2012 Waterfowl Nesting Study at Fish Springs National Wildlife Refuge

A Report Prepared by:

Ryan Haffele
U.S. Fish and Wildlife Service
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Introduction

The breeding period is most critical for temperate nesting duck population dynamics as most mortality and all production occurs (Johnson et al. 1992). Vital rates that are affected during this period of the annual cycle (nest success and adult hen survival) have been shown to have the most influence on population changes of the midcontinent mallard (*Anas platyrhynchos*), and presumably, other upland nesting ducks with similar life history traits (Hoekman et al. 2002). Predators have been found to be the main cause of mortality to nests and hens during the breeding period (Ricklefs 1969), accounting for more than 70% of nest failures in most studies (Sovada et al. 2001, Emery et al. 2005). Since the North American Waterfowl Management Plan (Environment Canada et al. 1986; NAWMP) was established with the main goal of increasing duck populations to the levels of the 1970s, managers have focused their efforts on increasing nest success. Most management to date has been focused on increasing suitable nesting cover (Williams et al. 1999, Emery et al. 2005) and attempts to control predator populations through direct intensive predator management (i.e. lethal removal; Sovada et al. 2001).

Recent studies have shown that increased amounts of perennial cover on the landscape have a positive influence on nest success (Stephens et al. 2005, Arnold et al. 2007). Planted cover has also been shown to be the best management practice to increase early season nest success (Emery et al. 2005), with earlier hatched young being more likely to be recruited into the fall population (Dzus and Clark 1998, Dawson and Clark 2000). Management strategies that increase perennial cover on the landscape provides a practical management activity in regions like the Prairie Pothole Region (PPR), where soils and climate are suitable to such activities. At Fish Springs National Wildlife Refuge (FSNWR), however, climate and soil limitations restrict managers from planting typical perennial cover stands like in the PPR, as salt tolerant vegetation is needed to survive in the salt desert ecosystem. Thus, typical management practices used to increase nest success by increasing nesting cover are likely rendered ineffective at FSNWR.

An alternative management practice used to increase nest success has been intensive predator management. This intensive management includes the exclusion of predators from quality nesting habitat (Lokemoen et al. 1982) and the removal of predators via trapping and shooting (Greenwood 1986, Sargeant et al. 1995). Predator removal has historically been focused on mesopredators like red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), and raccoons (*Procyon lotor*), which have been found to have a greater impact on nest survival than coyotes (*Canis latrans*; Sovada et al. 1995). Predator composition at FSNWR does not have the complexity of other waterfowl production regions, however, with the most abundant predators being coyotes and ravens (*Corvus corax*). Removal of avian predators, like ravens, is difficult and often ineffective (Parker 1984).

The effectiveness of predator removal at increasing nest success has been equivocal, with some studies indicating increased localized success (Garrettson and Rohwer 2001, Pieron and Rohwer 2010) while others found no effect of predator removal on nest success (Greenwood 1986, Beauchamp et al. 1996, Dassow 2010). Additionally, Amundson (2010) indicated areas with increased nest success due to predator removal did not increase local population sizes due to decreased duckling survival in predator removal areas. With variable results thus far, there is great uncertainty as to the effectiveness of predator removal as a management tool to increase nest success.

Currently, FSNWR is in the process of creating a Habitat Management Plan (HMP) to guide the management of trust resources on the refuge. In order to write and implement the HMP, baseline data regarding trust resources currently on the refuge is needed. A wealth of historical data on duck production at FSNWR is available, however, no data or monitoring has occurred since 1993. The purpose of this study was to determine the current duck production on FSNWR with the goal of using the information gathered to guide management to maximize duck production on the refuge.

History of Duck Production at Fish Springs

FSNWR was established as an inviolate sanctuary for migratory birds, with previous management focusing on waterfowl production (FSNWR Marsh Management Plan, FSNWR Comprehensive Conservation Plan). Since establishment, refuge employees have estimated waterfowl production (number of ducklings fledged to flight stage) on the refuge using a variety of techniques (i.e. brood counts, line-transect nest searches, hand dragging, ATV dragging). This data provides a synopsis of production since the refuge was established.

Prior to the establishment of the impoundment system on the refuge, duck production was estimated to be low (McKnight 1969), with very little open water present on the refuge. An impoundment system was created in the early 1960s to increase the attractiveness of the refuge to breeding ducks. To estimate the duck production that was occurring on the refuge, a nesting study was conducted on the refuge in 1960 to gather initial data. No nests were found during nest searches, however 7 nests [6 mallard, 1 cinnamon teal (*Anas cyanoptera)*] were found during other refuge tasks and by the muskrat trapper (FSNWR Annual Narrative 1960). After this initial study, production during the years of impoundment establishment (1960-1964) was estimated using brood counts. Counts were conducted every 4-5 weeks from June to August. Much of the refuge was drained during these years to facilitate dike and road construction. In 1960, 42 broods were identified; 35 mallard, 3 cinnamon teal, 2 redhead (*Aythya Americana*), and 2 pintail (*Anas acuta*; FSNWR Annual Narrative 1960). Brood counts indicated that approximately 500 ducklings hatched in 1961 and 1962, with the primary species being mallard, green-winged teal (*Anas crecca*), cinnamon teal, and redheads (FSNWR Annual Narrative 1961; 1962). In 1963, estimates of production increased to 640 ducklings with the primary species again being mallards, cinnamon teal, and redheads (FSNWR Annual Narrative 1963). Production was estimated to be similar in 1964, with redhead numbers increasing and the first gadwall (*Anas strepera*) brood being identified (FSNWR Annual Narrative 1964).

The impoundment system was completed in the summer 1964 and all impoundments were inundated that winter (FSNWR Annual Narrative 1964). Brood counts were again used to estimate production from 1965-66. In 1965 production estimates nearly doubled to 1,120 ducklings (FSNWR Annual Narrative 1965), with similar estimates in 1966 at 1,056 ducklings (FSNWR Annual Narrative 1966). Production estimates were quite high after impoundment establishment compared to other spring fed salt marshes in the area prompting the initiation of an intensive nesting ecology study to determine the causes of the increased productivity. This study took place from 1967-1968 and was directed by a graduate student from Utah State University. Throughout the duration of the study, 312 nests of 9 species were found, with the predominant nesting species being mallard, cinnamon teal, and redhead. Apparent nest success ($\frac{\#\ of\ nests\ found\ that\ were\ successful}{total\ number\ of\ nests\ found}$) during the study was 63%, with predators accounting for the majority of nest loss (25%). Using a combination of brood counts and nest survival data, production estimates during the study were 2,445 and 3,595 ducklings in 1967 and 1968, respectively. Reasons for the increased production at the refuge were not entirely known, however low predator activity and increased invertebrate populations due to recently flooded habitat were cited as likely causes (McKnight 1969). To maintain duck production on the refuge, McKnight (1969) recommended that water levels in management units be periodically drawn-down to increase invertebrate populations to provide food for nesting hens and broods.

After the completion of the nesting study, management to promote duck production focused on full-pool management, keeping pools at optimal levels for as long as possible throughout the year. During this time, production estimates were again estimated using brood counts. Starting in 1969, counts were conducted weekly opposed to every 4-5 weeks as previously completed (FSNWR Annual Narrative 1969). This method continued from 1969-1974. Production estimates decreased during this time period, from a high of 2,375 in 1969 to 700 in 1974 (FSNWR Annual Narrative 1969; 70; 71; 72; 73; 74).

A new method (hereafter; pair count method) for estimating duck production on the refuge was initiated in 1975 (FSNWR Annual Narrative 1975). This method used a combination of three techniques to calculate an overall production estimate for the refuge. The techniques used included; pair counts to estimate the breeding population size, nesting surveys to determine nest success, and brood counts to estimate brood survival. Production was then calculated as; (# breeding pairs – nest failures) X (average class I brood size). This was considered the initial production on the refuge. Brood mortality was then calculated as; (average class I brood size – average class III brood size). This mortality rate was then subtracted from the initial production estimate to calculate overall production on the refuge. Using this method production estimates increased dramatically with 1975 estimates at 3,568 ducklings and 1976 estimates at 7,270 ducklings (FSNWR Annual Narrative 1976). Production estimates again decreased over the next few years, dropping to 4,500 in 1977 and 4,400 in 1978 (FSNWR Annual Narrative 1977; 78). Estimates from this method may be biased high, as an important assumption of this method is that all nesting pairs counted attempt to nest. This assumption is unlikely to be met, as studies have shown that not all sexually mature adult waterfowl breed each year (Sedinger et al. 1995), with one study estimating 85% of mallards initiate nests (Coluccy et al. 2008). Additionally, pair counts may have included pairs of breeding ducks that were still migrating to other breeding grounds north of the refuge, thus overestimating the true breeding population of the refuge.

The decline in production estimates continued in 1979, with an estimated 2,137 ducklings produced on the refuge (FSNWR Annual Narrative 1979). During this year, a new method, distance sampling using line transects (hereafter; transect method), was tested for trying to get a more accurate estimate of duck production. This method involves walking designated transects searching for nests and measuring the perpendicular distance of each nest from the transect. These distances were then used to estimate a nest density corrected for detection probability for the refuge using Program TRANSECT (Laake et al. 1979). Production was then calculated by; (estimated nest density X available nesting habitat X calculated nest success X average class IIc/III brood size). This method was tested on two study plots in 1979 and expanded in 1980 (FSNWR Annual Narrative 1979). Results from 1979 yielded small sample sizes and were not used to calculate production. After expanding the method in 1980, sample sizes were still too low to estimate production, and the pair count method was utilized again. This estimated production at 2439 ducklings with nests found using the transect method having a success rate of 54%.

To increase nesting habitat and nesting success on the refuge for waterfowl (primarily geese), man-made pothole islands were created in 1979 and 1980 in the Pintail, Ibis, Gadwall, and Harrison units. Blowouts were created using dynamite to make the potholes with nesting islands in the middle of the blowouts (FSNWR Annual Narrative 1979). Other potholes were created by digging trenches to create islands in patches of baltic rush (*Juncus balticus*). These islands were created in suitable nesting habitat [i.e. baltic rush and salt grass (*Distichlis spicata*)]. Islands made in Gadwall and Harrison suffered heavy erosion from wind action despite seeding the island with saltgrass. Due to the erosion of previously created islands, all potholes created after 1979 were larger and created in shallower water to try and alleviate erosion problems.

In 1981 the transect method was fully implemented in all units except Gadwall and Egret. A total of 65 miles of transects were walked 3 times by staff throughout the nesting study. A total of 62 nests were found with an apparent nest success of 58%. Sample sizes were again deemed too small to get an accurate measure of production, and the pair count method was again used. This method estimated 4,744 ducklings produced (FSNWR Annual Narrative 1981).

In 1982, the transect method was used to estimate production for all species for which staff located nests of. A total of 30 nests were found using this method with an apparent success rate of 77%. Production for species that were observed during pair count surveys but no nests were located [canvasback (*Aythya valisineria*), green-winged teal, and ruddy duck (*Oxyura jamaicensis*)] was estimated using the pair count method. Overall production for the refuge was estimated by adding the production of all species together, resulting in an estimate of 2,661 ducklings produced. Additionally, to determine the effects of various management actions to increase nesting on the refuge, primarily nesting potholes, an intensive nesting study was conducted. This included hand dragging 20 acre plots where pothole islands had been created in patches of baltic rush using a 65 foot heavy rope. A total of 14 nests were found during this operation, with 4 of the pothole islands being utilized by nesting hens (FSNWR Annual Narrative 1982).

Staff continued to use the transect method to estimate duck production for species where nests were found on the refuge from 1983-1985. Like 1982, production for species that no nests were located for but were observed during pair counts was calculated using the pair count method. The number of nests found during transect surveys continued to decline during this time period, dropping from 28 in 1983 to only 8 in 1985. Production estimates for 1983 was 2,924 ducklings (FSNWR Annual Narrative 1983). In 1984, production was calculated using both the transect method and the pair count method due to low nest numbers. The transect method estimated 2,753 ducklings, while the pair count estimated 1,850 ducklings (FSNWR Annual Narrative 1984). In 1985 the production estimate was 2,311 ducklings. After 1985, the transect method was abandoned due to low sample sizes and the occurrence of beaten paths that had been formed from walking transects over the previous years, which was felt may have affected duck nesting or predator activity (FSNWR Annual Narrative 1985).

Production was again estimated using the pair count method in 1986 and 1987. Production estimates were 2,730 ducklings in 1986 (FSNWR Annual Narrative 1986) and 3,550 ducklings in 1987 (FSNWR Annual Narrative 1987). Another new method was used to estimate production in 1988, Hammond's estimation formula on brood count data (hereafter; Hammond's method). Hammond's method helps reduce operational bias when surveying for Class III broods, which has been found to be high in published brood sizes (Hammond 1970, Cowardin and Johnson 1979). By reducing operational bias, more precise estimates of production should be obtained. Production calculated using this method yielded an estimated 1,130 ducklings produced (FSNWR Annual Narrative 1988).

Duck production on the refuge appeared to be declining and well below historical levels. To try and reverse recent trends, staff altered water management on the refuge in 1988, implementing the rotational draw-down system recommended by McKnight (1969). Prior to this, the main management activity to provide suitable habitat for duck production was full pool management, where water levels within each pool were kept at optimal levels for as long possible throughout the year. Pool levels still decreased each year due to evaporation, but no pools were intentionally drawn-down as they were in the new system. The goal of the rotational draw-down was to increase invertebrate production, providing more food for nesting and brood rearing activities. With this, 2 units were drawn down each year to promote mineralization and restore nutrients within wetlands to increase invertebrate production. Priority pools in Shoveler, Mallard, Avocet, and Curlew were also identified for nest production. Northern pools were not considered a priority for duck nesting, as they provide very little duck nesting habitat (FSNWR Marsh Management Plan).

Starting with the 1989 field season and continuing through 1993, production estimates for the refuge were estimated using standard prairie style nest dragging techniques. This involved two all-terrain vehicles (ATV's) dragging a 100 foot, 5/16 inch chain over vegetation to find duck nests. After location, nests were revisited every 7-10 days until fate (successful, depredated, or abandoned) was determined. Nest success was determined using the Mayfield Estimation Method (Mayfield 1975). These estimates were then expanded to pair counts and brood counts to get an estimate of production (FSNWR Annual Narrative 1989).

Staff selected search plots on the refuge by selecting areas that provided the best nesting cover and also had a high number of breeding pairs in the immediate area. Plots were selected in Ibis, Shoveler, Mallard, Curlew, Avocet, and the Springs units, totaling an estimated 400 acres. Due to the high interspersion of water and islands, ATV use was restricted to accessible areas. Areas that could not be searched with ATVs were searched using the beat out method. Plots were searched 2 times during the nesting season, with the exception of plots that proved to be too difficult to search due to the terrain and were dropped after the initial search.

A total of 60 duck nests were located in 1989, with 46 of them providing suitable data for nest success analysis. Nest success using the exposure method was 9%, while apparent nest success (for comparison to earlier years before Mayfield method) was 33%. Total production was estimated at 588 ducklings, well below estimates using other methods (FSNWR Annual Narrative 1989). In 1990, searching efforts located 91 nests, however, the majority of these nests (53) were found incidentally as hens flushed from nests when vehicles passed on the roads and not from actual nest searching activities. Nest success increased to 20% this year, possibly due to an increase in predation on colonial nesting species on the refuge. Overall production was estimated at 1,378 ducklings (FSNWR Annual Narrative 1990). Nest production again declined in 1991, with only 41 nests being located with a success rate of 12%. Overall production was estimated at 737 ducklings (FSNWR Annual Narrative 1991). In 1992, 78 nests were located with a success rate of 18%, and an overall production estimate of 1,695 ducklings. The final year of nesting studies on the refuge occurred in 1993 with 97 nests being located with a success rate of 5%. Production estimates for the year were 230 ducklings (FSNWR Annual Narrative 1993). Nesting studies were no longer conducted on the refuge, as staff felt they had a good enough understanding of duck production on the refuge and turned their management focus to other species. The average Mayfield nest success estimate during the nest dragging years was 12%, despite active control of predators on the refuge. Predator control included the shooting, trapping, and snaring of coyotes, trapping and relocation of gopher snakes, and harassment and shooting of ravens (FSNWR Animal Control Plan 1990).

After the completion of nesting studies, the 12% nest success average was used in accordance with brood counts and pair counts to estimate production in 1994, with an estimated 754 ducklings produced (FSNWR Annual Narrative 1994). The last year with any record of nest production estimates was 1995. Again, the 12% nesting success average was used with pair counts and brood surveys to estimate production, with an estimated 937 ducklings produced (FSNWR Annual Narrative 1995).

Methods

Drag plots were established within each management unit of the refuge for nest searching (Figure 1). Plots were established by creating 160 acre grids over each management unit in ArcGIS (ESRI, Redlands, California, USA) and randomly selecting one grid per unit to search. Units that were drained for management purposes (Egret and Curlew) and contained no water were not searched this year. I systematically searched all suitable nesting cover in each drag plot. Nests were located using teams of 2 dragging a 50 m cable-chain behind all-terrain vehicles (Klett et al. 1986). Speeds were kept between 3-8 km/h by keeping ATVs in low gear allowing drivers to stay in a straight line and watch the cable drag (Klett et al. 1986). Dragging at speeds faster than 8 km/h increases the likelihood of the chain passing over a nest without flushing the hen. I searched for nests between 0700 and 1400 to maximize the probability of the hen being on the nest (Gloutney et al. 1993). I alternated the starting location of fields for each drag to prevent the same area of the field being searched during the same time of day, reducing the possibility of a hen being on an incubation break during subsequent searches. Due to the numerous sloughs and islands interspersed within the landscape, I systematically searched all islands and vegetation where ATVs were unable to access. These searches consisted of 2-4 individuals searching each island on foot, on occasion with the assistance of a dog. I marked each nest found with a 1-m wooden lathe painted orange to allow easy visualization in the field by searchers. The wooden lathe was placed 10-m north of the nest and numbered to give each nest its own unique identification. Orange flagging was tied to vegetation near the nest bowl at each nest to assist with relocation. Nests were monitored on 7 day intervals until fate was determined (e.g., successful, depredated, abandoned). I determined the clutch size and incubation status at each visit. Incubation status was determined with a simple field candler (Weller 1956) made from 1 ½ -inch radiator hose. I recorded the date, field, species and Universal Transverse Mercator coordinates for each nest. After each visit, the nests were covered using material from the nest and a marker in the form of an X made out of vegetation was placed on top. If the X was found undisturbed on the next visit, I considered it abandoned due to investigator disturbance and censored it from survival analysis. I calculated the daily survival rate of nests using the Mayfield method (Mayfield 1975). Due to a small sample size, modeling to determine factors having the most influence on nest success was not possible. I assumed a 35-day exposure period (Klett et al. 1986) to convert DSR to point estimates of nest success.

Results

A total of the 8 nests were found at FSNWR through nest searching efforts including; 2 Mallards, 3 Gadwalls, 1 Northern Shoveler (*Anas clypeata*), 1 Canvasback, and 1 Cinnamon Teal. Of the 8 nests located, 3 successfully hatched, resulting in a daily survival rate of 0.969. The estimated Mayfield nest success rate was 33.61%. Hens nested in similar vegetation, with 4 nesting in baltic rush, 3 nesting in alkali sacaton (*Sporobolus airoides*)/baltic rush, and 1 nesting in saltgrass. Nests were placed, on average, 204.3 ± 59.26 (SD) m from roads and 94.0 ± 22.77 m from water. The average vegetation height for nests was 37.5 ± 4.63 cm with an average visual obstruction of 28.75 ± 4.87 cm and a litter depth 3.19 ± 0.90 cm.

Discussion

Duck production appears to be at an all-time low at FSNWR. Comparisons to the most recent nest production studies (1989-1993) on the refuge indicate nest success has increased on the refuge, however, the low number of nests found does not likely provide an accurate estimate, leaving any inference from the results very weak. Long-term trends of production estimates on the refuge show a climax of production in the 1970's with a continual decline until estimates were stopped in 1995 (Figure 2). This trend, however, cannot be interpreted as the actual trend in production as direct comparisons between years using different methods is not appropriate, making any inference about the effectiveness of management practices weak. For example, since both water management and the method used to calculate duck production changed in 1988, it is not possible to accurately determine if trends in duck production are a result of the management action or the method used to estimate production.

Due to the lack of nests found in this study, brood surveys were conducted during bi-weekly avian surveys. These surveys were not meant to serve as a production estimate, rather to try and identify if more hens were nesting on the refuge than implied by nest searching efforts and went undetected. These surveys resulted in a minimum (maximum cannot be determined due to inability to differentiate broods from one survey to the next because no individuals were marked) of 10 broods on the refuge. This is likely an underestimate of broods on the refuge as surveys were conducted from roads while completing other tasks, making it unlikely to census all broods, especially dabbling duck broods which prefer to rest and forage in emergent cover (Ringelman and Flake 1980). Despite the deficiencies in survey methods, the low number of broods observed suggests this study provided a relatively accurate sample of nesting activities on the refuge. There are many possible factors that may be limiting duck production on the refuge, including poor nesting cover, heavy predation pressure, or limited food availability.

Quality nesting cover is an essential component of waterfowl habitat (Baldassarre and Bolen 2006). Nesting cover provides protection from predators (Duebbert 1969) and helps control the microclimate around the nest-site (Gloutney and Clark 1997), with denser cover typically providing greater benefits than less dense cover (Schrank 1972). Due to the harsh climate and soil conditions at FSNWR, the composition of vegetation is limited to species that have adapted to local conditions. This prevents managers from planting typical nesting cover, like in the PPR, that have been shown to provide benefits for duck production (Emery et al. 2005).

The majority of suitable nesting cover, as perceived by anecdotal evidence of nest locations, is made up of saltgrass, baltic rush, and emergent marsh vegetation (FSNWR Annual Narrative 1976). Rush species (*Juncus* spp.) have also been found to be a preferred nesting cover in other areas (Keith 1961). The extent of these vegetation types is limited on the refuge, however, with patches of each type found interspersed with other non-suitable nesting vegetation like pickleweed (*Salicornia virginica*), common reed (*Phragmites australis*), and iodine bush (*Allenrolfea occidentalis*). This interspersion creates a matrix of suitable habitat on the landscape, rather than large continuous blocks of habitat which are thought to more beneficial to duck production than small isolated patches (Ball et al. 1995, Reynolds et al. 2001). Nesting densities are likely increased in the matrix of suitable habitat which may attract predators through a numerical response (Holt 1977). If predators find higher densities of nesting hens in certain habitat patches, they may develop a search image for nests in these habitats (Nams 1997), increasing predation risk for hens on the refuge and limiting production. Thus, it is possible that a lack of suitable nesting cover is limiting production on the refuge.

A lack of nesting cover is likely not the only factor limiting duck production at FSNWR. Consistent predation pressure from the primary predators (coyote, raven, and gopher snakes (*Pituophis melanoleucus*) on the refuge may be impacting production as well. Predators have been found to be the driving force in the evolution of avian breeding biology, as predation accounts for the majority of nest losses (Ricklefs 1969, Martin 1993, Lima 2009). This predation pressure is thought to impact nest success and nest-site selection, with hens selecting optimal nest-sites to increase fitness (Sargeant 1972, Greenwood et al. 1995). Results from this study showed the highest Mayfield nest success rates recorded on the refuge, however, it also showed the fewest number of nests located on the refuge. The increased success this year may have been a result of fewer hens nesting on the refuge, allowing hens that did nest in the area to select the safest nesting locations available. This should be interpreted with caution, however, as the small sample size likely did not give a good representation of nest success for the refuge.

Since modern techniques to estimate nest production were initiated on the refuge (i.e. nest dragging, Mayfield Method), nest success and production has been low, averaging ~12% (See History of Duck Production at FSNWR). These estimates were attained even when predator control methods were conducted. These control methods included the removal of coyotes and ravens before nesting was initiated and throughout the duration of the nesting season (FSNWR unpublished data). This heavy predation pressure may have impacted the number of hens nesting on the refuge. Previous studies have found that perceived predation pressure can impact reproductive investment of avifauna. Fontaine and Martin (2006) found increased parental investment of passerines on areas where predators were experimentally removed. Another study found decreased clutch sizes (a surrogate for reproductive investment) of Collared Flycatchers (*Ficedula albicollis*) in areas with experimentally increased predation rates (Doligez and Clobert 2003). Finally, Dassow (2010) found evidence that dabbling duck hens are able to identify and avoid high predator density areas when selecting a nest site. If nesting hens are able to identify perceived predation pressure, then the high predation rates on the refuge may have resulted in fewer hens nesting on the refuge.

Another factor that may be limiting production on the refuge is food availability. Egg production and incubation is very costly to nesting hens, resulting in lower body mass and body condition (Ankney and Afton 1988). Hens that are in better body condition (i.e. more nutrient reserves) are more likely to successfully hatch a clutch (Gloutney and Clark 1991). Nesting efforts have been found to fluctuate with water levels, presumably due to a lack of food available to hens and broods (Krapu et al. 1983). The primary food resource for nesting hens and broods are invertebrates (Kaminksi and Prince 1981, Ankney and Afton 1988), therefore, management efforts emphasizing an increase in food availability should focus on increasing invertebrate abundances.

With the impoundment system in place, an adequate water supply is available during the nesting and brood rearing season at FSNWR. Water levels were historically maintained at optimal pool levels for as long as possible throughout the year, with the southern priority nesting pools having very little fluctuation (FSNWR Marsh Management Plan). The implementation of a rotational draw-down system on pools in 1988 was focused on increasing food availability by increasing invertebrate populations. Initial studies examining the impact of the draw-down system suggested an increase in invertebrate abundance on pools that were allowed to dry and then flooded again (FSNWR unpublished data). Management has remained unchanged since the implementation of the draw-down system, making it unlikely that food availability has changed substantially since these initial studies. Monitoring efforts of invertebrate populations was terminated in 1997, however, and the long term effect of this management practice is unknown. Re-evaluating the food availability on refuge pools is needed to ensure management efforts are providing an adequate food supply for nesting waterfowl.

Management Implications

Duck production remains extremely low at FSNWR, despite production being the main priority for the refuge. It is possible that the one year of data collected for this study is an anomaly, and production is greater on the refuge than indicated. Future monitoring is needed to accurately assess production on the refuge and determine appropriate management actions. Increasing the amount of suitable nesting cover may help increase production, however, it is unlikely that an increase is possible due to the extreme local conditions. Another option to increase production is predator control. Previous efforts to increase production using this technique appeared futile, however, if predator control is initiated, more intensive removal efforts of coyotes and ravens than have occurred in the past are likely needed to have an impact on nest survival. Future research is needed on the impacts of the rotational draw-down system on invertebrate populations to determine if food availability is limiting duck production. Based on recent data and the results of this study, FSNWR does not appear to provide the adequate resources for high levels of duck production. Management of the refuge may be better served to provide habitat during important migration periods (i.e. spring migration).

Figure 1. Map of nest drag plots within management units for the 2012 duck nesting study at Fish Springs National Wildlife Refuge, Utah.

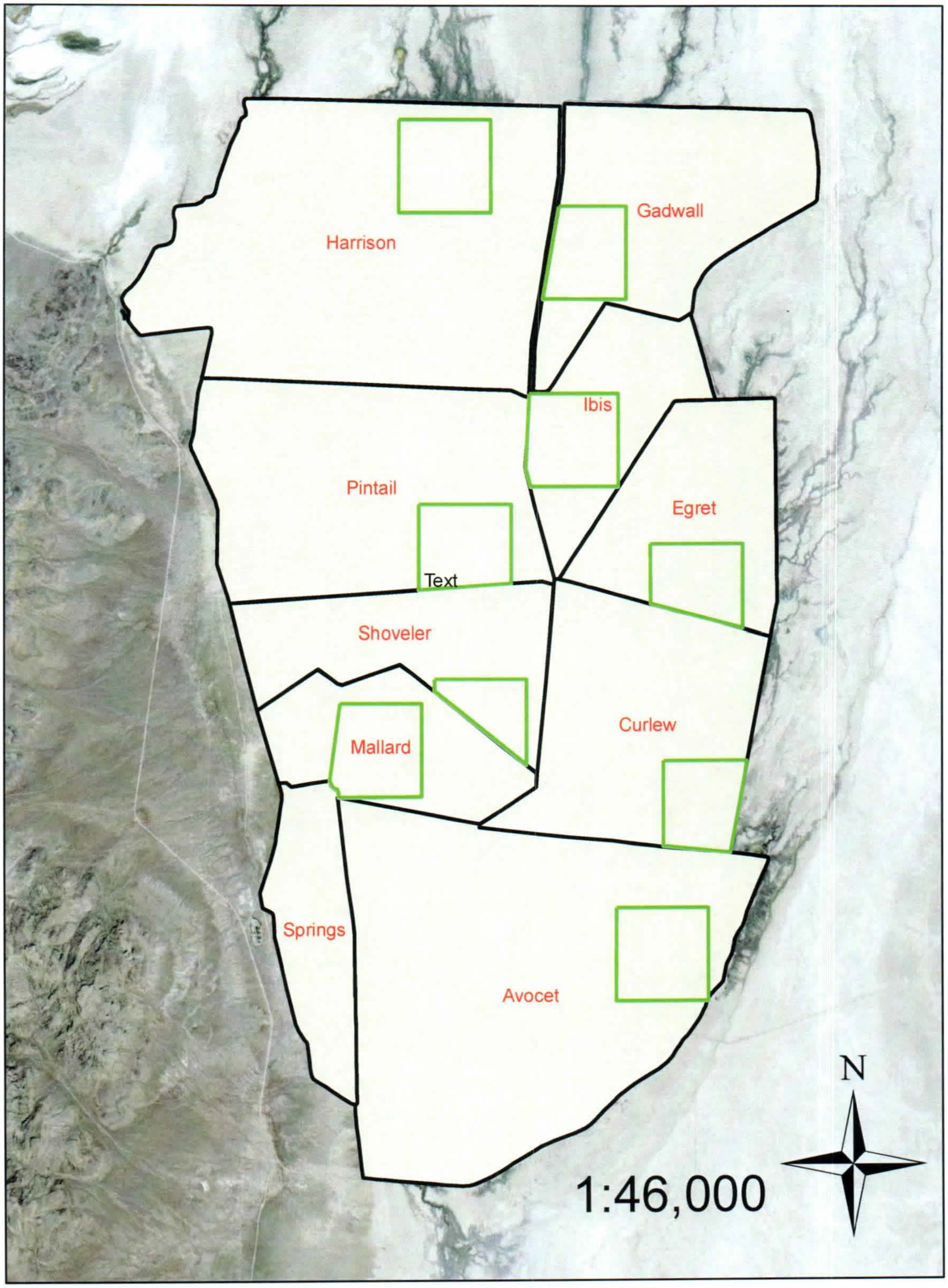
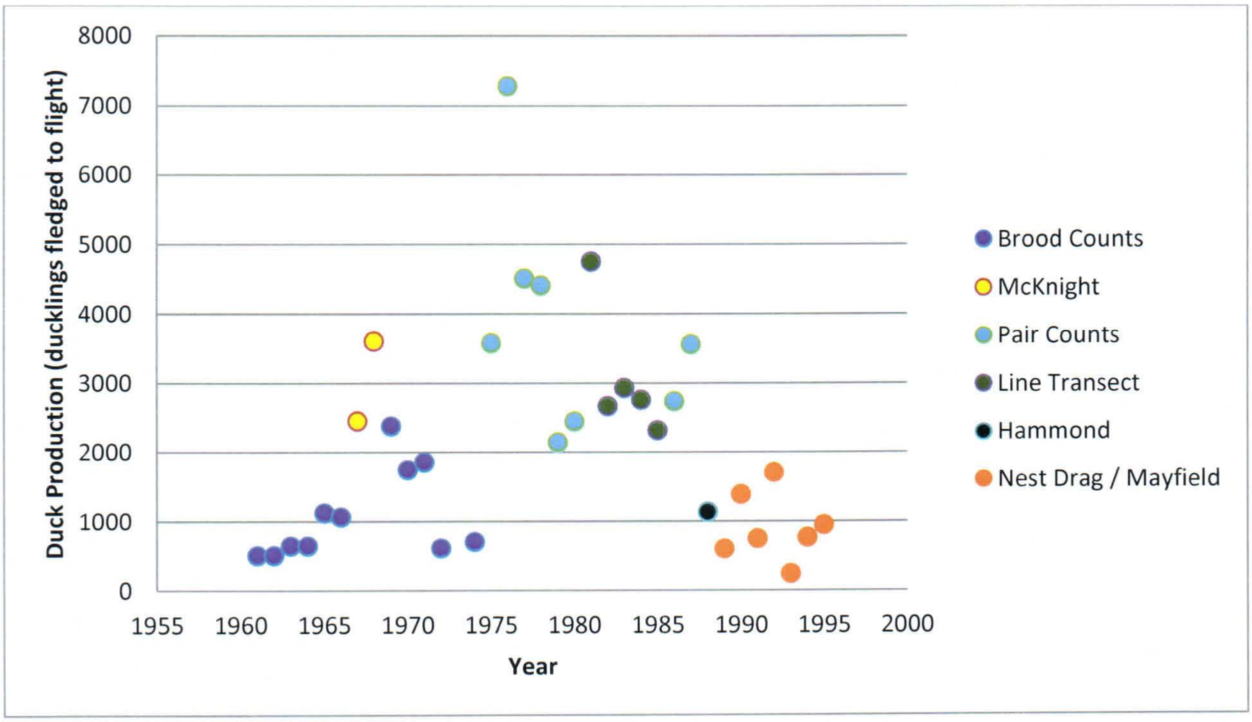


Figure 2. Duck production (number of ducklings fledged to flight stage) estimates, displayed by method, from 1960-1995 on Fish Springs National Wildlife Refuge, Utah. (Brood count estimates used the number of class III broods found during the summer. McKnight method used a combination of brood counts, nest success, and nest density to estimate production. Pair counts estimated production by multiplying the number of breeding pairs counted in spring by the average nest success and brood survival during the nesting season. The line transect method used distance sampling to estimate nest densities and multiplied the densities by the amount of nesting cover available, nest success, and brood survival to obtain a production estimate. Hammond's method used a modified brood count method. Nest drag / Mayfield method found nests through nest dragging with all-terrain vehicles and used the Mayfield method (Mayfield 1975) to calculate nest success. This estimate was then multiplied by the number of breeding pairs and brood survival to get a production estimate).



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