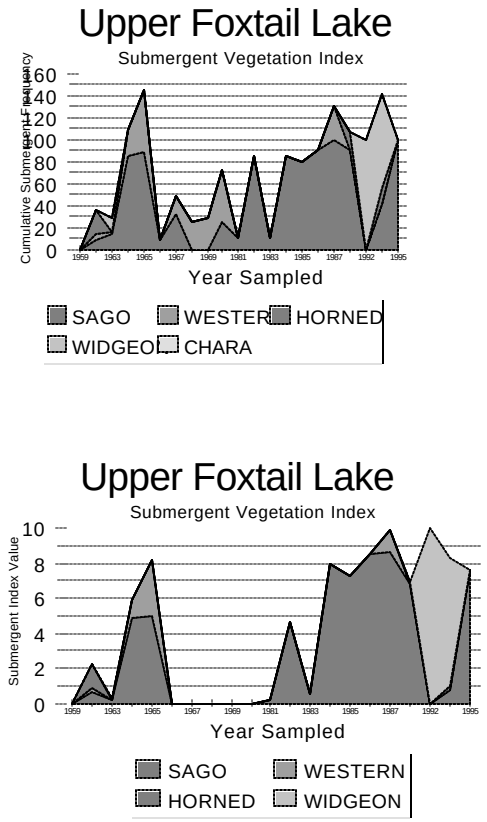
Figure 30: Duck species composition and foraging guild density for Upper Foxtail Lake, 1970-98.



Submergent vegetation surveys were only conducted in Duff's Pond which covers 21% of the total Upper Foxtail area. This unit was comprised of sago, western, and horned pondweed's with significant dominance changes occurring at different points during the 21 years this unit was sampled. Index values alternated accordingly with horned pondweed dominant during early years (1959-62), sago pondweed during the middle period (1963-1991), and more recently, wigeongrass through the middle 1990's. Western pondweed was well represented during middle years but missing density values did not allow for calculation of an index value.

Duff's Pond had one of the deepest average water depths among Stillwater NWR wetland units (68 cm), and also maintained the lowest salinity range (1257 ppm to 2462 ppm; average of 1753 ppm). Water clarity was quite high at 26 cm; however, so was the percent of plots which did not contain submergent vegetation (38%). When characterizing Upper Foxtail Lake (and resulting waterfowl use), it should be understood that 79% of the unit consisted of vegetation other than submergent. It is possible that high water level fluctuations have produced a mix of early successional, seed-producing plants which would explain the disproportionately high granivorous species use throughout the sample period. Alternatively, this unit could be used as a staging point, similar to Stillwater Point Reservoir, based on proximity to agricultural lands.

Figure 31: Submergent vegetation availability by frequency and density in Upper Foxtail Lake, 1959-96.



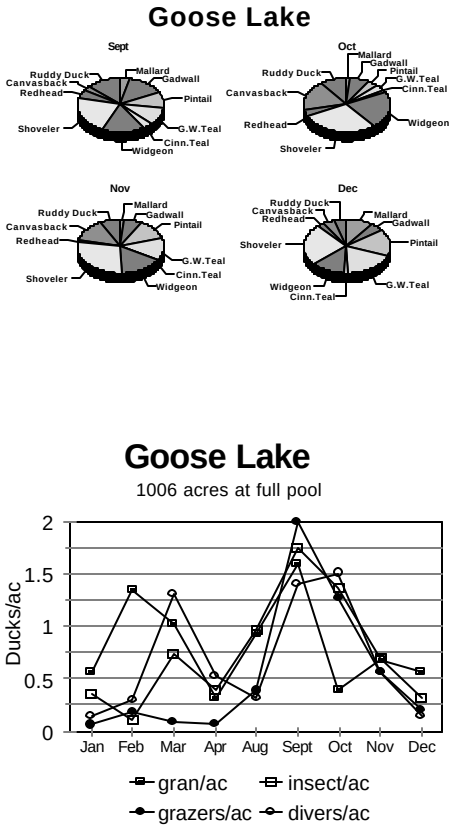
Non-Sanctuary Wetland Units

Goose Lake

Table 10: Duck species numbers by month in Goose Lake, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Wigeon	Shoveler	Redhead	Canvasback	Ruddy Duck	Total
Jan	137	17	141	223	10	35	305	30	45	50	994
Feb	88	23	630	406	35	125	56	44	127	70	1602
Mar	24	44	569	353	68	35	623	43	196	967	2921
Apr	29	38	39	197	42	14	290	39	81	304	1072
Aug	119	293	456	270	311	58	579	140	53	96	2373
Sept	221	822	539	656	244	958	1310	302	149	808	6008
Oct	43	282	169	153	65	910	1212	139	750	425	4148
Nov	34	152	281	311	0	362	649	18	307	188	2302
Dec	122	51	199	226	15	150	298	27	55	57	1199

Figure 32: Duck species composition and foraging guild density for Goose Lake, 1970-98.



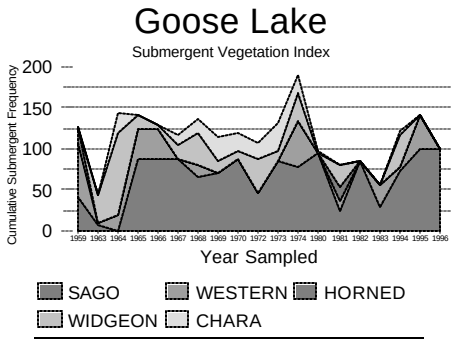
Goose Lake is a 1,006 acre unit located in the center of the refuge. This unit is the first to receive water from the sanctuary wetland units, and can be hydrated or drained from several different points. Considering it's proximity to Stillwater NWR water sources, it has consistently maintained permanent water averaging approximately 90% of full pool (909 ac). Average seasonal acreage ranged from 834 ac (83% full pool, February) to 971 ac (97% full pool, December), providing one of the most consistently available units for duck use throughout the survey period.

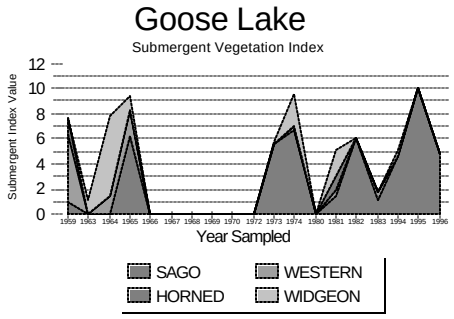
Waterfowl use was variable with different species and guilds dominant through different months of the year (table 10; figure 32). As would be expected in a perennial unit, diving ducks and grazers were observed at higher densities through most months with granivore peak use occurring in February and then again in September. The overall waterfowl population peaked in September with hunting season apparently having an effect on species distribution. As with other units, September use was evenly split among a variety of species; however, use shifted to canvasback, shovelers, wigeon, and ruddy ducks

from October through December. Waterfowl density remained relatively low throughout the year with a peak density of 6.7 ducks/ac recorded in September (evenly split among foraging guilds), to a low 1.1 ducks/ac in January.

Considering low monthly variation in acreage, submergent vegetation production has remained high in this unit (figure 33). Sago pondweed has been the dominant submergent vegetation species throughout the 19 years this unit was sampled, with all other primary species well represented. Little variation in water depth (average 34 cm) and relatively low salinity (average 2706 ppm), has promoted extensive coverage by submergent vegetation. Goose Lake recorded one of the lowest unvegetated frequencies (12.6%) and few other species are present other than an emergent fringe around the shoreline and seasonally flooded saltgrass meadows. Average index values for sago pondweed ranged from 0.036 (1963) to 6.7 (1974), with an average value of 2.51 across all years. Other species index values were 0.54, 0.13, and 0.73 for western pondweed, horned pondweed, and wigeongrass, respectively.

Figure 33: Submergent vegetation availability by frequency and density in Goose Lake, 1959-96.





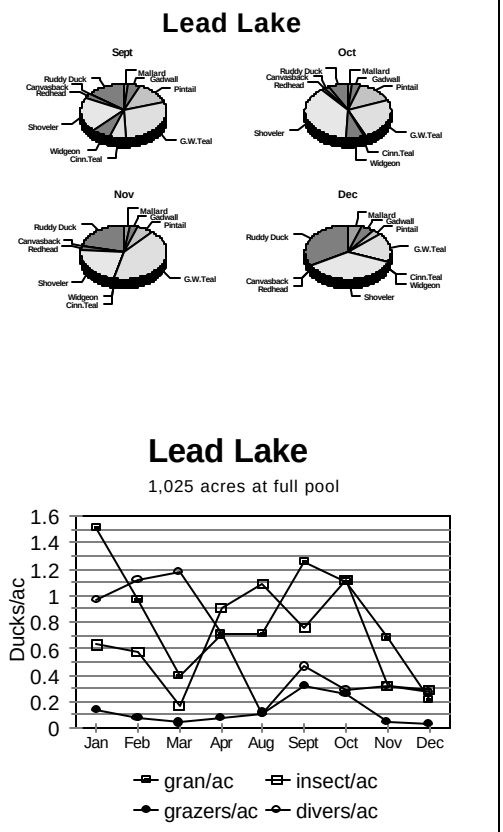
Lead Lake

Table 11: Duck species numbers by month in Lead Lake, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Wigeon	Shoveler	Redhead	Canvasback	Ruddy Duck	Total
Jan	35	127	40	1332	0	0	584	10	0	883	3010
Feb	91	42	263	450	17	20	457	78	255	553	2225
Mar	40	24	117	217	21	13	141	33	40	1025	1671
Apr	34	38	67	496	37	30	734	73	11	484	2004
Aug	31	86	106	457	307	10	615	50	0	41	1704
Sept	38	103	351	703	146	178	512	39	10	353	2433
Oct	32	73	327	553	25	144	896	30	40	168	2288
Nov	31	37	72	488	0	0	274	20	10	244	1176
Dec	41	32	26	129	0	0	256	0	0	241	725

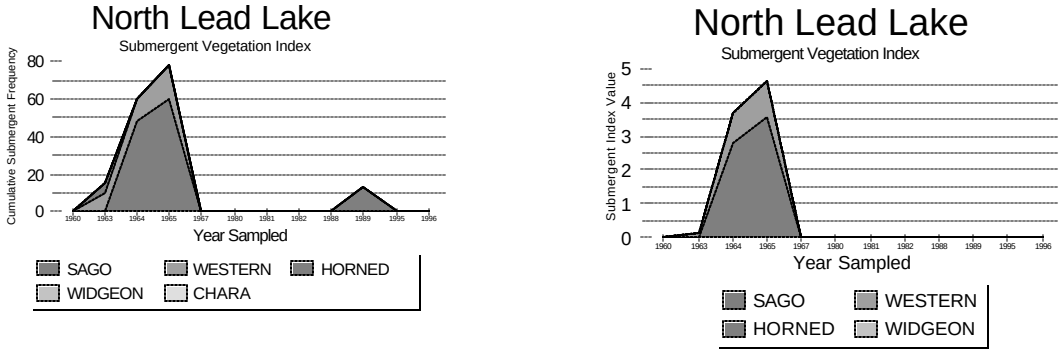
Duck numbers, as compared to other Stillwater NWR wetland units, were quite low in this 1,025 acre unit. Acreage ranged from 827 ac (81% full pool, February) to 943 ac (92% full pool, March) with little variability noted within or among years. Green-winged teal, northern shoveler, and ruddy ducks were the primary species using this wetland throughout the annual cycle with little change in species composition occurring during the hunting season (table 11, figure 34). Numbers tended to drop through the early and mid parts of the season; however, Lead Lake's peak duck count occurred in January, likely related to the depth and openness of the unit for wintering birds. Waterfowl density was also low with a high of 3.2 ducks/ac (January) and a low of 0.8 ducks/ac recorded in December. Foraging guild composition was dominated by granivores and insectivores from August - January (primarily related to green-winged teal and northern shoveler numbers); however, a shift towards diving ducks occurred during spring with a peak of 1.18 divers/ac recorded in March (83% ruddy ducks).

Figure 34: Duck species composition and foraging guild density for Lead Lake, 1970-98.



Low duck use was consistent with low frequency of submergent vegetation occurring in this unit over time (figure 35). During the 12 years this unit was sampled, no vegetation was encountered on transects 7 years with an average unvegetated frequency of 72.6%. Possible reasons for this result include the high average depth (70 cm) combined with high

Figure 35: Submergent vegetation availability by frequency and density in Lead Lake, 1959-96.



water turbidity (clarity to 11 cm). Salinity ranged between 1335 ppm and 2178 ppm with an annual average of 1990 ppm. This salinity level is in the optimal ranges for both western and sago pondweeds (which dominated most samples); however, frequency and the submergent vegetation index were low throughout the sampling period with combined indices only reaching 2.1 on average. This unit was among the poorest for both waterfowl use and submergent vegetation production over the respective sampling periods.

Nutgrass Unit

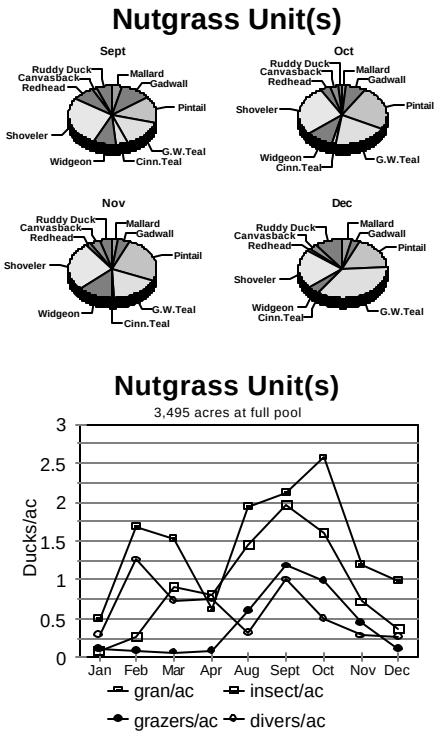
Table 12: Duck species numbers by month in the Nutgrass units, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Wigeon	Shoveler	Redhead	Canvasback	Ruddy Duck	Total
Jan	196	235	434	958	10	107	293	43	267	446	2989
Feb	303	80	2588	2380	68	186	796	183	830	2771	10185
Mar	113	100	2210	2160	431	112	2232	126	169	1831	9484
Apr	33	72	198	1259	228	128	1720	137	39	1574	5389
Aug	886	1221	2168	1989	1546	350	2215	347	70	398	11189
Sept	611	1777	2457	2550	685	1351	4534	1321	286	1014	16585
Oct	181	1224	4039	3226	177	1645	4505	651	427	332	16407
Nov	140	342	1924	1384	35	960	2044	148	290	343	7611
Dec	193	136	982	1877	24	215	1135	103	126	575	5365

As sampled during the waterfowl surveys, the Nutgrass unit is divided among the present, South, North, and West Nutgrass subunits. Combined, these subunits encompass 3,495 acres with average acreage ranging from 2,609 ac (75% full pool, August) to 3179 ac (91% full pool, January). Waterfowl use has been high over the years with an average total duck count ranging from 2,989 (January) to 16,585 (September; table 12). Species composition is comprised of all ten primary species during September, with northern shoveler, green-winged teal, and northern pintail most common (figure 36). This trend is fairly consistent throughout the annual cycle and October's peak count (occurring during hunting season in most years), is nearly identical to the September count.

Similar to other Stillwater NWR wetland units, species composition was fairly consistent among the 10 primary species in September. This trend shifted during hunting season with American wigeon and

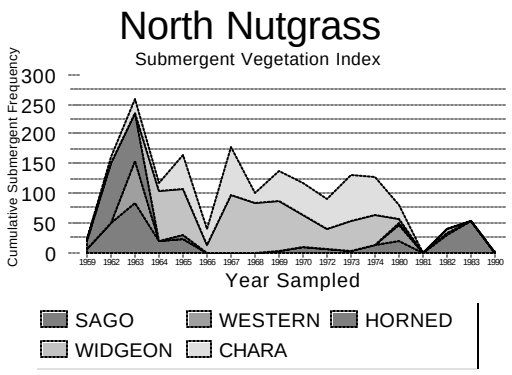
Figure 36: Duck species composition and foraging guild density for the Nutgrass units, 1970-98.

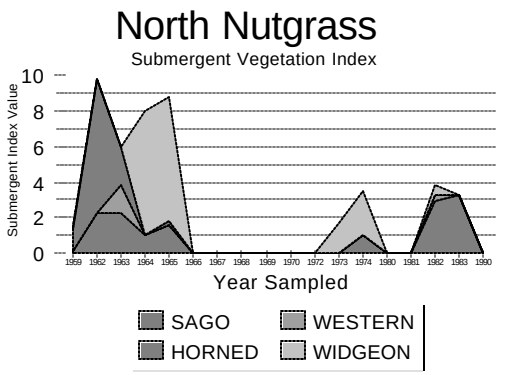


ruddy ducks increasing proportionally from October through December. Overall density ranged from 6.3 ducks/ac (September) to 1 duck/ac (January) with granivorous species leading composition and density in all months but April. A bimodal peak density was noted for granivorous and diving duck species (February and September/October) while insectivores and grazers were much more common during fall months. The diving duck guild was strongly dominated by ruddy ducks, with canvasback encompassing a small percentage of overall use and redheads decreasing as hunting season progressed.

Submergent vegetation production was nearly even with the Stillwater NWR average, but species composition was much different than other units (figure 37). Over the 18 years this wetland unit was sampled, species dominance shifted among all five species. This makes perfect sense when you consider the average water depth (22 cm), the salinity range (3037 ppm to 26,890 ppm; average 7,723 ppm), and the fact that wide variation exists in wetland acreage over the growing season. During early years, lower salinity levels provided conditions suitable for establishment of sago, western, and horned pondweeds. As water became less available through the middle years, salinity increased and

Figure 37: Submergent vegetation availability by frequency and density in the Nutgrass units, 1959-96.





wigeongrass and chara became the dominant species. This trend has oscillated over time; however, all sample years were characterized by an average of 73% vegetative coverage among sample points. This produced average index values of 0.82, 0.17, 0.61, 0.67, and 1.36 for sago pondweed, western pondweed, horned pondweed, chara, and wigeongrass, respectively. While these averages were small, this resulted in an average submergent vegetation index value of 3.63 among all years. Overall, high duck use numbers and good submergent vegetation productions would rank this unit among the better non-sanctuary wetland units at Stillwater NWR.

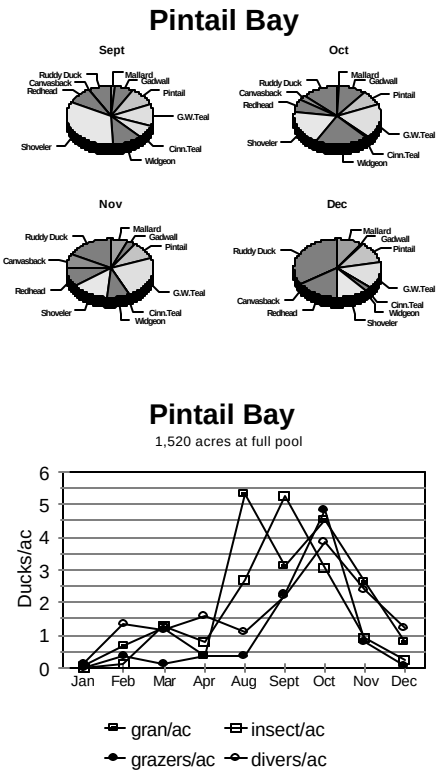
Pintail Bay

Table 13: Duck species numbers by month in Pintail Bay, 1970-98.

Month	Mallard	Gadwall	Pintail	G.W.Teal	Cinn.Teal	Wigeon	Shoveler	Redhead	Canvasback	Ruddy Duck	Total
Jan	0	0	60	0	0	0	0	70	5	60	195
Feb	33	295	738	254	22	197	148	419	219	1266	3591
Mar	27	107	712	1004	87	80	1731	491	119	1010	5368
Apr	28	228	194	192	65	199	843	533	51	1194	3525
Aug	241	231	4888	348	680	119	2083	465	0	640	9694
Sept	259	878	1163	1650	842	1315	4294	1118	35	999	12552
Oct	74	1418	1145	2656	37	2724	2550	1082	368	1788	13842
Nov	353	173	565	1280	0	475	751	573	445	958	5574
Dec	177	25	237	306	0	45	240	300	10	698	2037

Pintail Bay is a 1,520 ac, open wetland unit, located at the north central portion of the refuge. As our northernmost wetland unit, Pintail Bay has been subject to wide water level fluctuations over the years with an average low of 845 ac (56% full pool, November) and high of 1,463 ac (94% full pool, February). Waterfowl use has been quite high over the years with Pintail Bay density, consistently the highest among non-sanctuary units (table 13; figure 38). Species composition was strongly dominated by northern shoveler during early fall; however, all 10 primary species were well represented throughout months. Abundance and density were highest in fall, with the highest spring use density at 3.7 ducks/ac (March), primarily comprised of green-winged teal, northern shoveler, and ruddy ducks. Foraging guild analysis is quite complex in this unit with multiple peak use periods occupied or shared among guilds. For example, granivorous species peaked at 5.3 birds/ac in August, but also experienced a secondary peak in October during the early hunting season. The August peak was followed by insectivores (predominantly northern shovelers) in September, and then by grazers in October (both American wigeon and gadwall). Overall density ranged from 0.2 ducks/ac (January) with a peak density of 16.3 birds/ac. in October.

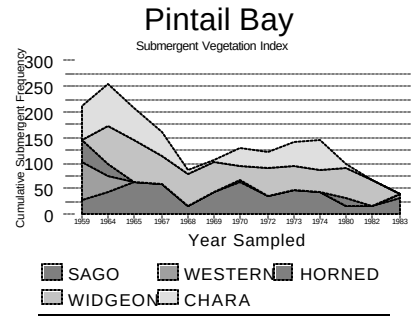
Figure 38: Duck species composition and foraging guild density for Pintail Bay, 1970-98.

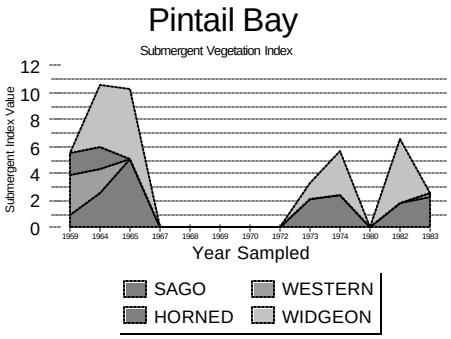


Similar to the Nutgrass Unit, this peak corresponds with the first month of the waterfowl hunting season.

Submergent vegetation frequency has been variable over the 13 years this unit was sampled with a nearly equal distribution of sago pondweed, chara, and wigeongrass (figure 39). While chara was not included in the submergent vegetation index, it would have resulted in similar index values as calculated for sago pondweed and wigeongrass. Water depth in this unit has averaged fairly shallow (27 cm) while salinity ranges are wide with a low of 3762 ppm and a high of 34,692 ppm (average 10,558 ppm). Water clarity has been low with an average depth of 11 cm, but unit shallowness and high salinity have facilitated growth of the three dominant species. Few sample points remained unvegetated (11.9%); however, low submergent vegetation index values represent only fair density over the years, which has likely resulted in relatively poor seed production in all but the earlier sample years.

Figure 39: Submergent vegetation availability by frequency and density in Pintail Bay, 1959-96.



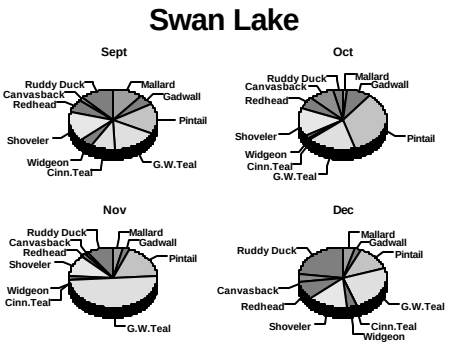


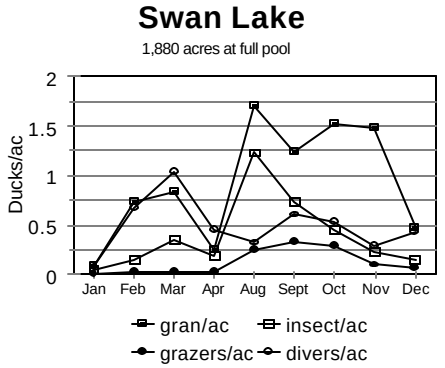
Swan Lake

Table 14: Duck species numbers by month in Swan Lake, 1970-98.

Month	Mallard	Gadwal	Pintail	G.W.Teal	Cinn.Tea	Wigeon	Shovele	Redhea	Canvasbac	Ruddy Duck	Total
Jan	50	0	93	27	5	10	92	31	32	78	416
Feb	111	10	528	434	23	34	202	105	177	662	2285
Mar	27	23	775	320	59	20	401	96	34	1226	2981
Apr	12	32	39	288	52	10	193	255	50	246	1177
Aug	131	174	1094	368	545	56	610	183		120	3280
Sept	294	170	434	442	249	136	440	191	50	327	2733
Oct	37	223	894	463	10	39	400	163	233	79	2542
Nov	80	69	439	1164	0	45	268	50	30	234	2378
Dec	62	35	199	346	0	60	200	150	50	341	1443

Figure 40: Duck species composition and foraging guild density for Swan Lake, 1970-98.

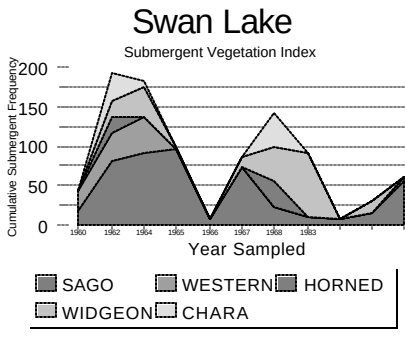


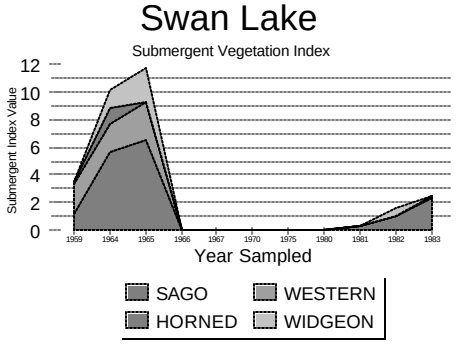


Swan Lake is a 1,880 acre unit subdivided into two separate subunits; Swan Lake and Swan Check. Located in the northcentral portion of the refuge, water levels are subject to fluctuation with a low acreage of 918 ac. (49% full pool, October) and a high of 1,776 ac (94% full pool, January) averaged over the survey period. This unit has remained fairly low relative to annual duck counts (table 14; figure 40). September species composition was evenly distributed among the 10 primary duck species; however, higher proportions of northern pintail followed by green-winged teal were associated with October through December surveys. Ruddy ducks represented a large percentage of the December count, but the peak for this diving duck occurred in March (1,226). Overall duck density was relatively low compared to other Stillwater NWR wetland units ranging from a low 0.2 ducks/ac (January) to a high of 3.5 birds/ac in August. Duck numbers progressively dropped over the hunting season from August through January. Spring densities were also relatively low and primarily comprised of northern pintail, northern shoveler, and ruddy ducks.

Submergent vegetation establishment over the 11 sample years, has been variable with all five submergent species represented along transects

Figure 41: Submergent vegetation availability by frequency and density in Swan Lake, 1959-96.





(figure 41). Submergent vegetation transects have been located in the southernmost segment of this unit which is typically deeper than northern arms of the unit (average 33 cm). Considering this units location, salinity ranges were surprisingly low ranging from 2,980 ppm to 6,720 ppm (average of 3000 ppm). No water clarity samples were collected during the 11 sample sessions corresponding to the years data were collected (1959-1983). Samples were not collected from 1984-1995 based on dry conditions.

From 1959-1965, submergent vegetation index values were high with a peak index value of 11.74 recorded in 1965. This was the second year following unit hydration which exemplifies the resilience and drought tolerance of submergent vegetation species. Index values were quite low during the early 1980's and then were non-existent until the past few years. Overall, duck use has been fairly low (with the exception of granivorous species), while submergent vegetation has been variable with no samples available to evaluate recent years.

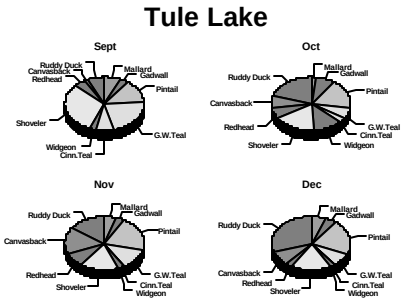
Table 15: Duck species numbers by month in Tule Lake, 1970-98.

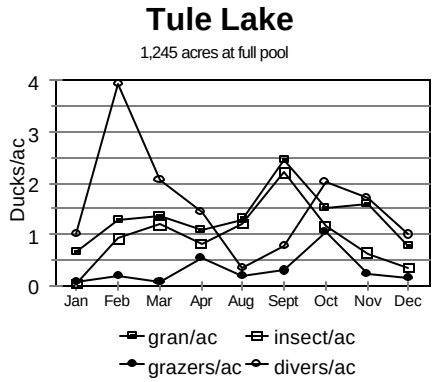
Month	Mallard	Gadwal	Pintail	G.W.Teal	Cinn.Tea	Wigeon	Shovele	Redhea	Canvasbac	Ruddy Duck	Total
Jan	117	23	293	360	30	45	28	217	412	442	1967
Feb	166	73	560	807	40	150	1053	153	1802	2455	7258
Mar	43	72	726	880	177	36	1249	76	105	2254	5619
Apr	24	140	26	936	122	360	612	64	180	957	3420
Aug	207	153	446	590	447	32	711	192	30	100	2908
Sept	343	167	774	1175	401	100	1646	264	58	385	5314
Oct	96	331	775	302	140	488	758	276	349	875	4389
Nov	146	113	707	415	0	78	507	262	560	484	3272
Dec	118	106	432	163	0	40	325	60	180	617	2042

Tule Lake

Tule Lake is a 1,245 ac unit located in the center of the Stillwater NWR open area. Ranging from 771 ac (62% full pool, August) to 1,198 ac (96% full pool, March), this unit has been more consistently hydrated during spring months (January through March), with waterfowl numbers responding to this trend (table 15, figure 42). High average duck counts of 7,258 and 5,619 were documented for February and March, with ruddy ducks the most prominent species during both periods (34% and 40%, respectively). Other important spring migrants included northern pintail (560/570), green-winged teal (807/880), and northern shoveler (1,053/1,249); however, all of these species experienced peak population levels in fall. Species composition during fall varied by month, with northern shoveler, green-winged teal, and northern pintail represented throughout the year. Canvasback numbers increased until November and then dropped off through December, although ruddy ducks were still the highest use, diving duck species.

Figure 42: Duck species composition and foraging guild density for Tule Lake, 1970-98.

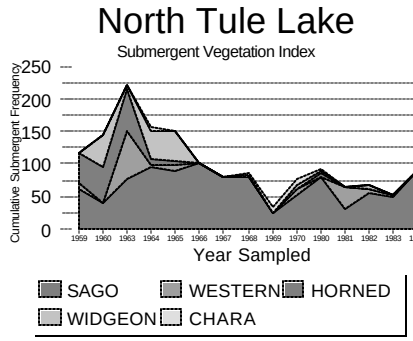


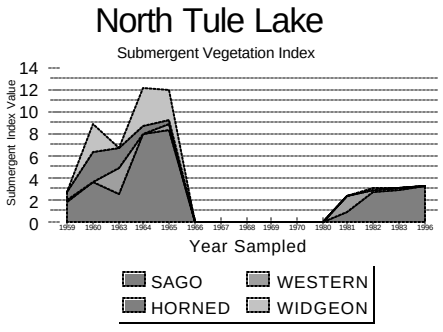


Foraging guilds also differed by period with all guilds but diving ducks experiencing peak density in September or October. Diving ducks displayed a bimodal peak with February and October highs recorded (3.93 and 2.02 divers/ac). Overall density was fairly low with a peak of 6.3 ducks/ac occurring in February. Similar to most non-sanctuary units, fall peaks occurred in September and October, with decreasing density as hunting season progressed.

Submergent vegetation production was excellent during the early years at Tule Lake (figure 43). Between 1959 and 1965, a large percentage of the marsh was covered by a mix of sago pondweed, western pondweed, horned pondweed, and wigeongrass with submergent vegetation indices ranging from 6.2 -12.2. Index values were not available from 1966-80; however, these values were considerably lower from 1981-present. Tule Lake's average depth (43 cm) and relatively low salinity range (1132 ppm to 5147 ppm), was ideal for sago and western pondweed growth and poor index values during the mid 1980's-96 cannot be explained. Over the 15 years this unit was quantitatively sampled, vegetation occurred at 82% of transect points.

Figure 43: Submergent vegetation availability by frequency and density in Tule Lake, 1959-96.





Overall, this unit would rate fair to good for waterfowl use and good for submergent vegetation production, with spring apparently, the most attractive month for migratory waterfowl.

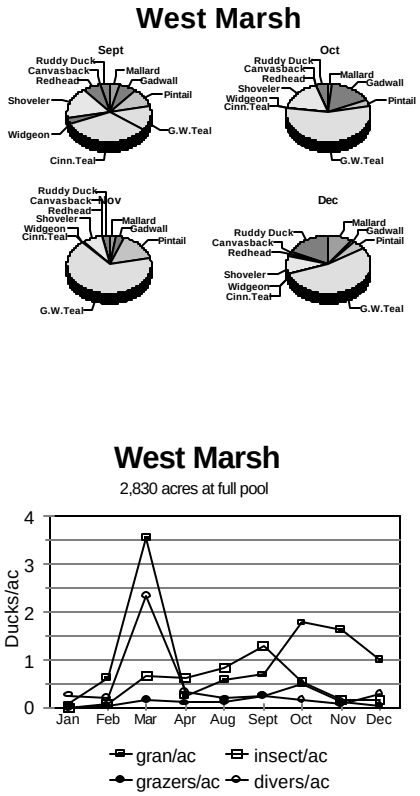
West Marsh

Table 16: Duck species numbers by month in West Marsh, 1970-98.

Month	Mallard	Gadwal	Pintail	G.W.Teal	Cinn.Tea	Wigeon	Shovele	Redhea	Canvasbac	Ruddy Duck	Total
Jan	35	0	0	50	0	0	0	0	0	460	545
Feb	69	12	445	812	55	50	90	120	95	155	1903
Mar	58	18	777	1175	58	60	323	225	175	900	3768
Apr	32	74	37	204	100	30	645	94	23	236	1474
Aug	131	138	240	452	589	23	553	94	0	150	2370
Sept	149	253	393	476	1246	129	658	253	0	123	3679
Oct	40	605	113	2033	30	0	618	0	0	170	3608
Nov	62	100	412	1782	0	25	206	0	0	65	2651
Dec	170	15	93	975	0	0	175	30	20	310	1788

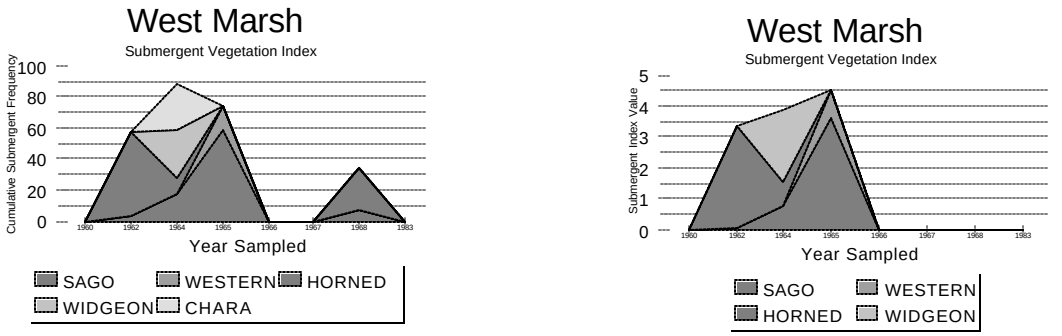
West Marsh (2,830 ac at full pool), encompasses West Marsh, Millen Lake, and Willow Lake. Rarely full during the survey period, West Marsh ranged from 560 ac (19.8% full pool, March) to 2,123 ac (75% full pool, February), with an annual average of 1,402 ac (50% full pool). West Marsh was only hydrated 8 years from 1977 - present, with wetland acreage not maintained throughout most sample years. Duck species responded accordingly with shallow, ephemeral habitat species comprising the largest percentage of annual use (table 16). Green-winged teal, cinnamon teal, northern shoveler, and northern pintail were the primary species utilizing this unit with ruddy ducks contributing to overall composition from December through March. Green-winged teal comprised more than 50% of total species use during hunting season months (56%, 67%, and 55%, respectively, for October, November, and December; figure 44). By foraging guild, granivorous species were strongly dominant in all months but January (diving ducks, 69% ruddy ducks), and August - September (insectivores, >50% cinnamon teal). Proportionally, this unit maintained the largest percentage of shallow water foraging specialists of all Stillwater NWR wetland units evaluated in this analysis.

Figure 44: Duck species composition and foraging guild density for West Marsh, 1970-98.



Relative to infrequent hydration schedules, West Marsh has not produced submergent vegetation as well as other units; however, this unit was only sampled 4 times (1962, 64, 65, and 68) over the 1959 - 1996 survey period with drought common even during the 1960's (figure 45). When surveyed, West Marsh averaged 49 cm in depth, and had salinity ranges from 1,813 ppm to 2,475 ppm (average of 1,997 ppm). Water clarity was poor (11 cm) and 64% of transect points remained unvegetated across sampling periods. As a result, frequency and submergent vegetation index values remained low with a peak submergent index of 4.5 recorded in 1965. With the low salinity readings, sago pondweed and western pondweed were the two most common submergent species; however, infrequent hydration and corresponding ephemeral conditions did not allow for a significant submergent vegetation component in this units soil seed bank. Overall, West Marsh does not retain duck numbers as most other units have; however, this unit has been important for shallow water foraging specialists among years when it was at least partially hydrated.

Figure 45: Submergent vegetation availability by frequency and density in West Marsh, 1959-96.



Wetland Unit Rankings

Barber (1978), performed a ranking evaluation of Stillwater NWR wetland units based on overall waterfowl numbers, ducklings produced, and submergent vegetation production. Considering that Barber's analysis only covered a five year window, this evaluation will cover waterfowl use (based on duck density within wetland units), combined with submergent vegetation index values using long-term data sets. Waterfowl production has been infrequently monitored through Stillwater NWR's history, therefore, Barber's rankings will be included in this analysis, allowing for an evaluation of Stillwater NWR wetland units using all available data from 1959-1998 (table 17).

Table 17: A comparison of current wetland unit rankings by submergent vegetation production, duckling production, and annual waterfowl density, and Barber (1978) rankings, Stillwater NWR, 1959-98.

Wetland Unit	2000 Submergent Vegetation	2000 Waterfowl Density	Barber Duckling Production	2000 Overall Rank	Barber Overall Rank
Dry Lake	1	3	1	1	1
Pintail Bay	2	5	3	2	2
East Alkali Lake	3	1	12	3	11
Lower Foxtail Lake	4	4	10	4	5
Tule Lake	8	8	2	4	6
Upper Foxtail Lake	5	7	6	4	7
Cattail Lake	7	2	9	4	8
Nutgrass	9	10	4	8	3
Goose Lake	6	12	5	8	4
Lead Lake	14	9	8	10	13
West Marsh	12	13	7	11	10
Division Pond	13	6	14	12	14
Pt Reservoir	10	11	13	13	9
Swan Lake	11	14	11	14	12

The top two units, Dry Lake and Pintail Bay, have retained their overall rankings since the 1978 evaluation; however, some turnover has occurred among other units. East Alkali has become considerably more important, primarily based on ranking jumps in the submergent vegetation index (14 to 3) and waterfowl density (5 to 1). Submergent vegetation was not sampled in East Alkali Lake during Barber's (1978) study (see figure 25), suggesting that water was not directed to this unit between 1974 and 1978 in any quantity.

The poorest rated units, are typically deeper and/or located in the northwest corner of the refuge which are more subject to drought as limited water resources are redirected to shallower units with a better developed infrastructure. Lead Lake, Willow Lake, and Swan Lake are located in the northwest corner of the refuge, and with the exception of Lead Lake (which receives water from Canvasback Gun Club during fall), do not have an efficient delivery system. The latter two units have maintained an average of 48%/8 years and 57%/11 years fall water coverage, respectively (based on water coverage estimated from waterfowl surveys/years sampled from submergent vegetation surveys). Stillwater Point Reservoir has acted as a storage reservoir and has not been managed for waterfowl based on the need to maintain more northern units such as Foxtail Lake (87%/25 years), Dry Lake (86%/28 years), East Alkali Lake (67%/14 years), and Pintail Bay (59%/13 years).

An examination of unit specific waterfowl density by foraging guild suggests that different wetland units are more important for different species of waterfowl (table 18). For example, East Alkali Lake is the number 1 ranked unit for total waterfowl density; however, this ranking is primarily related to grazing and diving ducks while granivores and insectivores received a number 3 ranking for this unit. The number 1 fall duck density ranking for the latter two guilds was held by Dry Lake (3 overall) and Cattail Lake (2 overall) which were the 1 and 4 ranked wetlands when all factors were considered (table 17). The top seven units during fall for granivores, and 6 of the top seven for all other guilds were sanctuary wetland units.

Table 18: Waterfowl density unit rankings, by foraging guild, for fall months (Sept. - Dec.), Stillwater NWR, 1970-98.

Wetland Unit	Granivores	Insectivores	Grazers	Divers	All Ducks
East Alkali Lake	3	3	1	1	**1**
Cattail Lake	4	1	2	5	**2**
Dry Lake	1	4	3	2	**3**
Lower Foxtail Lake	2	2	4	3	**4**
Pintail Bay	8	5	5	6	**5**
Division Pond	6	6	11	4	**6**
Upper Foxtail Lake	5	12	7	7	**7**
Pt Reservoir	7	10	9	9	**8**
Tule Lake	10	8	10	8	**9**
Nutgrass	9	7	8	11	**10**
Goose Lake	13	9	6	10	**11**
Swan Lake	12	14	13	13	**12**
West Marsh	11	13	12	14	**13**
Lead Lake	14	11	14	12	**14**

While many units maintained a relatively consistent ranking among foraging guilds, other units appear to be preferred by one guild over others, or conversely, have displayed a lower density of one guild compared to others. For example, Upper Foxtail Lake received an overall ranking of 4 (table 17), a total fall waterfowl density ranking of 7, and an insectivore ranking of 12. Apparently, this unit did not contain life history elements necessary for insectivorous species, primarily northern shoveler. Other units displaying this pattern include Pintail Bay (8 for granivores, 5-6 for other guilds), Division Pond (11 for grazers, 4-6 for other guilds), and Goose Lake (13 for granivores, 6-10 for other guilds).

Table 19: Relationship between submergent vegetation production and annual/fall waterfowl density at Stillwater NWR, 1959-98.

Category	r-squared	p-value
ANNUAL		
Total Ducks	**0.3849**	0.0179
Granivores/ac	0.2558	0.065
Insectivores/ac	0.2751	0.0542
Grazers/ac	0.0177	0.6505
Divers/ac	0.3754	0.0198
FALL		
Total Ducks	0.4456	0.0091
Granivores/ac	0.3825	0.0184
Insectivores/ac	0.4099	0.0137
Grazers/ac	**0.4994**	0.0137
Divers/ac	0.2969	0.0439

As a possible explanation for guild patterns within specific units, a regression analysis was performed with annual and fall guild density compared with submergent vegetation index values (table 19). The results of this analysis suggest

that submergent vegetation quality has little effect on duck density within wetland units with grazing ducks displaying no relationship between grazer density and submergent vegetation ($r^2 = 0.0177$, $p = 0.6505$). While overall duck density was somewhat correlated with submergent vegetation quality ($r^2 = 0.3849$, $p = 0.0091$), remaining guilds did not maintain a significant p-value ($p<0.05$).

During fall, the relationship is somewhat stronger with all correlation coefficients significant at the ?=0.05 level. The strongest relationship occurs with grazing species (gadwall and American wigeon) with a correlation coefficient of 0.4994. Values drop from insectivores, granivores, to divers, with no explanation available for the poor correlation between diving ducks and submergent vegetation production. No correlation coefficients exceed 0.50, suggesting that interactions among a variety of factors, including other vegetative communities, may require evaluation to formulate hypotheses relative to waterfowl use of Stillwater NWR wetland units.

Discussion

Comparison of Separate Analyses

Through analysis of the separate results sections, it was necessary to use different subsets of the data to ensure that we were using all relevant and accurate data relative to the analysis focus. A close evaluation comparing results among these separate data sets will reveal some discrepancies in values offered. For example, the monthly wetland hydration schedules offered in figures 3 and 7 were prepared from an analysis of all observation periods where wetland acreage was recorded. These results include 0 values (where individual wetlands were dry) and considered two blocks (sanctuary and non-sanctuary areas) including Big Water and Battleground Point. While adding up the wetland unit calculations (Stillwater NWR Wetland Unit Evaluation section), only 14 units were used and average acreage was calculated for each individual wetland unit, only for years where the unit was hydrated. Therefore, 0 values were excluded in order to index wetland acreage relative to submergent vegetation production and duck density. This results in a schedule that displays a spring peak wetland acreage from the area analysis and a late winter peak in the wetland unit analysis. The former analysis is more indicative of total wetland acreage over time and should, therefore, be used to examine median and average wetland acreage values for the period evaluated. Each individual analysis in the results section should be referenced for the correct values for the parameters examined. With these thoughts in mind, the following discussion will examine the results of each independent analysis, and offer management suggestions to incorporate this information into Stillwater NWR management.

Waterfowl Population Chronology

Waterfowl use at Stillwater NWR becomes quite complicated when you consider that individual species vary in timing of use and preference for refuge habitats. For example, mallards and Canada geese can be observed on the refuge during any month of the year, only absent when the wetlands

completely freeze. Other species such as green-winged teal and American wigeon can be observed in the wetlands in all but summer months, while cinnamon teal, arrive in late spring, breed at the refuge, and then have migrated south by early October. Even with these species-specific chronological differences, the results of this analysis indicate that the largest waterfowl populations are present on Stillwater NWR between August and October.

Reasons for waterfowl population declines following October are unclear, but are likely related to a combination of natural migratory response, increasing public use pressure, depleted food reserves, and availability of other habitats in or adjacent to Stillwater NWR. With cinnamon teal, migration typically occurs before the onset of hunting season, thus increased public pressure beginning in early October and/or depleted food supplies would not appear to have much of an impact.

Species such as mallards are actively foraging on a combination of foods while redheads, American coots, American wigeon, gadwall, and other species are selectively foraging in submergent vegetation. It has been hypothesized that large numbers of birds foraging in submergent habitats during the August-October peak use period, lead to depleted seed reserves (Bill Henry, pers. comm.). This would provide one viable reason for decreasing waterfowl numbers following October.

Considering that many waterfowl species, particularly large-bodied species, tend to migrate only as far south as weather conditions dictate (Bellrose 1980:40, Simpson, 1988:537, Ringelman et al. 1989:325), population declines through October cannot easily be attributed to weather conditions. Bellrose (1980:41) offers that species specific migrations that occurs before weather and food become limiting "appear to be programmed in the endocrine system, probably going back eons in time when food shortages necessitated migration." This typically occurs with smaller bodied duck species (such as cinnamon teal), which are not equipped to tolerate extended cold periods.

Green-winged teal are an exception to this rule with the peak Stillwater NWR population occurring in November, and in most years, on into December and January. Considerable research has been conducted on this species and results suggest that they compensate for cold weather by foraging primarily at night, when energy produced through foraging helps maintain their high metabolism (Tamisier 1974). Based on analysis of time activity budgets, green-winged teal spent 90% of nocturnal hours foraging, while 60% of daylight hours were spent resting. Other nocturnal time activity budget studies reveal that mallards (Paulus 1984b, Magee unpublished doctoral dissertation), gadwall (Paulus 1984a), and northern pintail (Miller 1985), follow similar patterns as fall migration progresses. Possible reasons for this occurrence include increased metabolic efficiency for thermoregulation, decreased incidence of avian and mammalian predation, and avoidance of hunting related disturbance (Paulus 1987, Magee unpublished doctoral dissertation, Baldassarre and Bolen 1994, see Delong and Schmidt 1998).

Seasonal variation in diurnal activity patterns have also been documented which infer that other species (primarily dabbling ducks) spend considerable time foraging at night. For example, northern pintail spend 33%, 13%, and 7% of daylight hours feeding during August-September, October-November,

and December-January, respectively (Miller 1985). Progressively more daylight time is spent resting, or in courtship activities over these periods, typically in open bodies of water in large flocks. Energetic demands tend to increase across these periods, thus logically, one could assume that more foraging time is required to meet these demands. This is similar to what is observed on Stillwater NWR with larger pintail flocks generally censused on large open bodies of water with extensive submergent vegetation (e.g., Lower Foxtail Lake, Pintail Bay, and North Nutgrass). These data would suggest that pintail are not actively foraging in these large open water bodies, but are instead, using them as staging areas to nocturnally forage in nearby shallow wetlands. While diurnal activities such as pair bonding are extremely critical to eventual waterfowl production, waterfowl surveys conducted during late morning or midday periods, may erroneously consider that all needs of the species utilizing these wetlands are provided within the unit during that time period.

While it is possible that waterfowl are fulfilling all life history requirements within individual units, the occurrence of nocturnal foraging flights at Stillwater NWR would suggest otherwise. Any hunter who has spent time on the marsh shortly before sunrise or after sunset, has witnessed these flights with large groups of mallards, pintail and/or green-winged teal entering shallow wetlands, usually with rising water levels. All three of theses species prefer shallow water for foraging (<8 in; Fredrickson and Taylor 1982), which is typically available near shoreline or in smaller units where disturbance pressure is greater (avian, mammalian, and human). Therefore, it would appear with these granivorous species, that social interaction and rest occur on large wetland units during the day, while foraging occurs in shallower sites during night as cold weather and disturbance increase throughout fall and early winter months.

Seasonal Distribution of Duck Species

Based on the results of this analysis, there is very little question that hunting related disturbance changes distribution of waterfowl populations on the refuge (figure 5). From 42-69% of all waterfowl inhabit 25-30% of Stillwater NWR wetland area (the proportion found in the sanctuary) from October - January. Prior to hunting season, roughly equal proportions utilize hunted and sanctuary wetland units while following hunting season, more ducks utilize hunt area habitats. However, the question still remains whether waterfowl are fulfilling their life history requirements while at the refuge. In other words, are the needs of waterfowl being met during the waterfowl hunting season at Stillwater NWR?

Certain species such as canvasback, appear to select sanctuary habitats throughout the year, but significantly alter distribution to sanctuary wetland units after hunting season commences. All species displayed a distributional shift to sanctuary wetlands in October. While not observed at Stillwater, canvasback on the upper Mississippi River, feed nocturnally, as higher quality feeding areas are subject to higher levels of hunting disturbance (Thornburg 1973). Preferred diet at this location consisted of hardshelled invertebrates (fingernail clams (pelyepoda) and snails (Gastropoda)) with very little vegetative material found in esophageal analyses (Gale 1969, Thompson 1969, Thornburg 1973). Pelycepods and gastropods have been found at higher densities in sanctuary wetlands at Stillwater

NWR (Bundy 1997), providing for the possibility that this shift may be related more to habitat preference as opposed to disturbance tolerance.

Granivorous species (mallard, northern pintail, and green-winged teal) display the most profound distributional shift among foraging guilds examined in this analysis. Habitats preferred by these species are not more prominent on sanctuary wetlands and the observation of nocturnal foraging flights suggest that they are moving to other wetland areas to acquire bioenergetic reserves. As suggested in the previous discussion, sanctuary wetland units are more open and typically dominated by submergent vegetation, providing ideal conditions for diurnal activities including resting, courtship, and predator avoidance. But, activities such as flight are energetically costly (12.4 - 15.3 times basal metabolic rate; Prince 1979), thus, proximity to suitable foraging sites would appear important to providing for the fall requirements of dabbling duck species.

Sanctuary wetland habitats are relatively close to the nearby Canvasback Gun Club and agricultural lands located southwest of the refuge. Canvasback Gun Club only hunts on Wednesday, Saturday, and Sunday and focuses on fall waterfowl habitat provision so it is possible that granivorous species are acquiring forage resources on non-hunt days or at night at this location. This does not explain the distributional shift where granivorous ducks are observed at higher densities in hunt area units prior to and after hunting season (figure 11). This would suggest that for granivores, hunting related disturbance pushes birds into lower quality habitats whereby, adaptation is required to obtain necessary life history elements. The impacts of this adaptive shift cannot be quantified through analysis of these data.

Carson Lake and Stillwater Marsh Comparison

It has been hypothesized that fall waterfowl population decreases at Stillwater NWR, are compensated by increasing waterfowl densities at other locations within the Lahontan Valley landscape. It was believed that Carson Lake, which, similar to Canvasback Gun Club, focuses primarily on fall and later spring habitat management, would increase in waterfowl numbers as Stillwater declined. As figure 12 displays, this is not the case, and although Carson Lake tends to maintain, or slightly increase in their November waterfowl population, overall Lahontan Valley totals decline similar to Stillwater NWR.

This is primarily related to the overall waterfowl numbers which utilize the respective areas, with Stillwater NWR typically holding 75% of fall migratory duck species. This can partially be explained by geographic location with Stillwater NWR as the first location that northern or northeastern migrants would arrive. After arrival, it would seem likely that species would move throughout the respective wetland areas and the valley, seeking preferred habitats in which to acquire energetic reserves for further migration. To some extent, this would appear to be the case, with larger proportions of dabbling duck and diving duck species untilizing Carson Lake and Stillwater NWR, respectively. However, for all duck species and foraging guilds, larger numbers and densities are recorded for Stillwater through all periods except spring. This difference is much more prominent during waterfowl hunting season with 3 times as many ducks utilizing Stillwater NWR.

This would suggest that disturbance not only impacts Stillwater NWR waterfowl distribution, but also, Lahontan Valley distribution when you consider that until recently, Carson Lake did not provide any non-hunted area during the waterfowl hunting season. More recently, Carson Lake has provided a sanctuary area in the Sump unit and this past hunting season, imposed a boating restriction during four weekdays. Recent Carson Lake waterfowl use data following implementation of these restrictions were not available for analysis; however, this information may be the best available to quantify seasonal impacts relative to hunting disturbance among the Lahontan Valley wetland areas.

Habitats available at these two sites would appear to be the primary factor influencing seasonal waterfowl use. Stillwater has typically focused on maintenance of submergent vegetation throughout summer months to promote waterfowl breeding and to provide food for fall migratory waterfowl. Carson Lake has provided breeding habitat, but can also provide flooded pasture habitats which are heavily utilized by geese, dabbling ducks, and during spring, prebreeding waterfowl and shorebirds. It is interesting that Carson Lake duck populations surpass Stillwaters during March which leaves some question as to whether habitat provision, or geographic distribution is the more important element (with northward migrants arriving at Carson lake first). The answer likely resides somewhere between these two hypotheses.

Just as Stillwater NWR is the first arrival location for fall migratory waterfowl, Carson Lake would be the first during spring migration. This would appear to be more important during spring as habitat specialization is not as pronounced among waterfowl species. During prebreeding periods, nearly all duck species incorporate aquatic invertebrates as a large proportion of their diet, primarily to build up protein reserves for egg formation and prebasic molt (Krapu 1979, Baldassare and Bolen 1994). In the Lahontan Valley, invertebrate resources are best provided and most available in wet meadow and moist-soil habitats with densities of 1,285 total invertebrates/m^2 recorded in wet meadow habitats (Bundy 1997). A large percentage of Carson lake habitat is in shallowly flooded, grazed pasture status which provides ideal foraging conditions for birds (e.g., ducks and shorebirds) selectively foraging on invertebrates or grazing on spring germinating grasses (e.g., Canada geese).

This habitat type distribution also helps explain seasonal use by the four foraging guilds considered in this analysis. Carson Lake is strongly dominated by granivorous and insectivorous species (typically specializing in shallow habitats), while a more even mix among guilds is observed at Stillwater. The complexity of Stillwater marsh is one possible answer as a variety of different habitats, water depths, and related forage items are available on an annual basis. Although not considered in this analysis, piscivorous species (e.g., common merganser) are almost exclusively observed at Stillwater, which can be explained with fisheries resources maintained through breeding duck and summer submergent habitat maintenance. Therefore, a combination of habitat provision (and related preferences among waterfowl species), human disturbance, and geographic location, would appear to influence waterfowl seasonal use patterns within the Lahontan Valley.

Stillwater NWR Wetland Unit Analysis

Through this analysis (waterfowl and submergent vegetation data), there are several general paradigms which can be gleaned relative to Stillwater NWR wetland units including:

1. Southern units tend to remain more perennially hydrated than northern units
2. Submergent vegetation production is typically better in the southern units
3. Salinity gradients, from south to north, tend to dictate which submergent vegetative species will become established
4. Waterfowl densities are typically higher in larger, open units
5. Fall waterfowl densities are generally highest in sanctuary wetland units
6. Specific wetland units provide for the seasonal needs of specific species and guilds

At first glance, it would appear that the factors considered, wetland acreage, submergent vegetation production, and average waterfowl density, would be the best indicators of waterfowl use patterns at Stillwater NWR. However, the poor relationship between submergent vegetation indices and most foraging guild specific waterfowl use would suggest that these are important factors, but not the only factors related to seasonal distribution, and further, may not be the most important indicators relative to waterfowl use potential of the Stillwater Marsh.

September through December waterfowl use shifts would suggest that habitat type selection is not necessarily related to wetland unit selection and that disturbance likely has more influence on habitat utilization by most species. Waterfowl are one of the most adaptable wildlife groups (Bellrose 1980); therefore, these impacts may not be at a level which adversely effects this groups survival while at Stillwater or at other points during annual migration. It is likely, however, that habitat management strategies and philosophies primarily incorporated to benefit this group, misrepresent the seasonal importance of submergent vegetation, and greatly underestimate the importance of other habitat types common to the Stillwater Marsh.

For years, alkali bulrush (*Scirpus maritimus*) was considered one of the most important food plants produced for waterfowl in Great Basin marshes and managers produced vast acreage of this shallow emergent species (Kadlec and Smith 1989). More recent research indicates that while alkali bulrush contains a high energetic content, it is low in crude protein and difficult for most waterfowl species to digest (Pederson and Pederson 1983, Miller 1987), suggesting that promotion of this species may be adverse to the migrational needs of waterfowl. Alkali bulrush does provide suitable nesting sites for a variety of waterbirds including American coots, Redheads, and to a lesser extent, canvasback, so this vegetative species does help fulfill other waterbird life history requirements.

Submergent vegetation, primarily sago pondweed has also been considered one of the most important waterfowl food plant among Great Basin habitats (Kadlec and Smith 1989). All vegetative parts are consumed by a variety of waterfowl species and foraging guilds, energetic content is quite high

(Kantrud 1990), therefore, for the majority of waterfowl species utilizing Great Basin habitats, sago pondweed is likely the most important food item. However, sago is not the only plant utilized by waterfowl and, while it appears to provide for some elements of waterfowl life history strategies, a focus on one species or habitat type, over the complement of species available would be shortsighted.

All submergent vegetative species are important to various waterfowl species and guilds with wigeongrass heavily utilized by American wigeon, green-winged teal, and northern pintail (Gorden et al. 1987, Kantrud 1991), horned pondweed by lesser scaup and northern shoveler (Hurley 1990), and chara by American wigeon (Kadlec and Smith 1987). Submergent vegetation also provides valuable invertebrate substrate, although fairly simple invertebrate communities comprised of few species are often associated with their occurrence at Stillwater NWR (Bundy 1996). However, submergent vegetation is widely distributed throughout Stillwater NWR wetland habitats while other wetland plant communities, such as wet meadow, moist-soil, and emergent comprise a relatively small percentage of wetland units.

This analysis would suggest that most sanctuary wetland units and much of the hunted area are strongly dominated by submergent vegetation. These units can be characterized by high seasonal waterfowl use (primarily during hunting season months), but as indicated earlier, these habitats are not necessarily providing forage for granivorous species, and are certainly providing little cover for thermoregulation for the majority of late fall and winter duck populations. Similarly, non-sanctuary units such as Tule Lake, Pintail Bay, North Nutgrass, and Goose Lake are providing excellent stands of submergent vegetation, but with the exception of North Nutgrass, provide little in the way of other vegetation in most years. A small percentage of Pintail Bay, primarily at the southern end, contains other vegetation types; however, in most years, submergent vegetation is strongly dominant in this unit. Shoreline complexity in Tule Lake would aid in providing thermoregulatory and disturbance related benefits, however, most of this unit, like the others considered, are dominated by submergent vegetation communities.

Altering water management in these units to produce wet meadow, moist-soil, and emergent vegetation could meet with limited success, considering that continued perennial water, and resulting submergent vegetation establishment, have likely shifted seed bank composition to submergent vegetation seeds, tubers, and rhizomes (van der Valk 1981, Kadlec and Smith 1989). Submergent communities are very important to waterfowl, and it may not be productive to attempt to shift units where years of management have produced productive submergent vegetation stands, to communities that may not be available in the seed bank. However, other units have experienced more ephemeral water conditions over the years and annual plants and grasses germinating during drawdown, are likely plentiful in the seed bank . Units such as Swan Lake and Willow Lake appear to contain these elements, and if salinity can be reduced to a level that supports germination (Kadlec and Smith 1989), these units would appear to be the most conducive to promoting establishment of other habitat types contributing to waterfowl use at Stillwater NWR.

Wetland Unit Rankings

Factors used for ranking wetland units may not incorporate all elements necessary for an accurate assessment of unit importance to waterfowl. Waterfowl tend to move into sanctuary wetlands during hunting season months, therefore, the importance of the submergent habitat type may be overestimated in unit rankings. Additionally, how waterfowl species and guilds are utilizing submergent vegetation should be considered (i.e., resting, courtship, and/or foraging), and where species are going during nocturnal foraging flights needs to be determined. With this information, it would then be possible to accurately assess the importance of individual units for waterfowl species.

Five of the top seven units in this ranking are sanctuary units which exemplifies this finding with the top two non-sanctuary units, Pintail Bay and Tule Lake, characterized by large open areas dominated by submergent vegetation, and road closures which restrict vehicular access to portions of the unit. This combination of openness and restricted access would suggest that species may be utilizing these units as a means to minimize disturbance impacts. Additionally, if granivorous species are utilizing these open units more for resting and courtship areas (as offered earlier in this discussion based on nocturnal foraging), then foraging unit importance is underestimated for this guild.

Among foraging guilds, correlation coefficients for waterfowl density and submergent vegetation index values are poor when all months are considered. This result is particularly interesting when you consider that grazing species (gadwall and American wigeon), which are believed to specialize in submergent vegetation (Bellrose 1980), have the poorest correlation at Stillwater NWR (table 19). This pattern is completely opposite during fall, with the highest correlation coefficient calculated from August - December for grazing species (0.4994, $p < 0.05$), as it is for all foraging guilds except diving ducks, which have a stronger relationship with submergent vegetation when all months are considered. To understand this relationship, it is again important to understand the life history requirements among species within particular guilds and the diurnal use patterns within different time periods.

For grazers, there is a spring shift towards a more invertebrate dominated diet prior to breeding and molting (consistent among most species and guilds). Prior to and during breeding, gadwall shift to a diet containing 72% animal matter, comprised of insects and crustaceans (Swanson et al. 1979), which have been shown to be less abundant in Stillwater NWR submergent habitats (Bundy 1996). The poor correlation between diving ducks during fall and submergent vegetation indices cannot be easily explained based on life history requirements as the literature indicates that the two dominant fall species (redhead and canvasback) tend to focus on sago pondweed and other forms of submergent vegetation (Bellrose 1980). If consistent with the Mississippi River data (Thornburg 1973), and Stillwater canvasback are selecting for hard shelled invertebrates (e.g, gastropods), it is possible that submergent vegetation fringed by emergent vegetation (hemi-marsh; Weller and Spatcher 1965) would be the more appropriate indicator as gastropod density is typically highest in emergent habitats at Stillwater NWR (Bundy 1997).

Sanctuary wetland habitats, regardless of reasoning, provide the most heavily used areas during hunting season months, which is when the largest waterfowl concentrations are found at Stillwater NWR. Among all foraging guilds, at least six of the top seven units (measured in duck density) occur in the sanctuary (all seven for granivores). While it is uncertain if this distributional shift is impacting condition of duck species utilizing Stillwater NWR during fall migration, it is likely that hunting impacts initiate this distributional shift.

Management Implications

It appears from this analysis that some modification to habitat management and/or public use strategies would seem prudent to adequately provide for waterfowl using Stillwater NWR. As initially suggested and considered in the Stillwater NWR Environmental Impact Statement for the Comprehensive Conservation Plan (CCP/EIS), additional sanctuary in more diverse habitat could be provided in the existing public use area. Additional data are needed to support such a change at this time; however, means to assess waterfowl condition should be developed and monitored in successive years to elucidate whether such a change would be necessary.

Habitat management strategies focusing on habitat types with limited distribution would be another method to improve waterfowl condition. Considering the data, undisturbed foraging habitat for granivorous species would appear to be an identified need for Stillwater NWR fall water management. Habitat types of importance to this foraging guild include shallowly flooded areas with a high density of small seeds for foraging, submergent habitats for diurnal use, and emergent habitats and/or units with high shoreline complexity (i.e., many coves with wind protection from a variety of directions) for thermoregulation. Ideally, these habitats would be located within close proximity to each other to minimize metabolically expensive behaviors such as flight. Areas where foraging habitat can be provided include pasture areas in the existing Stillwater NWR, and units towards the north end of the hunt area where ephemeral water supplies have provided an extensive annual plant component within the soil seed bank.

Additionally, it is possible to provide increased undisturbed foraging and thermoregulation habitat in the existing hunt area, without significantly changing the design of the existing public use program. While the C1 Alternative (Stillwater NWR CCP/EIS) would have closed down two Stillwater NWR wetland units to waterfowl hunting, a second C Alternative would retain all of the historic hunt area, provide a quality hunting experience for the majority of Stillwater NWR waterfowl hunters, while providing considerable undisturbed habitat during most days for migratory waterfowl. The C2 Alternative designates two Stillwater NWR units as walk-in only hunting areas, which will decrease disturbance relative to boat travel, presumably decrease hunter density in designated units, while providing a quality hunting experience for those individuals willing to walk to their hunting spots. During the 1998 and 1999 hunting seasons, 24.5% and 21.6% of Stillwater NWR waterfowl hunters used boats to access their hunting areas (unpublished data on file at Stillwater NWR) making walking the most common method to access hunting sites.

In theory, a walk-in only hunting zone would provide relatively undisturbed, daytime foraging habitat for a variety of waterbirds, while providing an additional opportunity for hunters seeking a low density hunt at Stillwater NWR. If access is restricted to designated points, accompanied by road closures and elimination of boats, waterfowl would be allowed access to the majority of selected units on most days, because it is anticipated that fewer hunters would be willing to walk great distances to hunt. Units where this strategy could be implemented must be large, and somewhat isolated, to create at least, a minimal barrier to the majority of hunters. While it is possible that hunter density may increase near access points, it is believed that hunter density will be greatly reduced further away from access points based on the effort required for hunters to reach these sites. Additionally, it is believed that more walk-in hunters would result in less disturbance than a few boats. At present, four units are being considered for this designation at Stillwater NWR: North Nutgrass, Pintail Bay, Swan Lake, and Willow Lake.

When waterfowl densities only are examined, Pintail Bay and North Nutgrass would be the logical selection as walk-in only hunt units. However, as previously discussed, how and for what reason waterfowl are using these sites is uncertain. These two units are both typically comprised of submergent vegetation communities, are large open units which provide diurnal staging areas for most species, and among other hunt area units, maintain the largest populations of waterfowl through fall months. Conversely, The other two units being considered, Willow Lake and Swan Lake, have maintained much lower waterfowl densities over the years, typically retain low submergent vegetation index values, and retain the lowest waterfowl populations during fall months. Initially, it appears that Willow and Swan Lake would not be good choices for this designation; however, a variety of factors must be considered in this analysis including:

1. What habitats are limited for species and guilds of migratory waterfowl?
2. What reasons and at what time are these units being visited by waterfowl?
3. What values can each unit provide for migratory waterfowl?
4. Which areas are most disturbance prone at present?
5. Which areas would provide the better opportunity for hunters to have a good chance to harvest birds in a low hunter density environment?

Open submergent habitats are relatively common at Stillwater NWR as nearly all sanctuary wetland units are primarily comprised of this habitat type. The unit rankings suggest that these are the most valuable for waterfowl use, but timing of use and location of units used during other time periods needs to be considered. Altering management to produce proportionally limited habitat components such as emergent, wet meadow, and moist-soil vegetation in these open submergent areas could be futile considering that continued submergent vegetation management has reduced the amount of other plant seeds available in the seed bank. However, Swan Lake and Willow Lake contain the appropriate seed bank constituents to promote growth of moist-soil and wet meadow habitat types.

The reasons Pintail Bay and North Nutgrass have the reported duck densities would seem clear from the previous discussions. These units provide large open areas where waterfowl can forage, rest, or communicate (courtship displays), depending on the foraging guilds utilizing them. As shown for granivorous species (mallards, northern pintail, and green-winged teal), these are important resting and communication areas; however, observation of nocturnal foraging flights, and the rates of nocturnal foraging activity reported in the scientific literature suggest that these units are not used primarily for foraging purposes among granivorous species. Past years observations (1995-99) suggest that increasing foraging activity occurs in units such as Swan Lake and Willow Lake with the onset of foraging flights occurring just following sunset and just after sunrise; therefore, the importance of these units to granivorous species has likely been underestimated based on the time when surveys were conducted.

Values provided by each unit appear equally clear. Large open units such as North Nutgrass and Pintail Bay provide protection from land based predators, and opportunities for various species and guilds to fulfill diurnal life history requirements; however, little thermoregulatory cover is provided for later season months. Swan Lake and Willow Lake are highly complex units with myriad coves, penninsulas, open pools, and an emergent vegetation shoreline (in the case of Willow Lake). While these units provide less protection from predators (as compared to North Nutgrass and Pintail Bay), they do provide foraging habitat and thermoregulatory cover for a variety of species. Habitat complexity is also more diverse in these units providing habitat for a variety of other fall waterbirds, while the relative submergent vegetation monoculture at Pintail Bay and North Nutgrass provide for few other than waterfowl and migratory shorebirds (during September and October).

While disturbance cannot be quantified from this analysis, it can be inferred through results of this analysis combined with related scientific information. The most important factor relative to disturbance would appear to be species and/or guild response to increased hunting pressure. As shown in the results, granivorous species display the most obvious distributional shift during hunting season with an apparent preference for hunt area units prior to hunting season and a strong presence in sanctuary units during hunting season. The top seven units granivores use during hunting season are the seven sanctuary units evaluated with Pintail Bay and North Nutgrass coming in 8 and 9 respectively (table 18). The lower ratings for Swan Lake and Willow Lake (11 and 12) may not account for increased utilization during different periods of the daily cycle.

Among hunted units, Pintail Bay is the only unit which has a density increase at the beginning of hunting season while North Nutgrass has similar densities in September and October. All other hunt area units see declines from September through October. This suggests two possibilities: open areas provide more security from disturbance and are, thus, more heavily used by waterfowl as hunting season progresses and/or the existing hunt program on Pintail Bay and North Nutgrass does not impact waterfowl distribution to the same extent as other hunted units, thus additional restrictions (such as a walk-in only hunt zone) may not be necessary on these units. The reasoning behind this is that birds can see forms of disturbance (whether mammalian (including humans) or avian) coming from great distances and can then respond accordingly. Whether in a boat or on foot in an open unit, ducks are going to

observe the distraction as it begins and can either choose to remain or fly away as the disturbance vector approaches. In units such as Swan or Willow Lake, shoreline complexity and related high numbers of isolated coves and islands allows disturbance in one cove not to impact waterfowl activities in other coves. Boats in these units can easily access many coves during a single trip; however, a hunter on foot would not necessarily travel as far, access as many coves, or cause an easily observable approach such as a boat over water, thus minimizing disturbance in the majority of coves, throughout most days.

This same consideration also provides for a better hunting opportunity in Swan and Willow Lake. While birds may leave a particular cove or point an individual chooses to hunt, many other coves within the unit are likely not being hunted and are, thus, available for waterfowl use. The number of coves provides many opportunities for hunters to find an isolated location with few other hunters, where a good probability of being able to decoy birds exists. Implementing a walk-in only hunt at Pintail Bay or North Nutgrass would not necessarily provide the same opportunities as little cover is available within these units for hunters to walk in and hide. Most available hunting area is shoreline (excluding the southern portion of Pintail Bay) and is easily accessible by vehicle (except northern Pintail Bay) providing little opportunity other than already exists for hunting in these units. As stated, walking in is the most common method used to access hunting locations for most (>75%) of Stillwater NWR waterfowl hunters, and would provide an area where walk-in hunters would not need to be concerned about boating disturbance, or boat hunters who easily pass locations that walk-in hunters spent considerable effort accessing.

During waterfowl hunting season, Pintail Bay and North Nutgrass contain the highest average duck density among hunted units; however, the previous discussion has shown that Swan and Willow Lake would make the better walk-in only designation units at Stillwater NWR. Willow and Swan Lake appear to provide more benefits for fulfilling waterfowl life history requirements (including foraging habitat provision for granivorous species, open pools for resting and communication, and thermoregulation protection), likely have been used at higher rates outside of survey periods, and have seen waterfowl population decreases as hunting season progresses. Therefore, the opportunity exists to do more to provide a diversity of habitat types, fulfilling a wider variety of waterfowl life history strategies, while providing a better opportunity for the majority of Stillwater NWR hunters by designating Willow and Swan Lake as walk-in only access under the Stillwater NWR Comprehensive Management Plan.

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Appendix 1. Median densities (number/ha) for species of aquatic migratory birds in sanctuary and hunted wetlands at Stillwater National Wildlife Refuge, northwestern, Nevada, August - March, 1977-98.

Species	Sanctuary[a]	August	September	October	November	December	January	February	March	All months[b]
American wigeon	N	0.143(1)[c]	0.333(3)	0.745(1)	0.253(2)	0.029(4)	0(6)	0.064(1)	0.053(1)	0.104A[d]
	Y	0.218(0)	0.645(0)	1.892(0)	0.626(0)	0.080(2)	0.028(4)	0.050(1)	0.019(2)	0.149B
Cinnamon teal	N	0.886(0)	0.282(0)	0.028(2)	(8)[e]	(8)	(8)	0.017(2)	0.159(1)	0.022A
	Y	0.369(0)	0.271(0)	0.155(3)	(8)	(7)	(10)	0.007(2)	0.113(0)	0.060A
Green-winged teal	N	0.416(0)A	2.291(0)A	1.211(0)A	0.678(1)A	0.524(1)A	0.049(2)A	1.429(0)A	2.417(0)A	
	Y	0.209(1)A	0.666(0)A	6.489(0)B	7.437(0)B	1.710(1)A	0.140(3)A	0.775(1)A	0.719(0)A	
Gadwall	N	0.499(1)	0.990(2)	0.786(0)	0.137(2)	0.060(2)	(6)	0.058(1)	0.086(0)	0.112A
	Y	0.693(0)	0.810(0)	2.639(0)	0.763(0)	0.159(1)	(7)	0.093(1)	0.066(1)	0.426B
Mallard	N	0.116(1)A	0.111(0)A	0.150(0)A	0.063(1)A	0.154(0)A	0.034(0)A	0.214(0)A	0.066(0)A	
	Y	0.357(0)A	0.549(1)A	1.931(0)B	1.678(0)B	1.414(0)B	0.349(0)B	0.449(0)A	0.097(0)A	
Northern pintail	N	0.767(0)	0.931(1)	1.409(0)	0.675(1)	0.563(0)	0.081(1)	0.493(0)	1.357(0)	0.721A
	Y	0.487(0)	0.728(0)	3.519(0)	1.958(0)	1.567(1)	0.213(2)	1.334(0)	0.755(0)	1.045B
Northern shoveler	N	1.402(0)	1.876(0)	3.830(0)	1.216(2)	0.382(1)	0.007(4)	0.303(1)	3.035(0)	1.309A
	Y	1.011(0)	1.877(0)	6.632(0)	2.753(0)	0.457(0)	0.119(2)	0.037(1)	0.259(0)	0.734A
Canvasback	N	(7)a[f]	(8)a	0.042(3)A	0.079(3)A	0.019(3)A	(6)a	0.266(1)A	0.053(0)A	
	Y	0.006(5)a	0.072(3)a	3.345(0)B	4.068(0)B	1.630(0)B	0.037(2)a	0.386(1)A	0.486(0)B	

Redhead	N	0.247(0)A	0.188(3)A	0.103(3)A	0.009(4)A	0.009(4)A	(6)a	0.072(1)A	0.115(1)A	
	Y	0.494(0)B	0.783(0)B	0.827(0)B	0.117(1)A	0.031(2)A	(7)a	0.031(1)A	0.032(1)A	
American coot	N	5.227(1)	3.281(1)	2.954(0)	0.853(2)	0.268(1)	0.045(3)	0.460(1)	0.260(1)	0.657A
	Y	8.223(0)	11.548(0)	8.093(0)	1.103(0)	0.536(1)	0.070(2)	0.276(2)	0.226(1)	0.820B
Ruddy duck	N	0.032(1)	0.063(2)	0.061(0)	0.079(1)	0.110(2)	0.025(4)	0.393(1)	1.144(0)	0.071A
	Y	0.039(1)	0.096(0)	0.529(0)	0.249(1)	0.387(0)	0.043(2)	0.485(0)	0.437(0)	0.318B
Canada goose	N	0.041(2)A	0.017(4)A	(6)a	(8)a	0.019(2)A	(6)a	0.012(1)A	0.003(0)A	
	Y	0.292(0)B	0.302(2)B	0.277(0)b	1.057(0)b	0.815(0)B	1.059(0)b	0.043(1)A	0.002(2)A	
Tundra swan	N	(11)a	(13)a	(9)a	0.010(4)A	0.295(1)A	0.016(3)A	0.170(1)A	0.004(2)A	
	Y	(11)a	(13)a	(9)a	0.602(0)B	0.905(0)B	0.439(0)B	0.167(1)A	0.020(1)A	

[a]Wetlands that were hunted and not hunted (sanctuary) were classified as N and Y, respectively.

[b]Because no month-by-sanctuary interaction (P ? 0.0783) was found for a species, months were combined to compare densities between sanctuary and non-sanctuary wetlands. Values were calculated as the median of cell (month) medians.

[c]Number of surveys with zero recorded for a species is in parentheses.

[d]Medians with the same upper-case letter did not differ (P ? 0.05) between sanctuary and non-sanctuary wetlands for a species.

[e]No median was calculated if >50% of surveys had zero recorded for a species.

[f]The frequency of surveys with birds recorded for a species with the same lower-case letters did not differ (P ? 0.05) between sanctuary and non-sanctuary wetlands.

Table 1. Median densities (number/ha) for species of aquatic migratory birds in sanctuary and hunted wetlands at Stillwater National Wildlife Refuge, northwestern, Nevada, August - March, 1977-98.

Species	Sanctuary[a]	August	September	October	November	December	January	February	March	All months[b]
American wigeon	N	0.143(1)[c]	0.333(3)	0.745(1)	0.253(2)	0.029(4)	0(6)	0.064(1)	0.053(1)	0.104A[d]
	Y	0.218(0)	0.645(0)	1.892(0)	0.626(0)	0.080(2)	0.028(4)	0.050(1)	0.019(2)	0.149B
	N and Y[e]	0.181abc[f]	0.489bd	1.319d	0.440ad	0.055cd	0.014d	0.057cd	0.036cd	
Cinnamon teal	N	0.886(0)	0.282(0)	0.028(2)	(8)[g]	(8)	(8)	0.017(2)	0.159(1)	0.022A
	Y	0.369(0)	0.271(0)	0.155(3)	(8)	(7)	(10)	0.007(2)	0.113(0)	0.060A
	N and Y	0.628a	0.277ab	0.092cd	e	ef	e	0.012dfg	0.136bcg	
Green-winged teal	N	0.416(0)Aab	2.291(0)Aa	1.211(0)Aa	0.678(1)Aab	0.524(1)Aab	0.049(2)Ab	1.429(0)Aab	2.417(0)Aab	
	Y	0.209(1)Aab	0.666(0)Abc	6.489(0)Bd	7.437(0)Bd	1.710(1)Aabd	0.140(3)Aac	0.775(1)Aabd	0.719(0)Aabd	
Gadwall	N	0.499(1)	0.990(2)	0.786(0)	0.137(2)	0.060(2)	(6)	0.058(1)	0.086(0)	0.112A
	Y	0.693(0)	0.810(0)	2.639(0)	0.763(0)	0.159(1)	(7)	0.093(1)	0.066(1)	0.426B
	N and Y	0.596ab	0.900a	1.713a	0.450bc	0.110c	def	0.076ce	0.076cf	
Mallard	N	0.116(1)Aa	0.111(0)Aa	0.150(0)Aa	0.063(1)Aa	0.154(0)Aa	0.034(0)Aa	0.214(0)Aa	0.066(0)Aa	
	Y	0.357(0)Aab	0.549(1)Aab	1.931(0)Bc	1.678(0)Bac	1.414(0)Bac	0.349(0)Bbd	0.449(0)Aabc	0.097(0)Ab	
Northern pintail	N	0.767(0)	0.931(1)	1.409(0)	0.675(1)	0.563(0)	0.081(1)	0.493(0)	1.357(0)	0.721A
	Y	0.487(0)	0.728(0)	3.519(0)	1.958(0)	1.567(1)	0.213(2)	1.334(0)	0.755(0)	1.045B
	N and Y	0.627ab	0.830bc	2.464bc	1.317bc	1.065ab	0.147a	0.914bc	1.056bc	
Northern shoveler	N	1.402(0)	1.876(0)	3.830(0)	1.216(2)	0.382(1)	0.007(4)	0.303(1)	3.035(0)	1.309A
	Y	1.011(0)	1.877(0)	6.632(0)	2.753(0)	0.457(0)	0.119(2)	0.037(1)	0.259(0)	0.734A
	N and Y	1.207abc	1.877ad	5.231d	1.985ad	0.420be	0.063fg	0.170egh	1.647abch	
Canvasback	N	(7)*a[h]	(8)*a	0.042(3)Aab	0.079(3)Aab	0.019(3)Aab	(6)*ab	0.266(1)Ab	0.053(0)Aab	
	Y	0.006(5)*a	0.072(3)*ac	3.345(0)Bbd	4.068(0)Bb	1.630(0)Bb	0.037(2)*ac	0.386(1)Aab	0.486(0)Bbce	

Species	Sanctuary[a]	August	September	October	November	December	January	February	March	All months[b]
Redhead	N	0.247(0)Aab	0.188(3)Aabc	0.103(3)Abcde	0.009(4)Abcd	0.009(4)Acf	(6)*df	0.072(1)Abcd	0.115(1)Abcd	
	Y	0.494(0)Bab	0.783(0)Ba	0.827(0)Ba	0.117(1)Abc	0.031(2)Acd	(7)*d	0.031(1)Acd	0.032(1)Acd	
American coot	N	5.227(1)	3.281(1)	2.954(0)	0.853(2)	0.268(1)	0.045(3)	0.460(1)	0.260(1)	0.657A
	Y	8.223(0)	11.548(0)	8.093(0)	1.103(0)	0.536(1)	0.070(2)	0.276(2)	0.226(1)	0.820B
	N and Y	6.725a	7.415a	5.524a	0.978bc	0.402b	0.058d	0.368bcd	0.243bcd	
Ruddy duck	N	0.032(1)	0.063(2)	0.061(0)	0.079(1)	0.110(2)	0.025(4)	0.393(1)	1.144(0)	0.071A
	Y	0.039(1)	0.096(0)	0.529(0)	0.249(1)	0.387(0)	0.043(2)	0.485(0)	0.437(0)	0.318B
	N and Y	0.035abc	0.080acdef	0.295dg	0.164abdg	0.249cg	0.034be	0.439fg	0.791g	
Canada goose	N	0.041(2)Aa	0.017(4)Aab	(6)*bc	(8)*b	0.019(2)Aac	(6)*bc	0.012(1)Aab	0.003(0)Aab	
	Y	0.292(0)Babcd	0.302(2)Bbc	0.277(0)**bcf	1.057(0)**c	0.815(0)Bc	1.059(0)**bc	0.043(1)Adefg	0.002(2)Ag	
Tundra swan	N	(11)*a	(13)*a	(9)*ab	0.010(4)Abc	0.295(1)Ade	0.016(3)Abcd	0.170(1)Ace	0.004(2)Aace	
	Y	(11)*a	(13)*a	(9)*ab	0.602(0)Bc	0.905(0)Bc	0.439(0)Bcd	0.167(1)Acd	0.020(1)Ad	

[a]Wetlands that were hunted and not hunted (sanctuary) were classified as N and Y, respectively.

[b]Because no month-by-sanctuary interaction (P ? 0.0783) was found for a species, months were combined to compare densities between sanctuary and non-sanctuary wetlands. Values were calculated as the median of cell (months) medians.

[c]Number of surveys with zero recorded for a species is in parentheses.

[d]Medians with the same upper-case letter did not differ (P ? 0.05) between sanctuary and non-sanctuary wetlands for a species.

[e]Because no month-by-sanctuary interaction (P ? 0.0783) was found for a species, sanctuary and non-sanctuary wetlands were combined to compare densities among months. Values were calculated as the median of cell (sanctuary and non-sanctuary) medians.

[f]Medians with the same lower-case letter did not differ (P ? 0.05) among months for a species.

[g]No median was calculated if >50% of surveys had zero recorded for a species.

[h]The frequency of surveys with birds recorded for a species with the same number of asterisks did not differ (P ? 0.05) between sanctuary and non-sanctuary wetlands.