Los Banos Wildlife Area Complex Waterfowl Pair and Brood Counts, 2001-2008

Cinnamon teal. Photo by Tommy J. Grove.

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Abstract

The California Department of Fish and Game traditionally focused on managing wildlife areas in the Central Valley for wintering waterfowl habitat. However, there have been efforts in the last 20 years to enhance nesting and brooding habitat as well. From 2001-2008 we monitored waterfowl responses to these practices by conducting pair and brood surveys at the Los Banos Wildlife Area and Volta Wildlife Area. We observed three common species of breeding waterfowl on these properties, including mallard, gadwall, and cinnamon teal, and we found they utilized these sites for breeding and nesting throughout the duration of the study. Wetland acreage was documented for pair and brood density calculations, which allowed us to analyze the potential effect of wetland availability on breeding waterfowl. Although we observed annual fluctuations in the number of pairs observed and in breeding success, these species consistently utilized and bred on both the Los Banos Wildlife Area and Volta Wildlife Area. After analyzing data from all of our surveys, we found that only mallard pairs decreased significantly over time. Although all species show a reduction in pairs during our study, this may simply be due to changes in the size of California's waterfowl population or other unknown factors. Management techniques used by the California Department of Fish and Game at these properties has been successful in providing suitable breeding sites for waterfowl, and we recommend the continued enhancement of nesting and brooding sites within the Central Valley.

Keywords: waterfowl monitoring, pair survey, brood survey, breeding success, Central Valley

Introduction

The state of California is known as an important wintering location for waterfowl but is not considered a primary breeding area (Chouinard and Arnold 2007). Twice a year waterfowl travel through California along the Pacific Flyway while migrating to and from wintering areas. During their migration, they historically utilized naturally occurring wetlands for loafing, foraging, wintering, and breeding; these sites were once sustained by rivers, which seasonally overflowed into wetland areas (Anderson 1956). However, due to the conversion of wetlands into agriculture, and the large water demands of both urban populations and agriculture, only 5% of California's historic wetlands still exist (Gilmer et al. 1982). The largest remaining contiguous freshwater wetlands in California are located within the Merced County Grasslands Ecological Area (GEA). The GEA (180,000 ac/72,843 ha) is composed of state, federal, and privately owned land and is made up of 33% freshwater wetlands (Isola et al. 2000). Due to the large numbers of wintering waterfowl and shorebirds utilizing this area, the American Bird Conservancy and the National Audubon Society have designated the GEA as a Globally Important Bird Area (Cooper 2004), and the Ramsar Convention on Wetlands (2011) designated the GEA as a Wetland of International Importance in 2005. In addition to accommodating wintering waterfowl populations, the GEA also supports a breeding population. In the late 1980's it was reported that Central Valley mallards (*Anas platyrhynchos*) were breeding in densities similar to those in the Prairie Pothole region of the upper midwest (McLandress et al. 1996). Although California has significantly less wetland habitat compared to the upper midwest, properties within the GEA may be significantly contributing to the local waterfowl breeding population.

The California Department of Fish and Game (DFG) manages approximately 3% of the land within the GEA, which is made up of several properties including the Los Banos Wildlife Area (LBWA) and the Volta Wildlife Area (VOWA). These properties are primarily managed to provide habitat for wintering waterfowl. During fall, and before migrating waterfowl begin arriving, DFG floods wetland fields to provide foraging habitat and offer refuge for these birds. In the spring, after migrating birds have left the Central Valley, they release water from the wetlands and the fields are dried. The timing of the water draw-down and summer irrigations are used to promote the growth of moist soil plants such as swamp timothy (*Crypsis schoenoides*), watergrass (*Echinochloa crus-galli*), and smartweed (*Polygonum amphibium*), which will later provide forage for the wintering waterfowl.

In the past, DFG provided very little summer habitat for breeding waterfowl but within the last 20 years they began implementing management practices with the goal of providing 10-15% of a property's acreage for spring nesting and summer brooding habitat. While most wetland fields are drained in the spring, DFG receives a limited amount of summer water which is used to flood reverse cycle wetland fields. As described by Chouinard and Arnold (2007), these wetlands are shallowly flooded from March through August and dominated by upland vegetation (e.g., *Hordeum* spp., *Rumex* spp., *Distichlis* spp.). Reverse cycle wetlands also produce high concentrations of aquatic invertebrates, which are an essential food source for broods (Chura 1961, Sedinger 1992, Sugden 1973) and hens (Swanson et al. 1985). McKnight and Low (1969) found that newly flooded uplands were heavily used by broods of several dabbling duck species and speculated that their preference was due to the high number of aquatic invertebrates. Similarly, Chouinard and Arnold (2007) found that on LBWA, brooding mallards preferred reverse cycle wetlands over permanent and seasonal wetlands, which may be due to the abundant food resources and decreased predation. Another study conducted by the Canada Wildlife Service found that as a wetland becomes more permanently flooded, aquatic invertebrate populations decrease (Whitman 1976). Thus, in order to maintain optimal conditions for waterfowl broods, hens, and other wildlife, DFG annually rotates groups of reverse cycle wetlands, which follow a three year cycle. In the first year, select fields are flooded during the summer months and then drained the following spring. In the second and third year, these fields are not flooded and are kept dry in order to promote nutrient recycling, which leads to increased aquatic invertebrate populations. During these two years, DFG disks these fields to promote annual plants or other desirable emergent flora and to control the growth of cattail (*Typha* sp.), tule (*Scirpus* sp.), or invasive plants. Because reverse cycle wetlands are managed in groups, when one group goes into the drying phase, another enters the flooding phase. This provides waterfowl access to optimal brooding habitat every year. In addition to reverse cycle wetlands, DFG manages upland habitat in an effort to support nesting waterfowl. Hens will typically nest in a site with vegetation that is thick enough to conceal them, preferably near a water source to minimize the travel distance to the brooding site. The combination of optimal brooding habitat and adjacent, suitable nesting uplands provide resident waterfowl with desirable breeding habitat on these properties.

LBWA and VOWA are most commonly utilized by three species of waterfowl in the spring and summer, including gadwall (*Anas strepera*), cinnamon teal (*Anas cyanoptera*), and mallard. Each species is unique and has different nesting and brooding preferences within the wetland and upland habitats. For instance, gadwall have been documented nesting in greater densities on islands (Duncan 1986, Sousa 1985), while cinnamon teal generally nest below dead vegetation that is densely matted (Gammonley 1996, Miller and Collins 1954, Wheeler and Harris 1970). Mallards also prefer to breed in dense upland vegetation but are very adaptable to most environments (Drilling et al. 2002, Miller and Collins 1954, Wheeler and Harris 1970). Since few studies have documented the productivity of areas within the Central Valley, DFG wished to learn how prolific these birds are and how they respond to habitat management practices at LBWA and VOWA. Thus, to better determine the reproductive success of the locally breeding waterfowl and their possible contribution to the California population, we started conducting pair and brood surveys at LBWA and VOWA. Our efforts began in 1994 on LBWA by conducting brood surveys, which were expanded the following year to include pair surveys. In 1996, we incorporated VOWA into our study area because we saw it as a potentially productive area. Initially, pair and brood numbers were recorded per mile, however we felt this was not the best method for calculating true densities so in 2001, we standardized the survey protocol and recorded birds per wetland acre. After collecting consistent data for several years, we concluded the waterfowl pair and brood surveys in 2008 and began analysis.

Study Area

LBWA and VOWA are part of the Los Banos Wildlife Area Complex located within the San Joaquin Valley, Merced County (Figure 1). The climate of this area is characterized by hot, dry summers and cool, wet winters, and the terrain at both properties is relatively flat (ranging in elevation from 29-33 m). The annual precipitation averages 27 cm per year and primarily occurs between November and March (California Department of Fish and Game 2008).

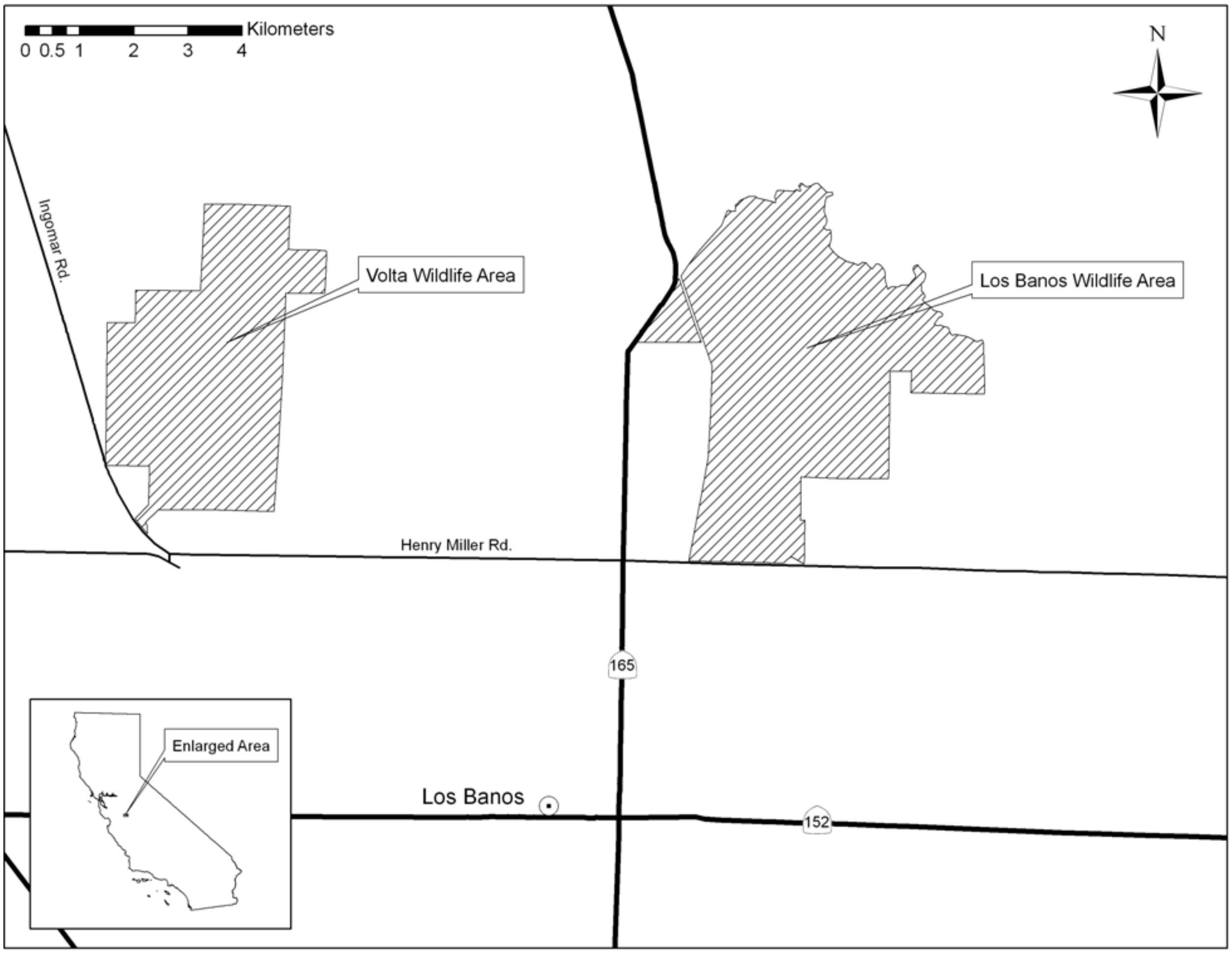

Figure 1. Properties surveyed for waterfowl pair and brood densities within the Los Banos Wildlife Area Complex, Merced County, California.

The LBWA (5,600 ac/2,266 ha) is owned and managed by DFG and is located approximately 6 km north of the city of Los Banos. This property is a combination of semi-permanent, permanent, reverse cycle, and seasonal wetlands, as well as annual grasslands, shrublands, and riparian habitat of mixed willow (*Salix* sp.) and cottonwood (*Populus* sp.). The LBWA also has permanent water located in Mud Slough, Salt Slough, ponds, lakes, and other waterways throughout the property.

The VOWA (3,899 ac/1,531 ha) is located approximately 10 km northwest of the city of Los Banos. Prior to 2004, the entire property at that time (2,884 ac/1,167 ha) was owned by the Bureau of Reclamation and managed by DFG. In 2004 and 2005, DFG purchased land adjacent to VOWA, known as the Volta Expansion, and acquired an additional 900 ac (364 ha). VOWA is mostly comprised of seasonal wetlands, with permanent water located in the Tri-Valley Drain and the Volta Wasteway, but also contains upland, and a small amount of willow and cottonwood riparian habitat. Compared with LBWA, the upland habitat at VOWA is limited and contains more open areas with sparse shrubs and alkaline soil.

Methods

Data Collection

We began waterfowl pair counts during the first full week of April and continued for a total of four weeks, alternating wildlife areas every week. Waterfowl are considered most active from 4:00-8:00 am (Dzubin 1967), however we started our visual surveys at 9:00 am because it is thought that a later time allows birds to move out of nesting cover (Hammond 1966). We only conducted surveys under favorable weather conditions, which included good visibility (no fog), no precipitation, and a code of three or less on the Beaufort wind scale. With one person driving, we surveyed with a minimum of two people while standing in the bed of a pick up truck and searched within 200 yd (183 m) along each side of the route. We did not exceed 20 mph (32 km/h) so that we could easily see and identify birds. We recorded mallard, gadwall, and cinnamon teal, and following classifications used in other studies, we considered a breeding pair to be any male and female pair, a single male (Hochbaum 1944, Low 1947), or groups of males equal to or less than four (Lynch 1951). During each survey, we used a paper map and drew the water located within 200 yd (183 m) of our driving route, and later used this to calculate the wetland acreage. Because aquatic habitat at LBWA is often separated by expanses of upland, we drove three separate routes consecutively, which in total were 10.3 mi (16.6 km). At VOWA we drove one primary route (8.2 mi/13.3 km) and we extended it in 2005 to include the Volta Expansion, which then increased our route to 13.2 mi (21.3 km). We also created an alternate route (1.2 mi/2.0 km) at VOWA in the event that poor road conditions, which often occur due to inclement weather, prevented us from surveying along our normal route.

After pair surveys were complete, we started the brood count surveys during the second full week of May and continued through the second week of July. As with the pair surveys, we alternated between wildlife areas each week. Also, we developed the brood survey routes to follow the same route as the pair surveys, but altered them each year as needed to include summer brood pond locations or to follow the availability of water. Our brood survey methods were consistent with the pair surveys, however we began half an hour after sunrise because this timing falls within Hammond's (1970) recommendation on when broods are most visible. When we located a brood, we noted the species, number of individuals, and age class; we determined age class by using Appendix vi in Hammond (1970). We recorded wetland acreage in the same manner as with the pair surveys.

Data Analysis

For both pair and brood surveys, we utilized geographic information system (GIS) software to digitize survey routes and create precise maps for recording wetland habitat data. After each route, we also used GIS software to digitize and calculate the amount of wetland habitat we surveyed. Our data was entered into Excel spreadsheets and we calculated pairs per wetland acre and broods per 100 wetland acres. With both pair and brood data sets, we performed simple linear regressions using NCSS 2001 (Hintze 2001) to determine trends for each species. We performed two-tailed hypothesis testing and used an alpha level of 0.05. All data was checked to see if they met the assumptions of normality and equal variance and if they did not, we transformed the data by using a natural log. All data is presented as means ±1 standard error.

Results

Because of inconsistent methodology in measuring waterfowl densities, we omitted data from all years prior to 2001. From 2001 to 2008 we conducted 210 surveys and assessed a total of 14,672 wetland acres at LBWA and VOWA. Because of fluctuating yearly water allotments and brood pond rotations from year to year, both properties showed annual variation in wetland availability (Table 1). Wetland availability ranged from 84 ac (34 ha) to 319 ac (129 ha) along survey routes at LBWA, and 82 ac (33 ha) to 356 ac (144 ha) at VOWA. On average we surveyed 192 wetland acres per year at LBWA and 153 wetland acres per year at VOWA. We were unable to perform brood surveys in 2005 and either survey in 2006 due to staffing limitations.

Table 1. Average number of wetland acres surveyed on the Los Banos Wildlife Area and Volta Wildlife Area during waterfowl pair and brood surveys, 2001-2008.

Year	Pair Count		Brood Count	
	LBWA	**VOWA**	**LBWA**	**VOWA**
2001	132.45	120.15	158.22	132.88
2002	179.33	101.05	183.16	151.78
2003	260.35	165.05	319.53	145.10
2004	109.60	150.15	180.94	152.88
2005	196.28	356.80		
2007	205.65	194.11	84.53	140.27
2008	268.34	93.81	211.14	82.72

Note: Brood surveys were not conducted during 2005 and no surveys were conducted in 2006.

Pair Surveys

At LBWA we conducted 14 pair surveys and counted a total of 2,105 waterfowl pairs between 2001-2008. Mallards represented the most common waterfowl species breeding there, ranging from 0.25 to 0.79 pairs per wetland acre (Figure 2). Cinnamon teal were the least common species we found and varied from 0.03 to 0.21 pairs per wetland acre. We witnessed that waterfowl pair densities fluctuated annually over the duration of the study and despite overall trends for all species appearing negative, we only found mallard pair densities to be significantly decreasing, although weakly correlated ($P=0.04$, $R^2=0.31$).

At VOWA, we performed 13 pair surveys and recorded a total of 1,422 waterfowl pairs between 2001-2008. As with LBWA, the most common breeding pairs we observed at VOWA were mallards, ranging from 0.20 to 0.77 pairs per wetland acre (Figure 3). We also observed that waterfowl pair densities fluctuated annually over the length of the study, with an insignificant decreasing trend for mallard and gadwall. We found that with cinnamon teal, the least common species throughout the study, the trend in pairs increased although not significantly ($P=0.64$, $R^2=0.03$).

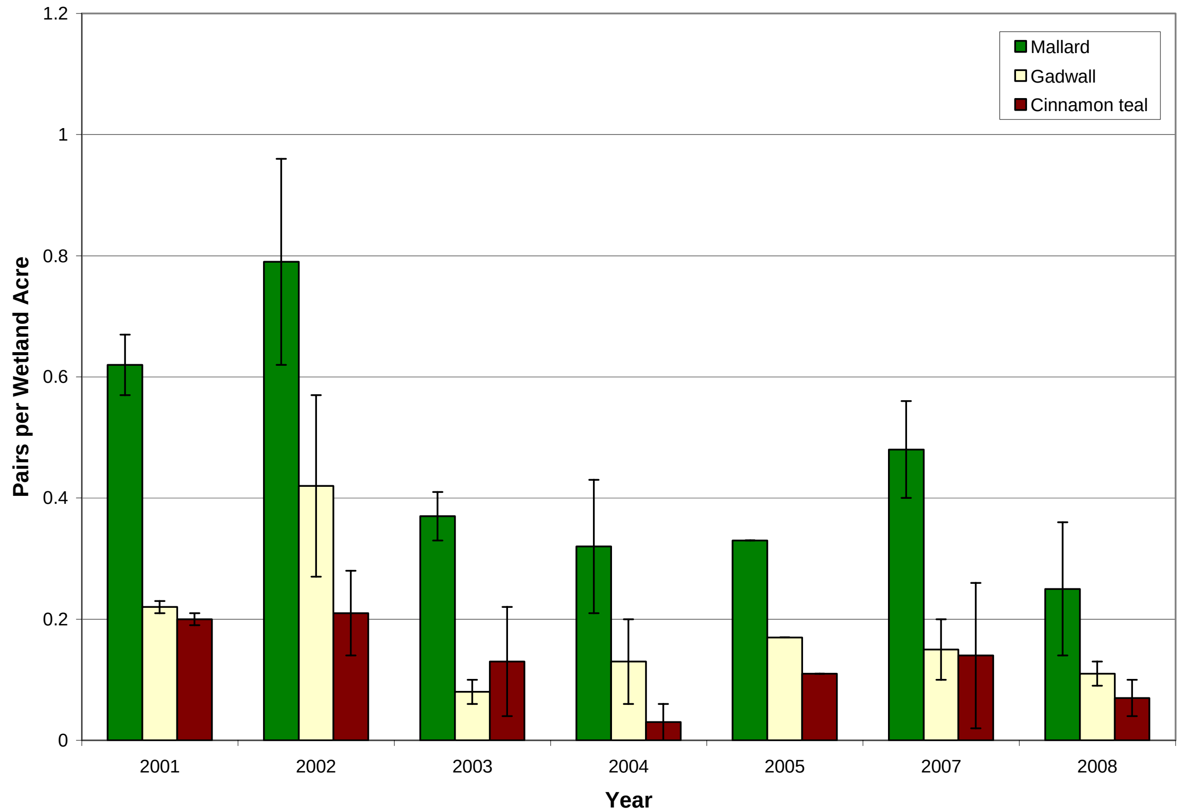

Figure 2. Average number of waterfowl pairs surveyed per species on the Los Banos Wildlife Area, 2001-2008. (Pair surveys were only conducted once in 2005 and none were conducted in 2006.)

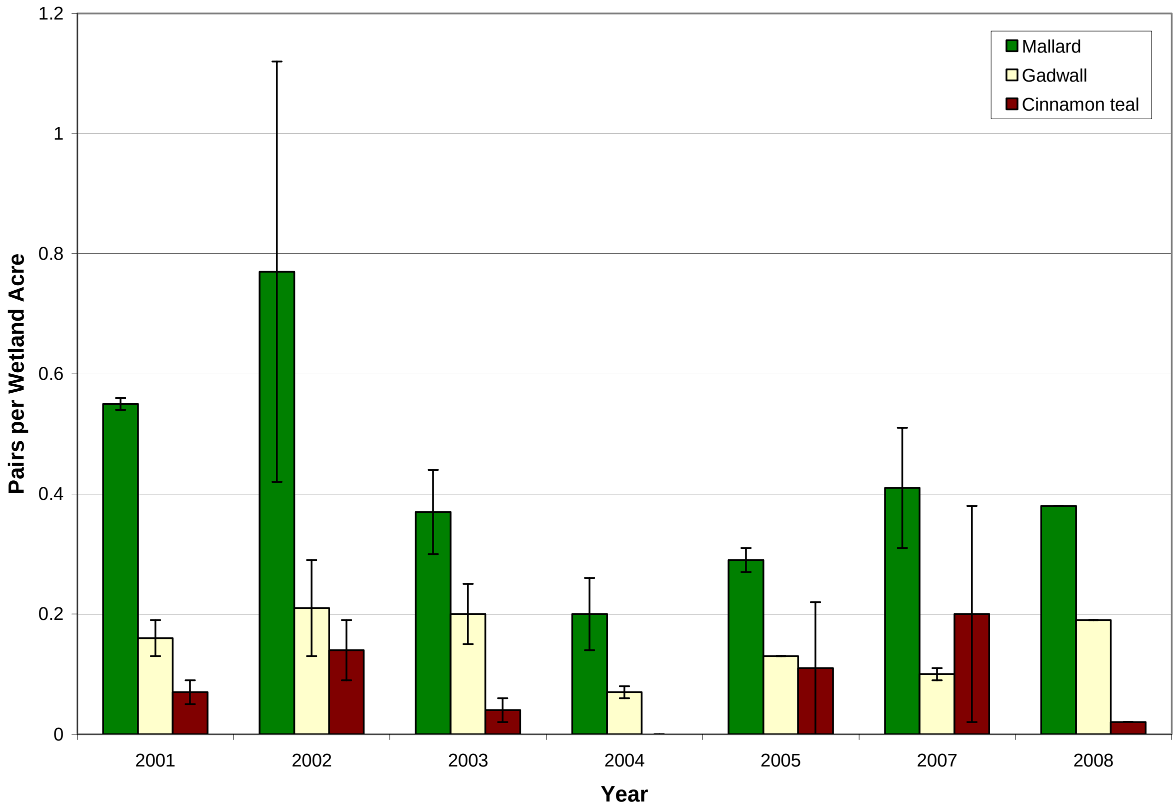

Figure 3. Average number of waterfowl pairs surveyed per species on the Volta Wildlife Area, 2001-2008. (Pair surveys were not conducted in 2006 and only once in 2008.)

Brood Surveys

At LBWA we conducted 92 surveys and counted a total of 104 broods from 2001 to 2008. Mallards were the most productive species we observed, with densities ranging from 0.61 to 2.48 broods per 100 wetland acres (Figure 4). We did not observe gadwall broods every year, but during years where they were present (2001, 2003 2004, 2008), broods ranged from 0.14 to 1.00 per 100 wetland acres. We found that brood densities for all species fluctuated annually with no significant trends.

At VOWA we performed 91 surveys and documented 128 broods from 2001 to 2008. The most common brood species we observed at VOWA were mallard and gadwall. Mallards ranged from 0.62 to 2.69 broods per 100 wetland acres, whereas gadwall varied from 0.14 to 4.31 broods per 100 wetland acres (Figure 5). Cinnamon teal broods were seen infrequently at VOWA and we only observed them in 2003 and

2008. As with LBWA, brood densities showed yearly fluctuations and we found no significant trends.

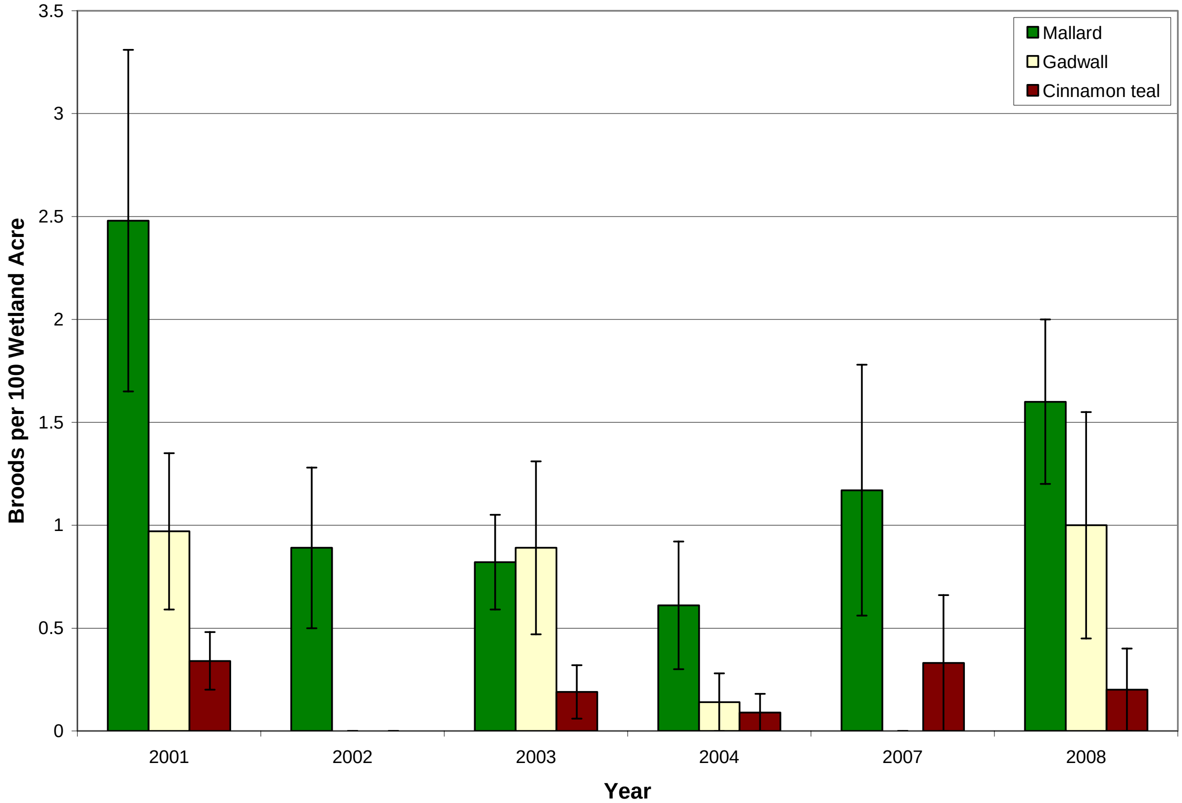

Figure 4. Average number of waterfowl broods surveyed per species on the Los Banos Wildlife Area, 2001-2008. (Brood surveys were not conducted in 2005 or 2006.)

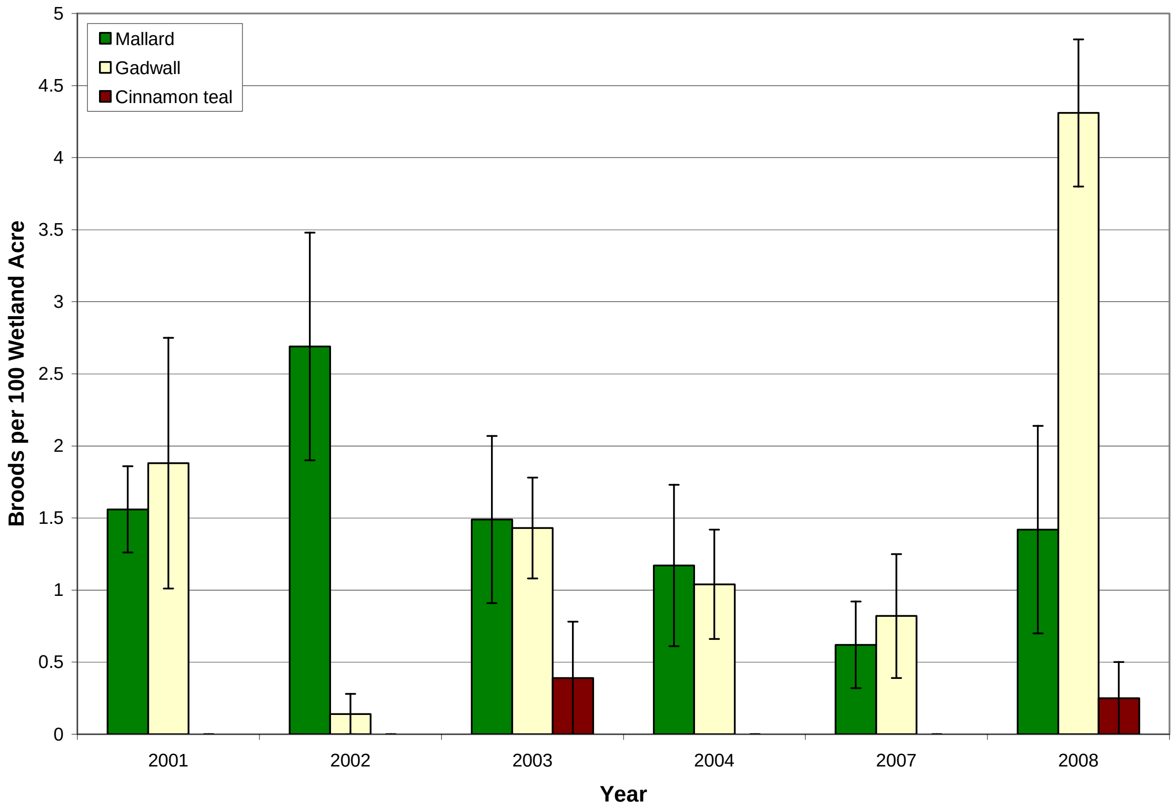

Figure 5. Average number of waterfowl broods surveyed per species on the Volta Wildlife Area, 2001-2008. (Brood surveys were not conducted in 2005 or 2006.)

Discussion

From 2001 to 2008 our pair and brood survey data showed that waterfowl consistently used both LBWA and VOWA as nesting locations and for brooding their young. The most abundant birds that we found during these surveys were mallards, which is consistent with earlier waterfowl nest-search and banding studies conducted within the GEA (Anderson 1956, California Department of Fish and Game 1998). The mallard's ongoing success at LBWA and VOWA may be attributed to their overall population size as well as their ability to utilize a large variety of habitats. In contrast, we found that gadwall and cinnamon teal were less represented on both properties, which again could be due to population size but these species also have more selective nesting preferences. For instance, we found cinnamon teal pairs and broods consistently at LBWA, whereas at VOWA we only recorded broods in 2003 and 2008. This may be accredited to the sparsely vegetated upland habitat at VOWA compared to

LBWA, as cinnamon teal prefer to nest in vegetation thick enough to completely surround the nest (Miller and Collins 1954). Although upland habitat at LBWA may be more suitable for cinnamon teal, the large expanses of aquatic habitat at VOWA may be better at supporting gadwall breeding. We found that at VOWA, gadwall consistently produced higher brood densities than at LBWA, which may partially be attributed to their high homing rates to natal and successful breeding areas (Lokemoen et al. 1990). The VOWA has a vast amount of permanent water via the Volta Wasteway, which is a wide and shallow water delivery system that has a limited amount of cattail and upland vegetation along its edge. Because this is a dependable source of water, gadwall can recognize and become familiar with the area (Oring and Sayler 1992). However, the primary brooding habitat at the LBWA is reverse cycle wetlands which are rotated annually and may make it difficult for gadwall to recognize. Most of the permanent water at LBWA may be too deep to allow broods to feed, and sloughs or other waterways have little aquatic vegetation. Without a suitable, large permanent water source it may be difficult for gadwall to recognize or become familiar with a specific brooding area at LBWA. However, because upland and aquatic habitat vary at both properties, we believe this may better support the Central Valley waterfowl population by catering to the different needs of individual species.

During the course of our study, we noticed that the annual fluctuations in waterfowl pairs at both LBWA and VOWA were comparable, and that all three species either increased or decreased in density at both properties during the same years. Because gadwall, cinnamon teal, and mallards seem to follow the same trend in a given year, this most likely reflects annual changes in the overall California waterfowl population. Unlike our pair counts however, we found that increases or decreases in brood densities were not comparable between LBWA and VOWA throughout our study. For instance, there was a decline in the number of broods observed at LBWA from 2001 to 2004, followed by an increase from 2007 to 2008. However, brood densities at VOWA began decreasing in 2003 and did not begin to increase again until 2008. The high variation in brood densities when compared between species and properties from year to year may be more attributed to biotic and/or abiotic pressures on hens, nests, and ducklings.

Biotic pressures such as predation, disease, and nest parasitism can have significant effects on nesting waterfowl. In the Prairie Pothole region of the Midwest, researchers found that 65-72% of all waterfowl nests lost were due to predation (Greenwood et al. 1995, Klett et al. 1988), and a separate study in the GEA reported predation to be the cause of 61-82% of nest failure (Anderson 1956). Additionally, the DFG reached this same conclusion when a nest-search study was conducted at LBWA in 1998 (California Department of Fish and Game 1998). As with nests, ducklings are also heavily predated upon and in California, survival rates range from 0.18 to 0.37 with an estimated two thirds of observable duckling mortality due to predation (Chouinard and Arnold 2007, Mauser et al. 1994). A similar study conducted within the GEA found that the duckling survival rate for the first 30 days was 0.39 and the highest known cause of mortality was due to avian and mammalian predation (California Department of Fish and Game 1997). Although not as substantial as predation, nesting waterfowl also face nest parasitism, occurring when a hen lays eggs in the nest of another. Mallard, gadwall, and cinnamon teal can exhibit intraspecific nest parasitism, but are also parasitized interspecifically by American coots (*Fulica americana*), ring-necked pheasants (*Phasianus colchicus*), and other duck species (Joyner 1973, Rienecker and Anderson 1960). When nests are parasitized, they often have lower host clutch size due to eggs being displaced by the parasitic hen, and they have lower success and hatch rates (Joyner 1976, Lokemoen 1991). Eggs and ducklings can also be lost to abiotic factors as well, such as flooding and weather exposure. Although natural flooding is not very common during nesting season in the Central Valley, summer irrigation of upland habitat (often for cattle grazing and row crops) can cause nests to be flooded and lost (Anderson 1956, California Department of Fish and Game 1998). Because we did not include nest or duckling fates in our study, we cannot conclude that the greater annual fluctuations we found in brood densities were due to these factors, but studies suggest they are contributors and should be taken into account.

During our study we also wished to analyze the potential effects of wetland availability on pair and brood densities. An increase in wetlands during the nesting and brooding season increases waterfowl production by providing more habitat, which in turn also helps to reduce predation of nests and ducklings (Anderson 1956, Gilbert et al.

1996, Mauser et al. 1994, McLandress et al. 1996). We believe this to be true, however our data often showed an inverse relationship between wetland availability and waterfowl densities. For example, during years when we observed a large amount of wetland habitat, we did not necessarily see higher pair and brood densities. However, this may be partly due to the increase in habitat making it more difficult to observe birds from a driving route such as ours (e.g. an increase in wetland habitat also supports thicker vegetation that is difficult to see past and waterfowl may be dispersed at distances that are no longer viewable). Therefore, our observations do not necessarily indicate that less waterfowl pairs and broods are present when there is an increase in aquatic habitat. Conversely, our data showed that years with fewer wetland acres did not result in especially low pair or brood densities either. This may simply be due to waterfowl becoming more concentrated when there is less aquatic habitat and they may be easier to see. For example, we observed a major increase in the number of broods for all species at VOWA in 2008 but the amount of available wetland acres was extremely low that year (Figure 5). However, the majority of the water available at VOWA in 2008 was located within the Volta Wasteway and minor ditches, all of which run parallel to a major access road, thus making broods more visible during our surveys than when viewing vegetated wetlands. Although our data does not show strong correlations, it is well documented that an increase in wetlands is associated with an increase in waterfowl productivity, thus summer water availability in areas with successful breeding is essential.

It is likely that there are more factors than wetland availability alone that may determine waterfowl pair and brood densities. The type of wetland (permanent, semi-permanent, annual, or reverse cycle) may be important for supporting waterbird use at LBWA and VOWA. For instance, different kinds of wetlands yield different varieties and concentrations of aquatic invertebrates, and seasonal wetlands are known to produce higher concentrations of invertebrates than permanent wetlands (Swanson and Meyer 1973). A study by Talent et al. (1982) found that mallard broods tended to move to wetlands containing high concentrations of chironomid (midge) larvae. Reverse cycle wetlands have also been found to support higher populations of invertebrates than in permanent and barrow areas of seasonal wetlands (de Szalay et al. 2003) and mallard broods have been documented nesting near permanent wetlands, but after hatching, the hen would move the brood through permanent water to reach a seasonal wetland or newly flooded impoundment (McKnight and Low 1969, Sayler and Willms 1988). Likewise, it has been found in the GEA that reverse cycle wetlands contain the highest concentrations of invertebrates during the peak of the mallard and cinnamon teal hatching season (de Szalay et al. 2003), and mallard broods prefer reverse cycle wetlands over seasonal and permanent wetlands (Chouinard and Arnold 2007). Although we did not record the type of wetland in which waterfowl broods were found, our data indicates that mallards may not be as affected by the different types of brooding habitats available on LBWA and VOWA as cinnamon teal and gadwall. For instance, cinnamon teal broods were found in higher densities at LBWA, which has more reverse cycle wetlands than VOWA, thus providing higher concentrations of invertebrates that may be an important factor for this species. Conversely, gadwall broods were found in higher densities at VOWA, and unlike other waterfowl species, they rely less on invertebrates and more on plant vegetation for food (Sugden 1973). Therefore, they may be less dependent on seasonal and reverse cycle wetlands than mallards and cinnamon teal. Additional surveys with a focus on habitat preference (aquatic and terrestrial), and nest and brood fates for more than one species might reveal niches that are important to each. Studying these aspects of waterfowl nesting and brooding ecology might also give a better understanding of what the requirements are to support a variety of species, thus providing an additional tool for future management.

The efforts by DFG to create and sustain upland nesting habitat and brooding sites have been successful and we recommend a continued effort in the future. Since waterfowl have demonstrated reproductive success at these properties and are not a species of special concern, we feel that further pair and brood surveys are no longer required at this time. It is clear that waterfowl utilize lands within the GEA during winter and summer because it is the largest viable wetland habitat remaining in the central San Joaquin Valley, thus continued water delivery to this area is of great importance. If DFG wishes to learn more about nest fates, brood fates, survival rates, predation, nest parasitism, or other effects on nesting and brooding waterfowl at the Los Banos Wildlife Area Complex, more extensive monitoring techniques will be required.

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Literature Cited

Anderson, W. 1956. A waterfowl nesting study on the Grasslands, Merced County, California. California Fish and Game 42(2):117-130.

California Department of Fish and Game. 2008. Rainfall data 1970-2008. Los Banos Wildlife Area unpublished data, Los Banos.

California Department of Fish and Game. 1998. Brief Summary of Waterfowl and Ring-necked Pheasant Monitoring on the Los Banos Wildlife Area in 1998. Los Banos Wildlife Area unpublished data, Los Banos. 4pp.

California Department of Fish and Game. 1997. 1996 Monitoring Summary for the following Wildlife Areas: Mendota Wildlife Area, Los Banos Wildlife Area, Volta Wildlife Area, and North Grasslands Wildlife Area. Mendota Wildlife Area, Mendota, Annual Report. 28pp.

Chouinard, M. P., and T. W. Arnold. 2007. Survival and habitat use of mallard (*Anas platyrhynchos*) broods in the San Joaquin Valley, California. Auk 124(4):1305-1316.

Chura, N. J. 1961. Food availability and preferences of juvenile mallards. Transactions of the North American Wildlife and Natural Resources Conference 26:121-135.

Cooper, D. S. 2004. Important Bird Areas of California. Audubon California, Pasadena. 286pp.

de Szalay, F. A., L. C. Charroll, J. A. Beam, and V. H. Resh. 2003. Temporal overlap of nesting duck and aquatic invertebrate abundances in the grasslands ecological area, California, USA. Wetlands 23(4):739–749.

Drilling, N., R. Titman, and F. Mckinney. [Online]. 2002. Mallard (*Anas platyrhynchos*). The Birds of North America. <http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/658doi:10.2173/bna.658>. Accessed January 8, 2010.

Duncan, D. C. 1986. Influence of vegetation on composition and density of island-nesting ducks. Wildlife Society Bulletin 14(2):158-160.

Dzubin, A. 1967. Assessing breeding populations of ducks by ground counts. Saskatoon Wetlands Seminar. Canadian Wildlife Service, Report Series No. 6:178-229.

Gammonley, J. H. 1996. Cinnamon Teal (*Anas cyanoptera*). The Birds of North America No. 209:1-19.

Gilbert, D. W., D. R. Anderson, J. K. Ringelman, and M. R. Szymczak. 1996. Response of Nesting Ducks to Habitat and Management of the Monte Vista National Wildlife Refuge, Colorado. Wildlife Monographs No. 131:1-44.

Gilmer, D. S., M. R. Miller, R. D. Bauer, and J. R. LeDonne. 1982. California's Central Valley Wintering Waterfowl: Concerns and Challenges. Pages 441-452 *in* K. Sabol ed. Transactions of the Forty-seventh North American Wildlife and Natural Resources Conference, Washington, D. C.

Greenwood, R. J., A. B. Sargeant, D. H. Johnson, L. M. Cowardin, and T. L. Shaffer. 1995. Factors Associated with Duck Nest Success in the Prairie Pothole Region of Canada. Wildlife Monographs No. 128:1-57.

Hammond, M. C. 1966. Waterfowl breeding population surveys. U. S. Fish and Wildlife Service, Mimeo Report, Upham, ND. 25pp.

Hammond, M. C. 1970. Waterfowl Brood Survey Manual. U. S. Fish and Wildlife Service, Towner, ND. 44pp.

Hintze, J. 2001. NCSS and PASS. Number cruncher statistical systems. Kaysville, UT.

Hochbaum, H. A. 1944. The Canvasback on a Prairie Marsh. The American Wildlife Institute, Washington, D. C. 201pp.

Isola, C. R., M. A. Colwell, O. W. Taft, and J. R. Safran. 2000. Interspecific Differences in Habitat Use of Shorebirds and Waterfowl Foraging in Managed Wetlands of California's San Joaquin Valley. Waterbirds 23(2):196-203.

Joyner, D. E. 1973. Interspecific nest parasitism by ducks and coots in Utah. Auk 90(4):692-693.

Joyner, D. E. 1976. Effects of Interspecific Nest Parasitism by Redheads and Ruddy Ducks. Journal of Wildlife Management 40(1):33-38.

Klett, A. T., T. L. Shaffer, and D. H. Johnson. 1988. Duck Nest Success in the Prairie Pothole Region. Journal of Wildlife Management 52(3):431-440.

Lokemoen, J. T., H. F. Duebbert, and D. E. Sharp. 1990. Homing and reproductive habits of mallards, gadwalls, and blue-winged teal. Wildlife Monographs No. 106:1-28.

Lokemoen, J. T. 1991. Brood Parasitism Among Waterfowl Nesting on Islands and Peninsulas in North Dakota. Condor 93(2):340-345.

Low, J. B. 1947. Review of new techniques-waterfowl. Transactions of the North American Wildlife Conference 12:339-346.

Lynch, J. J. 1951. This lone drake business. U. S. Fish and Wildlife Service unpublished report, Abbeville, LA. 13 pp.

Mauser, D. M., R. L. Jarvis, and D. S. Gilmer. 1994. Survival of Radio-Marked Mallard Ducklings in Northeastern California. Journal of Wildlife Management 58(1):82-87.

McKnight, D. E., and J. B. Low. 1969. Factors affecting waterfowl production on a spring fed salt marsh in Utah. Transactions of the North American Wildlife and Natural Resources Conference 34:307-314.

McLandress, M. R., G. S. Yarris, A. E. H. Perkins, D. P. Connelly, and D. G. Raveling. 1996. Nesting biology of mallards in California. Journal of Wildlife Management 60(1):94-107.

Miller, A. W., and B. D. Collins. 1954. A nesting study of ducks and coots on Tule Lake and Lower Klamath National Wildlife Refuges. California Fish and Game 40(1):17-37.

Oring, L. W., and R. D. Sayler. 1992. The Mating Systems of Waterfowl. Pages 190-213 *in* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu, eds. Ecology and Management of Breeding Waterfowl, University of Minnesota Press, Minneapolis. 645pp.

Ramsar Convention on Wetlands. [Online]. 2011. The Annotated Ramsar List: United States of America. <http://www.ramsar.org/cda/en/ramsar-documents-list-annotated-ramsar-15774/main/ramsar/1-31-218%5E15774_4000_0__>. Accessed October 7, 2011.

Rienecker, W. C., and W. Anderson. 1960. A waterfowl nesting study on Tule Lake and Lower Klamath National Wildlife Refuges, 1957. California Fish and Game 46(4):481-506.

Sayler, R. D., and M. A. Willms. 1988. Waterfowl production, brood ecology, and nesting island management on the Garrison Reservoir in North Dakota. Research Report No. 39. Institute for Ecological Studies, University of North Dakota, Grand Forks. 25pp.

Sedinger, J. A. 1992. Ecology of Prefledging Waterfowl. Pages 109-127 *in* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, G. L. Krapu, eds. Ecology and Management of Breeding Waterfowl. University of Minnesota Press, Minneapolis. 645pp.

Sousa, P. J. 1985. Habitat suitability index models: Gadwall (breeding). U. S. Fish and Wildlife Service, Fort Collins, CO, Biology Report 82(10.100). 35pp.

Sugden, L. G. 1973. Feeding ecology of pintail, gadwall, American widgeon and lesser scaup ducklings in south Alberta. Canadian Wildlife Service, Report Series No. 24. 45pp.

Swanson, G. A., and M. I. Meyer. 1973. The role of invertebrates in the feeding ecology of Anatinae during the breeding season. Pages 143-185 *in* Waterfowl Habitat Management Symposium. Moncton, New Brunswick, Canada.

Swanson, G. A., M. I. Meyer, and V. A. Adomaitis. 1985. Food consumed by breeding mallards on wetlands of south-central North Dakota. Journal of Wildlife Management 49(1):197-203.

Talent, L. G., G. L. Drapu, and R. L. Jarvis. 1982. Habitat use by mallard broods in south-central North Dakota. Journal of Wildlife Management 46(3):629-635.

Wheeler, R. J., and S. W. Harris. 1970. Duck nesting and production in the Humboldt Bay area of California. California Fish and Game 56(3):180-187.

Whitman, W. R. 1976. Impoundments for waterfowl. Canadian Wildlife Service, Occasional Paper No. 22. 21pp.