Reserve Report: American Kestrel Breeding Productivity, 2014

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Introduction
In spring 2014, the Reserve initiated a conservation project to expand American Kestrel (*Falco sparverius*) nesting populations into the Merced Vernal Pools and Grassland Reserve and to monitor their breeding success. Kestrels are common nesting birds in eastern Merced County, but there was no evidence that they currently nested in the Reserve. Kestrels are often seen foraging in the Reserve; we have observed them on 45 of 105 bird surveys conducted between January 2013 and August 2014 (Swarth unpubl. data). The maximum observed on one day was 12 in July 2013. The 6,500 acres in the Reserve represent a vast area of suitable nesting habitat for this small falcon.

In February and March 2014, a team of undergraduate students fabricated and erected ten handcrafted; wooden nest boxes in the Reserve. The boxes were strategically placed on existing fence posts and were monitored in May and June. The objectives of this study were:

- to attract kestrels to new, man-made nest boxes in the Reserve
- to measure nesting productivity in the boxes
- to band the kestrel chicks
- to band any adults that could be captured at the nest

Kestrels nested in 6 of 10 nest boxes and they produced a total of 15 fledged young which we banded. We also captured seven adults (6 females and one male) and placed bands on four birds. Three of the adult females had been banded on the Flying M Ranch; two in 2012 and one in 2013. This report summarizes the results of our study, the first conservation project to take place in the new Merced Vernal Pools and Grassland Reserve.

Background
American Kestrels are small falcons found across much of North America. They prefer open country for foraging and they require cavities for nesting. They are obligate secondary cavity nesters. Typically kestrels nest in small cavities in trees and cliffs. With deforestation and the subsequent loss of trees in many areas, kestrel populations have declined substantially across much of their range (Smallwood and Bird 2002, Smallwood *et al*. 2009). The availability of trees with suitable natural cavities can limit the areas they occupy for nesting. In parts of the United States there is a concerted effort by many organizations to stem these population declines by placing wooden nest boxes in areas

that contain suitable foraging habitat. Kestrels will readily adopt these boxes, which serve as substitute nesting sites for the tree cavities that they nested in historically.

Identification Field Marks

The American Kestrel is a robin-sized raptor with long, slender, pointed wings and a fairly long tail. Every time they alight on a perch, kestrels pump their tail several times – a classic behavior that helps to identify them. Up close it is possible to see two black vertical lines on the face. In flight, the long, narrow and pointed wings, long tail and rapid wing beats are characteristics they share with other falcon species. A kestrel could be mistaken for a Prairie Falcon, a much larger falcon that also occurs on the reserve. To recognize a kestrel, look for the bluish crown with the rufous or reddish patch on top, the reddish tail and reddish breast and black spots on a white belly. Males are slightly smaller than females and have blue-gray wings with dark primary feathers (Fig. 1). Females are reddish brown on the back, wings and tail. Their distinctive call is another clue that helps with identification – a loud, ringing *klee-klee-klee*. Kestrels prefer open areas and can be seen perched on power poles or electrical lines throughout Merced County and the San Joaquin Valley. They can also be easily identified because of their unique habit of hovering in place on fast beating wings over open areas as they search for insects and mice on the ground.

Figure 1. An adult male American Kestrel.

Reproductive Biology

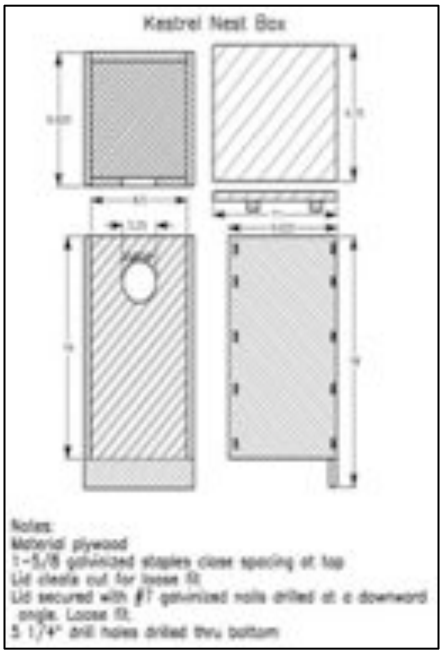
Kestrels are typically monogamous (Wegner 1976). In our area kestrels begin courting in February and March, and they mate and lay eggs in April and May. Timing of clutch initiation varies with latitude. The incubation period is 30 days and the male and female share the incubation duties. The male begins transferring food to the female 4-5 weeks prior to laying. The female typically lays one egg a day and incubation begins upon laying the second to last egg (Smallwood and Bird 2002). Clutch size is usually 3 to 5 eggs. The elliptical eggs vary in color from white to cream and are overlaid with rust colored brown blotches. Nestlings hatching timing is variable within a few days to a couple of hours. Usually the last egg of a clutch is faced with a competitive developmental disadvantage because of the lack of heat. Hatching asynchrony is the result of differences in parental incubation behavior and size (Bortolotti and Wiebe 1993).

The chicks are semi-altricial and open their eyes fully by the third day. Within a week their skin and talons develop color. By the second week, downy plumage covers most of the body and they are large enough to be banded.

The fledging period is 30 days. During this period both parents deliver prey to the chicks. A second brood may be produced, but these broods almost always have a lower chance of survival (Steve Simmons, pers. obs.).

During the first week after chicks hatch the male is the primary food provider, but thereafter the female takes the lead in bringing up to 40 items per day. Upon fledging the juveniles stay close to the nest, as they are dependent on the parents for food for about two weeks. Juveniles will likely migrate in August depending on prey availability and some go as far south as Mexico. Adults depart breeding grounds after old flight feathers are molted and new ones are grown.

METHODS



Nest boxes

Students built the 10 nest boxes on 22 February at Steve Simmons house in Merced, under the supervision of Steve and Bill Ralph. The boxes were made of thick, rough cut wood and measured 18 inches by 8 inches by 8 inches (see nest box schematic). The diameter of the circular opening was 3 inches. Each box received several handfuls of wood shavings to provide a clean, soft substrate for the eggs. We followed recommendations of Bird and Palmer (1988), who stated, “Nest boxes should be placed in open habitat, at least 3 m high and unobstructed. The bottom of box should be covered with 4–6 cm of wood shavings to cushion and insulate eggs.” The boxes were secured by bolts to wooden fence posts on 11 March and the geographical coordinates of each nest were recorded. Boxes were placed 2 m to 3 m above the ground and were spaced about 300 to 400 m apart. See Figure 2

Table 1. **Location of the American Kestrel nests in the Reserve.**

Nest Number	UTM Easting	UTM Northing
KB1	4139901	729007
KB2	4140165	729002
KB3	4140478	728901
KB4	4140659	728666
KB5	4140205	730579
KB6	4139994	730584
KB7	4139922	730948
KB8	4140108	731375
KB9	4139544	729055
KB10	4138847	728244

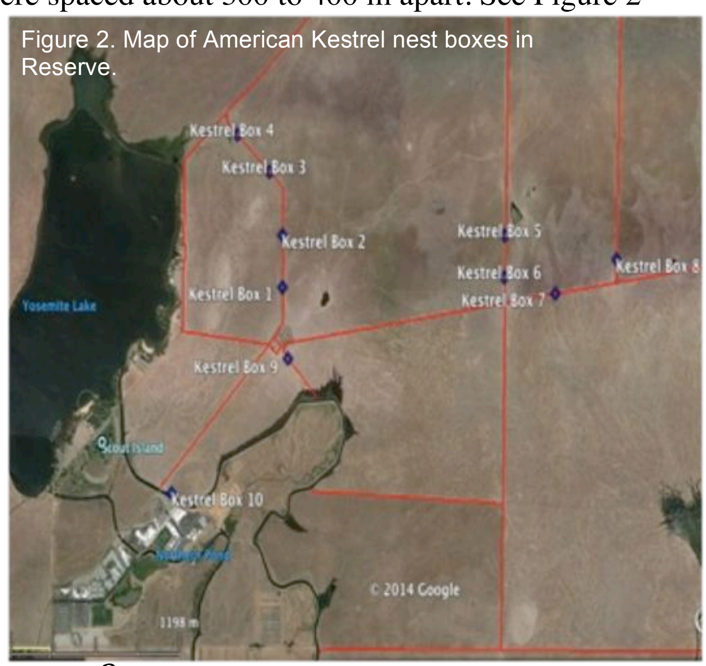


Figure 2. Map of American Kestrel nest boxes in Reserve.

and Table 1 for the location and geographic coordinates of the nest boxes.

Capturing, Handling, and Banding the Kestrels
We traveled from nest box to nest box in a truck. When we arrived at each nest we placed a small, custom-made round plug on a handle that fit inside the nest opening. This plug prevented the adult from flying out of the nest, making it possible to capture and band any adults that happened to be in the nest. We then used a 7-foot ladder to reach the top of the box (Fig. 3). Atop the ladder, we removed several short nails on the sides of top and slid a secondary top underneath. The secondary top was designed with a hole large enough to put one arm in to capture the adult kestrel (Fig. 4). If an adult was present it was promptly and carefully removed. With the bird firmly in hand and with wings held tight, we then checked for bands. We recorded the band number of any banded birds. If the bird was not banded we placed a band on the tarsus of the right leg. The band was opened with special pliers and carefully placed loosely around the bird's leg. Once placed around the leg, the open band was firmly secured in place with the pliers to ensure a comfortable, tight fit.


Figure 3. Aricia Martinez checks a nest box while Steve Simmons looks on.

If no adult was in the nest box at the time we checked, the lid was removed so we could examine the contents of the box. If chicks were inside the nest we carefully removed them, placed them in a cloth bag and carried them to the ground. The chicks were removed from the bag one by one to be banded. At this time we attempted to determine the gender of each chick by examining the coloration of primary flight feathers. Primaries are blue in males and are brown in females; however if chicks are too young they can't be sexed. Chicks were held with the left hand in order to have the right hand free to hold the pliers and bands. The right leg of the chick was held between two fingers in order to place the band. After the band was secured on the leg the chicks were put back in the bag and were carefully placed back in the nest.

We monitored the nest boxes on four days (14 May, 22 May, 5 June and 9 June) to determine clutch size, hatching success, fledging success and overall productivity, and to band the chicks.

Birds were banded under U.S. Fish and Wildlife Service permit #20416 issued to Steve Simmons. The UC Institutional Animal Care and Use Committee (AUP14-0002) authorized the research protocol.

Diet Investigation
Pellets are cast up regularly by raptors. They contain undigested prey remains such as bones, feathers, fur, fish scales and insect exoskeletal pieces. Pellets are an important source of information about what a raptor eats (Smallwood 1987). We collected these

regurgitated pellets from areas around the nests and will examine them in the lab to identify the remains and determine the diet of the kestrels.

Results

In mid-March, within several days of placing the boxes, we observed kestrels inspecting the boxes. We began checking the boxes in late April by which time clutches should have been complete and some chicks would have hatched. On 28 April, nest KB1 had 5 chicks. Other nests had eggs, but no chicks. Visits to all nests were made on 14 and 22 May, and 5 and 9 June.

Figure 4 Student Daniel Towes examines a nest box.

Table 2 indicates the clutch size, fate and productivity of the ten nests. Six of ten nests held eggs. Clutch size varied from 2 to 5 eggs. There were a total of 22 eggs in the 6 nests. Nests KB6 and KB8 had eggs, but failed to produce chicks. Two cold, abandoned eggs were collected. Their dimensions were 32 mm X 29 mm and 35 mm X 28 mm.

By the second week of May chicks were in four nests and eggs were in one nest. Of the 6 nests with eggs, four nests produced a total of 15 chicks. Nests KB1 and KB10 were the two most productive nests: 5 chicks fledged from each nest. Nest KB1 was on a fence post about 150 m north of the barn and nest KB10 was on a electrical pole next to Le Grand canal and adjacent to the main campus.

We also captured seven adults, four of which we banded (Table 2). Three of the females had been banded on the Flying M Ranch in 2012 and in 2013. The 2013 female was banded as a nestling, whereas the other two were banded as adults.

Table 2. American Kestrel egg and chick production, and number of adults banded or recaptured at the 10 Reserve nests in 2014. F = female; M = male.

Nest Box Number	Clutch Size	Number of Chicks Banded	Number of Adults Banded	Previously Banded Adults (recaps)
KB1	5	5 (1F & 4M)	0	F (#1783-41440)
KB2	0	0	0	0
KB3	0	0	0	0
KB4	0	0	0	0
KB5	4	3 (2F & 1M)	F (#1783-96235)	0
KB6	2	0 (1 cold egg)	F (#1783-96245)	0
KB7	2	2	0	F (#1783-45362)
KB8	4	0 (Eggs gone)	0	F (#1783-46241)
KB9	0	0	0	0
KB10	5	5	F (#1783-96227) M (#1783-96226)	0
Total 10	22	15	4	3

The distance from banding nest box at the Flying M ranch to the Reserve nest boxes, for the three banded females, varied from 3.3 to 5.5 miles (Steve Simmons, unpubl. data).

After all chicks had fledged, we visited the nest boxes one final time on June 9 to collect regurgitated pellets and prey remains, clean out the feces-encrusted debris, and recharge the box with fresh shavings. Pellets have been taken to Marilyn Fogel's lab where she and lab technicians are examining the prey remains to determine what the kestrels are eating.

<u>Notes from the Field</u>

May 14

Steve Simmons, Katharine Cook, Bryan Juarez, Cami Vega, and Chris Swarth set out to monitor the nest boxes at 8:00 am. Nest KB10 was the first nest we checked because it had 5 chicks on 28 April. Here we found five healthy chicks, now older than two weeks. The chicks were left undisturbed as they were still too young to band. There were no adults in the nest. We set a specially designed nest hole barrier within the nest, which would trap an adult in the nest after it returned to the nest. Typically parents bring in more than two prey items per hour so we knew she would return soon. Upon returning to this nest a short while later we found both the female and the male in nest. It was unusual to capture two adults in this manner, but it was fortunate for us because we were able to band both adults.

Nest KB9 was empty, but held some dried grass apparently from European Starlings that had initiated, but later abandoned the nest. We removed the grass.

Figure 5. Kestrel chicks in nest box KB1, 14 May 2014

Nest KB1 was checked next, where we found five chicks that were two or three weeks old (Fig. 5). The chicks (4 males and 1 female) were banded. The chicks were plump and looked well fed; we found the remains of two voles (*Microtus* sp.) inside the nest. A box trap was set to catch the parents, and we captured a previously banded female.

Nests KB2, KB3, KB4, and KB6 were all empty. The nest boxes were used as a perch for feeding kestrels so we were able to collect some prey remains.

Nests KB5 held three chicks (2 female and 1 male) and one egg. The chicks were too young to band and we captured a new female.

Nest KB7 held two chicks which were too young to sex, but old enough to band.

Nest KB8 held two eggs. According to Steve Simmons there was little likelihood that young could fledge from this nest because of the late date.

May 22
The four nests that were empty on May 14 (KB2, KB3, KB4, and KB6) were also empty today. Three chicks remained in KB5, but they were now old enough to band. We banded one female and two males. Nest KB7 held two chicks. We set up a nest box trap in KB7 and captured an adult female. Upon returning to the nest a short while later we discovered that we had caught the female and she was already banded. Steve had banded her at the Flying M Ranch in 2013 as a nestling.

In nest KB8 we found two additional eggs bringing the nest box total to 4 eggs. We captured and banded the adult female that was sitting on the eggs. The five chicks in nest KB10 were acquiring juvenile plumage and were now old enough to band.

May 28
Cami Vega and Chris Swarth observed the male kestrel from nest KB10 as it perched near the campus hydroelectric plant about 380 m southeast of its nest. A colony of Cliff Swallows nested on the south side of the power plant and adults were feeding chicks at this time. As we watched the male flew to the edge of the building near the nests, swooped out of sight and a few seconds later appeared with a Cliff Swallow in his talons. He flew onto an electrical wire where we could easily see the rust colored rump of the swallow. Unfortunately we could not determine if the swallow was an adult or a juvenile. A few seconds later the kestrel flew to the barbed wire fence near where we were observing it. It perched on a post (Fig. 6). The swallow was not moving. A few more seconds and the kestrel flew off, but it dropped the swallow. We thought the swallow was dropped into the tall grass so we immediately began searching the grass. We could not find the swallow and we suspect that the swallow was not dead and that it may have flown off. Unfortunately everything happened so quickly that we were uncertain if the swallow was dead or alive.

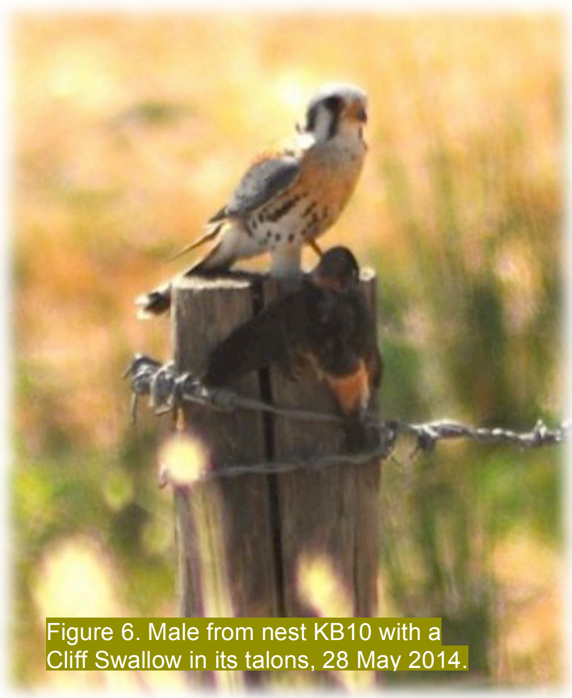


Figure 6. Male from nest KB10 with a Cliff Swallow in its talons, 28 May 2014.

June 5
Nest KB6 now held two eggs whereas it was empty on May 22. Steve doubted that these eggs would hatch considering the late date. Nest KB8, which had four eggs on 22 May,

was now empty. There were no eggshells in the nest, which suggests that a snake may have eaten the eggs. We have collected the shed skin of a Gopher Snake in the Reserve. The chicks from KB10 were still in the nest. All chicks from nests KB1, KB2, KB5, and KB7 had fledged. We observed several juveniles flying over the grasslands near their nests; these were probably the fledged young from the nearby nests. All other boxes were empty.

June 9
The five chicks from KB10 had fledged. Nest KB6 held a single cold egg (collected), but the other egg was missing. Cleaned all nest boxes and placed wood fresh shavings in each.

Behavioral Observations at Nest KB10

On May 16, Cami Vega and Chris Swarth observed nest KB10 for one hour, from 12:00 to 13:00. With binoculars we observed the nest from the east side of the new Student Services Building, adjacent to the Le Grand canal. We were about 75m from the nest. Our observations are summarized below:
12:02. Female kestrel on lower electrical wire above nest. She stares at ground.
12:10. Male arrives with mouse in talons. Flys to canal bank, lands, then flies to lower electrical wire but without the mouse. Where is the mouse? Did he eat it?
12:13. Female and male are perched on lower electrical wire above nest.
12:19. Male flies to ground below wire captures an insect and eats it. Male returns to wire. Male flies to ground again, captures an insect and eats it.
12:20. Female flies off. Male flies off.
12:25. Female returns with no food and perches on wooden crossbar at top of power pole.
12:25. A different female kestrel flies over the canal from east to west.
12:38. Female remains on wooden crossbar at top of power pole.
12:50. Female remains on wooden crossbar at top of power pole. No male in vicinity.
12:58. A Northern Mockingbird lands near the female kestrel, calls loudly and dives on the female.
13:00. Female flies into nest box.
13:01. Female flies out of nest box and perches on lower electrical wire.
13:02. Female flies out of sight to the south. Observations are ended.

Discussion and Conclusions

This conservation project demonstrates how a bird species such as the American Kestrel, which has special habitat requirements, can respond quickly and positively when a limiting factor such as nest sites are suddenly made available to them. Several factors may be responsible for this response. Researchers have found that the initial introduction of nest boxes to an area should be expected to result in high levels of occupancy (Smallwood *et al.* 2009). This is because there may be floaters (non-breeding birds without territories) in the population that are excluded from nesting by older, more experienced birds. Floaters are individuals that are able to enter the reproductive population as breeders when a breeding site or a potential mate becomes available. When new sites such as nesting boxes are provided the floaters may quickly take advantage (Penteriani *et al.* 2010). Another factor that may have caused the high occupancy that we documented could be related to the sudden loss of nesting boxes just a few miles south of the Reserve. For many years, Simmons monitored over 150 American Kestrel nest boxes on the adjacent 15,000-acre Flying M Ranch. In winter 2014, however, he was asked by the ranch owners to remove those boxes from the ranch. As a result, many kestrels that had formerly used the Flying M Ranch for nesting now had to look for nesting sites elsewhere. These factors – new nest boxes available in the Reserve and the loss of many nest boxes on the nearby ranch – likely played a role in our 60% nest box occupancy rate. Six of ten nest boxes were occupied within weeks of their placement and a total of 15 kestrel chicks fledged from these boxes. High occupancy and high productivity is especially encouraging considering that central California is in a severe drought, which could lead to depressed reproduction in many bird species.

Kestrel population declines have been largely ascribed to habitat loss and degradation (Smallwood *et al*. 2009), although disease and pollution are also important factors in some areas. The availability of trees with suitable natural cavities limits their breeding range. The availability of small mammals can be reduced because of drought, thus kestrel energy intake at these times can be limited by the prey they can find. Regardless, the mean nesting success (nesting attempts resulting in at least one chick surviving to banding age) was 68%. Though the study area appears suitable and kestrels had good reproductive success, there are simply fewer kestrels in the area than historically (Steve Simmons, pers. obs.). This decline may be associated with an increase in mortality during the non-breeding season due to the suitability of their wintering grounds (Smallwood and Bird 2002). The widespread decline in kestrel populations cannot be accredited to a single factor but it must be taken into consideration the importance of creating nesting habitats for them. We were pleased to discover that kestrels clearly found the Reserve to be suitable for nesting. We will continue to monitor the nests over the nest few years and will consider increasing the number of nest boxes.

There are several other American Kestrel nest box projects in this area. For example, Bill Ralph recently initiated a nest box program in the Merced County area. From his analysis and monitoring in 2014, Ralph concluded that this was a poor year for American Kestrels in terms of young produced. Many nestlings in his study were either predated, ejected by starlings, or suffered high mortality related to the drought. He monitored 151 nest boxes, however, there were only 35 nesting attempts and only 17 successful nests (a successful nest fledged at least one chick). In Ralph's study, out of 138 eggs laid, only 52 nestlings fledged: a success rate of only 38%. In contrast in our study, out of 22 eggs laid, 15 nestlings fledged: a success rate of 68%

Late clutches often are not as successful as earlier clutches. In our study no eggs hatched after 22 May. These eggs were laid later in the breeding season thus had a lower likelihood of survival. According to Steve Simmons' data from 2003-2012, the fledging success rate of kestrels drops significantly when a nest

Figure 7. Chris Swarth and Steve Simmons with visiting researchers.

is initiated late in the season. The likelihood of a nest being successful (eg. a nest that produces at least one fledgling) declines from over 80% if initiated in April and May to less than 11% when the nest is initiated in mid-May or later (S. Simmons, unpubl. data). See Table 3 for the percentage of successful nests by month that were monitored during ten breeding seasons.

Table 3. Monthly variation in nest success of American Kestrels in eastern Merced County, California, 2003-2012. Steve Simmons, unpubl. data.

	March	April	May	June	July
Total Nest Initiations	207	185	39	57	4
Number of Successful Nests	178	152	9	4	0
Percentage of Successful Nests	86.0%	82.2%	23.1%	7.0%	0

Kestrels are opportunistic raptors that take a wide variety of vertebrate and invertebrate prey. According to Sherrod (1978), terrestrial arthropods and small vertebrates, especially small rodents, are the main kestrel prey. Through a preliminary analysis of 18 pellets we collected at the nest boxes, we discovered that most pellets were composed primarily of insect parts. Pellets were dissected dry in accordance with the method of Davis (1975). Grasshopper and dragonfly exoskeletal remains predominated, however we also identified beetle and arachnid remains. Only a few pellets contained fur or animal bones. Of the pellets that were dissected, one contained the jawbone of a vole (*Microtus* sp.). We also collected four pocket gopher (*Thomomys bottae*) skulls that we found inside nest boxes KB1 and KB10. Pocket gophers are large prey, at 62 to 122 grams (Howard and Childs 1959), for a kestrel which weighs from 80 to 165 grams (Smallwood and Byrd 2002). Simmons has not identified gopher remains in kestrel boxes before and was surprised at this discovery.

Errington (as quoted in Davis 1975) discovered many years ago that *Falconiformes* pellets are imperfect indicators of diet compared with those of owls since digestion is more thorough in *Falconiformes*, leaving fewer of the hard parts of prey. We will recognize this bias in our eventual analyses of pellets.

Variation in food availability can influence kestrel clutch size and health (Dawson and Bortolotti 2002). The size and availability of the prey items may also influence sexual size dimorphism, nestling competition, and sex ratio within clutches (Anderson *et al.* 1993). For the past several years Central California and Merced County have experienced a serious drought. Dawson and Bortlolotti (2002) also found that food supply and weather influence parental provisioning, offspring size and mortality. Anderson *et al.* (1993) found that when food shortages occurred and only small prey is fed to nestlings, females survive at higher rates than males. Grasshoppers were observed in swarms throughout the grasslands in June and July, suggesting that this prey item was plentiful during our study.

In conclusion, we learned a tremendous amount about American Kestrel reproductive biology by erecting the nest boxes and following the fate of the breeding efforts. Kestrels are now a member of the breeding avian community of the Reserve. This winter we will further evaluate our findings to determine if we want to expand the number of nest boxes.

Future Research Questions

- The relationship between kestrel prey availability and weather.
  Dawson and Bortolotti (2000) examined how natural variation in abundance of prey impacts parent, and offspring size and survival.

- Kestrel foraging during the breeding season
  Rudolph (1982) looked at the hunting methods and foraging strategies during breeding.

- Kestrel clutch size and nesting success
  Tella *et al*. (2000) studied the trade-off between clutch size and nestling viability in a cross-fostering experiment that examined offspring immunocompetence by measuring the T-cell-mediated immune response of fledglings.

- Mating success and plumage condition
  Wiehn *et al*. (1997) examined the role of blood parasites in kestrel mating success and host fitness and found that reproductive effort may result in parasitic infections.

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