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# Effects of translocation on the Florida Burrowing Owl, athene cunicularia floridana

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Effects of Translocation on the Florida Burrowing Owl, *Athene cunicularia floridana*

by

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Dedication

This thesis is dedicated to my parents Lary Franklin Nixon and Gunilla Marie-Louise Nixon, as well as Kari Blitch who have been incredibly supportive during the process of acquiring my thesis. Especially to my father who took me out fishing on Sundays when I was a kid and said we were closer to god outside anyways. Thanks Dad!

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ABSTRACT

At present, the Florida Burrowing Owl is being threatened by extensive habitat development throughout their small range in the state. Unfortunately, developers are able to collapse burrowing owl burrows during the non-breeding season and flush the owls from an area. In other areas such as Arizona and British Columbia translocation is being utilized to mitigate the effects of development on burrowing owls. In March 2006, the only translocation of burrowing owls in Florida was conducted by Mosaic Phosphate Company.

The purpose of this thesis was to elucidate the effects of translocation on Florida burrowing owls. Topics of research include activity budgets, insect trapping, burrowing owl diet, prey availability, and hatching success for two populations of Florida burrowing owls in Hillsborough and Polk Counties, Florida.

Results of this study indicate that translocation has little effect on Florida Burrowing Owl activity budgets. There were significant differences in scanning, time spent in the burrow, and resting between the control and treatment groups (p < 0.05).

Though differences in behavior were present between translocated and non-translocated study groups, there was no statistically significant difference ($p < 0.025$) between the pre- and post translocation study group.

Results of the prey availability study indicate that while there are significantly different amounts of arthropods between study areas ($p < 0.025$), a threshold or satiation point may have been reached at these areas, as trapping results do not match diet results. This satiation point may have been due to cattle dung present at the burrowing owl's breeding areas, which provides a micro-habitat for many prey items.

While hatching success was lower for the post translocation group compared to the pre-translocation group, hatching success also was decreased for the control group. This overall decrease indicates that translocation was not the main factor affecting the hatching success of our study groups.

**Chapter 1: Effects of Translocation on the Behavior of Florida Burrowing Owls**

**Introduction:**

The Florida Burrowing Owl, *Athene cunicularia floridana* has been classified as a Species of Special Concern since 1979 by the Florida Fish and Wildlife Conservation Commission (Millsap 1997). The Fish and Wildlife Service has also classified the Florida burrowing owls as, a Bird of Conservation Concern (Klute et al. 2003). The *A. c. floridana* has been designated conservation status primarily due to population decline caused by habitat fragmentation, degradation, and loss of essential ecosystems (Ewel 1990).

Phosphate mining disturbs an additional 5,000 to 6,000 acres/year in Florida. Approximately 60% of these lands are upland or mesic habitats (Department of Environmental Protection, 2005), and pasture lands. Much of these mined lands support stable burrowing owl populations (R. Concuby pers. comm. 2005). In previous relocation attempts the owls were not moved far enough from the mining site and were repeatedly disturbed as they were pushed along by the leading edge of mining activity (Biological Research Associates and Mosaic Fertilizer, LLC 2005).

Mined lands are reclaimed as natural habitats, as well as improved pasture for cattle grazing. Florida burrowing owl colony once displaced during the mining, have not recolonized these reclaimed lands once mining operations had desisted.

Historically, colonies were expected to passively relocate of their own accord, possibly by dispersal. Reclamation of previously mined phosphate lands has the potential to produce a significant amount of suitable burrowing owl breeding habitat. Therefore, forms of colonization, other than dispersal could be utilized to encourage burrowing owl use of suitable breeding habitat within reclaimed phosphate lands.

Translocation has been used in many other localities where burrowing owls occur; such as California, Arizona, British Columbia, Oregon, and Washington. This method has been used to aggressively relocate burrowing owls to suitable habitat. Griffith et al. (1989) define translocation as, "…the intentional release of animals to the wild to establish, reestablish, or augment a population and may consist of more than one release."

Currently no data regarding translocation efforts and Florida burrowing Owl populations exist. However, studies have investigated translocation efforts involving the western burrowing owls. These studies may help in predicting how Florida burrowing owls may react to translocation and predict the potential of burrowing owls to assimilate to their new breeding habitat.

Previous studies have indicated that burrowing owls may not assimilate to translocation. Feeney (1997) documented that burrowing owls may not assimilate to translocation due to unfamiliar prey base, presence of predators, fault in Artificial Burrow System (ABS) design, and unfamiliar disturbance. Delevoryas (1997) studied the effect breeding had on success of translocation efforts. Breeding pairs exhibited higher site fidelity after translocation. The author also suggests that if burrowing owl habitat management (such as mowing) had occurred as scheduled, then the translocation would be more successful. Delevoryas also states that burrows may have been too close

together, so that males had territorial interactions which may have resulted in undue stress. He also states that supplemental feeding was overly extensive after release. The large mass of food routinely placed for burrowing owls may have attracted predators that also preyed on the burrowing owls (Delevoryas 1997).

Behavior is an important tool that can be used to measure the effects of translocation, by helping to understand how organisms interact with their environment. Behavioral studies may also help in planning future translocations, by elucidating causes where problems have occurred (Owen-Smith 2003). For instance if a species is translocated to an area that has much lower prey availability, one would expect to find an increase in hunting behavior. For a translocation area with a higher predator density, one would predict increases in scanning or levels of alertness. If the predator was an avian species, one would predict an increase of scanning aimed at the sky, where as a ground based predator would elicit more scanning towards the ground.

Bowen (2000) was the first to quantify and describe behaviors common to Florida burrowing owls, including burrow maintenance, feeding young, roosting, preening, hunting, and territory defense. Mrykalo (2005) investigated habitat transition probability and quantified the behavior of adult and juvenile burrowing owls, which included preening, scanning, hunting, feeding young, vocalizing, digging, self feeding, and thermoregulation. Juvenile behaviors he recorded included scanning, dozing, being fed by adult, vocalizing, digging, flying practice, stretching wings, and running into burrow (Mrykalo 2005).

A Florida Burrowing Owl translocation project conducted by Mosaic Fertilizer Company (Mosaic) offered a unique opportunity to study the effects of a translocation on

Florida burrowing owls. Ten Florida burrowing owls were captured from an area owned by Mosaic that is currently permitted to be mined. Burrowing owls were translocated to a previously mined tract and a reclaimed tract of land also owned by Mosaic. This study investigates the effect of the translocation on the activity budgets of two rural populations of the Florida burrowing owls.

**Hypotheses:**

*Activity Budget between populations:*

$H_0$: There will be no difference in activity budgets medians between Control and Treatment populations.

$H_A$: There will be a difference in activity budgets medians between Control and Treatment populations.

*Activity Budget among the same population:*

$H_0$: There will be no difference in activity budgets between pre and post translocation populations.

$H_A$: There will be a difference in activity budgets between pre and post translocation population, such as increased scanning or food gathering activities after translocation.

**Study Site:**

The control population located at Lonesome Mine, Mining Unit 16 (LM). The pre-translocated population was located at Fort Lonesome West (FLW), located adjacent to Mining Unit 16, on the west side of S.R. 39. Together these two tracts of land

comprise approximately 1,432 acres of typical improved pasture. The post-translocated

population was located at Fort Green Mine (FGM). FGM is located in Polk County,

Florida and is a 590 acre reclaimed tract of land similar to improved pasture. This parcel

of land was last mined in 1983 and reclaimed as Florida state law requires (Fla. Stat. Ch.

378 and Fla. Admin. Code Ch. 62C- 16). It is located approximately 5 miles south west

of the two Fort lonesome sites.

Climates for all three study areas were similar because they are located within 5

miles of each other. Southeast Regional Climate Center's weather station located in Fort

Green (FORT GREEN 12 WSW, FLORIDA (083153)) reports the annual average

temperature ranged from 45.5F to 91.6F and the average annual precipitation to be 54.85

inches.

**Methods:**

Twelve Florida burrowing owls were captured from an area owned by Mosaic that

is currently permitted to be mined. Burrowing owls were translocated to a previously

mined and reclaimed tract of land also owned by Mosaic.  During the capture, burrowing

owls were banded. At the reclaimed site, burrowing owls were released into enclosures,

where ABS were provided. During their stay in the enclosure, burrowing owls were

supplementally fed water, 20 crickets, and 2 mice per burrow per day. The birds were

released from the enclosure after 18 days.

One population underwent translocation by the methodology described previously

and the other remained in its natural habitat, undisturbed (thus, the translocated

population will be the treatment group and the non-translocated population will be the control group).

Observational periods were defined as continuous time, focal animal sampling (Altmann 1974). Cycling started with a randomly chosen individual and lasted for 30 minutes. Observations were conducted for each population (control and treatment) two days a week for 6 hours. Observations occurred at two times, morning (from sunrise to 12:00 noon) and evening (12:00 noon to sunset). The times of day that observations were recorded were staggered to allow for the coverage of all times and behaviors (Altmann 1974). The control population was observed from June 16, 2005 to May 30, 2006. The treatment population was observed for two periods. The first period was from June 10, 2005 to February 28, 2006 (pre-translocation population) and from April 2, 2006 thru July 8, 2006 (post translocation population).

Burrowing owls were observed and their behavior was recorded to determine differences in behavior that may occur due to translocation. This was accomplished by noting starting times each time a new behavior ensued. Burrowing owls were observed from approximately 100m, using a 60 x 80 spotting scope or binoculars to identify individuals and to observe changes in behavioral events. Times, events, and approximate location (i.e. at burrow/on perch, at burrow/on ground, away from burrow/on ground, and away from burrow/on perch) were recorded to the second and a voice recorder was utilized to allow constant monitoring of the subject. Date and time of each observational period were recorded, as well as the identity of each bird under observation.

In order to indicate the percent of time individual owls engage in each activity, behaviors were reduced to behavioral events. The behavioral events (Boxall and Lein 1989) observed for include:

*Burrow maintenance:* Digging of or altering burrow

*Comfort movements:* Stretching, yawning and fluffing of feathers

*Gular flutter:* Panting for cooling purposes

*In burrow:* Bird has gone into burrow and actions cannot be ascertained

*Out of burrow:* Bird is not visible, away from burrow, and actions cannot be ascertained

*Hunting:* Walking, running, hawking, and flying in a directed manner at some specific area or if the bird travels and comes back with a prey item

*Preening:* Any type of movements, where feathers are adjusted such as manipulating feathers with bill

*Pellet regurgitation:* Digging or altering burrow

*Scanning:* Active and alert, moving head to examine environment at least 6 times a minute

*Scanning/ cooling:* Same as above, only with wings held out slightly to sides

*Resting:* Sleeping or dozing, with closed eyes and retracted head

*Aggression:* Head bobbing and wing fanning in a directed manner

*Interspecies interaction:* Acting at or upon another burrowing owl

*Burrow Decoration:* Bringing non-food items to burrow

*Flight Practice:* Juveniles are flapping wings but not able to fly

*Other:* Any action that is not described above

Activity budgets were constructed from the observations and were used to investigate any shifts in time allocation between control and treatment populations (Boxall and Lein 1989), as well as between pre- and post- translocation periods. I define activity budget is the average proportions of time spent on various activities, by a group of burrowing owls. All adult daily totals were transformed into z-scores to normalize data. Student's T-test was performed to compare z-scores between populations and Mann-Whitney U-test was used to compare daily total medians between pre and post translocation in the treatment population for adults, males and females (Sokal and Rohlf 1994).

Videos complemented investigators observations for accuracy verification. The behavioral data from the videos was used to calculate observer error. The Mann-Whitney test was used to calculate observer error (Sokal and Rohlf 1994).

**Results:**

I collected approximately 480 hrs of observations for the control population and 608 hrs were collected for treatment population. 422 hours of observations were collected for the treatment population prior to translocation and 186 hours after translocation. Proportions of owl behaviors are shown in Table 1. The top three behaviors for the control population were scanning (47.08%), in burrow (33.61%), and resting (6.74%); for the pre-translocation population they were scanning (46.62%), in burrow (37.16%), and resting (7.36%); and for the post translocation

population were scanning (59.47%), in burrow (21.19%), and scanning/cooling (6.59%).

Table 1. Proportions of Total Behaviors Observed

| | Maintenance | Comfort | Gular Flutter | In Burrow | Hunting | Out of Burrow | Preening | Regurgitate | Resting | Scanning | Scan/Cool |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **_Control_** | | | | | | | | | | | |
| Adult | 0.32 | 0.81 | 0.06 | 33.61 | 1.82 | 1.35 | 3.55 | 0.06 | 6.74 | 47.08 | 4.61 |
| Male | 0.52 | 0.24 | 0.05 | 21.67 | 3.36 | 0.33 | 5.40 | 0.03 | 3.14 | 58.98 | 6.27 |
| Female | 0.39 | 1.47 | 0.05 | 28.41 | 2.55 | 0.63 | 4.27 | 0.02 | 3.23 | 50.67 | 8.31 |
| juvenile | 1.02 | 1.27 | 0.00 | 31.09 | 1.63 | 0.17 | 4.67 | 0.00 | 6.69 | 50.78 | 2.68 |
| **_Pre-trans_** | | | | | | | | | | | |
| Adult | 0.23 | 0.75 | 0.19 | 37.16 | 1.36 | 1.44 | 3.13 | 0.08 | 7.36 | 46.62 | 1.67 |
| Male | 0.36 | 0.14 | 0.00 | 23.69 | 2.62 | 0.00 | 4.98 | 0.00 | 0.22 | 64.80 | 3.19 |
| Female | 0.66 | 0.33 | 0.00 | 32.30 | 2.16 | 0.00 | 4.04 | 0.00 | 0.94 | 56.95 | 2.63 |
| juvenile | 0.60 | 0.13 | 0.00 | 34.67 | 1.30 | 0.23 | 5.73 | 0.00 | 1.43 | 54.20 | 1.70 |
| **_Post-trans_** | | | | | | | | | | | |
| Adult | 0.30 | 1.42 | 0.03 | 21.19 | 2.56 | 0.71 | 5.33 | 0.02 | 2.38 | 59.47 | 6.59 |
| Male | 0.28 | 1.27 | 0.00 | 21.05 | 2.98 | 0.41 | 5.03 | 0.00 | 1.28 | 60.75 | 6.95 |
| Female | 0.25 | 2.11 | 0.08 | 24.61 | 1.49 | 1.20 | 5.24 | 0.06 | 4.65 | 54.32 | 5.98 |
| juvenile | 0.66 | 0.53 | 0.00 | 28.09 | 0.92 | 0.00 | 3.88 | 0.00 | 6.64 | 47.76 | 11.51 |

Between Populations:

Prior to translocation, the adult control and treatment populations were similar (df = 61, and p > 0.05) except that scanning/cooling was greater for the treatment population (p = 0.001) in the morning. They were similar in the evening (df = 61 and p > 0.05) except that resting (p = 0.001) and scanning/cooling (p = 0.015) were greater for the treatment population in the evening.

After translocation the adult control and treatment populations had similar proportions of behavior (df = 31 and p > 0.05) in the morning. And the proportions of behavior were similar (df = 29 and p > 0.05) in the evening.

Within Population:

Proportions of behavioral events did not change significantly between the pre- and post- translocation adults (U > 52, n = 19 and 25 p > 0.05). Proportions of behavioral events did not change significantly after translocation for male morning behavior (U > 45, n = 9 and 19, and p > 0.05) nor for evening behavior (U > 41, n = 8 and 20, and p > 0.05). Portions of behavioral events did not change significantly after translocation for female morning behavior (U > 45, n = 9 and 19, and p > 0.05) nor for evening behavior (U > 41, n = 8 and 20, and p > 0.05).No significant error was indicated between field observations and videotaped sessions (U > 5, n = 6 and 6, and p > 0.05).

**Discussion:**

There were significant differences in behavioral time allotment between populations. Surprisingly there were no significant differences in behavioral time allotment amongst the treatment population pre and post translocation. Fortunately, this may indicate that translocation that was performed here may have little effect on burrowing owls.

Differences in thermoregulation between the control and treatment populations in the morning may have been caused by slight climate differences, such as wind flow that would cause certain areas to stay cooler longer in the morning, thus requiring there to be less thermoregulatory activities within that time period. The differences in thermoregulation and resting in the evening may have been due to the same factors.

Perhaps an investigation on microhabitat variables or wind barriers would elucidate on this discrepancy.

Lack of difference in behavior between pre and post translocation of the treatment population may indicate that the new habitat was similar to the original habitat. Indeed, the habitats were similar from the observer's perspective, in that both areas were improved pastures and stocked with about the same number of cows per acre. Both areas also had water sources nearby and were approximately the same distance from tree lines. Vegetation structure also appeared similar in that it was low growing ground cover vegetation dominated by grasses. Insect trapping showed that there was greater abundance of prey (Scarabaeidae) at the pre-translocation habitat, but behaviorally there is no indication that the owls increased hunting or scanning activities.

Interestingly, for a short period just after release, the post translocation population had a coyote frequenting their burrows, but apparently caused little interference with daily behaviors of the owls. Perhaps burrowing owls easily adapt to their new surroundings. This concept is supported by Wesemann's (1986) findings in Cape Coral, where Florida Burrowing Owl density tolerated disturbance of the vacant lots. It is important to note that population density increased after 60% of the vacant lots were developed. It may be that translocated burrowing owls also do well in rural settings when there is limited disturbance in relocated areas.

Activity budgets differed from those reported by Mrykalo (2005) in that he reports scanning, thermoregulation, and hunting to be the most observed behaviors respectively, where as this study shows scanning, in burrow, and thermoregulation (scan/cooling) to be the top three behaviors, respectively. A possible reason why these

populations spend more time in the burrow is that there is less need for hunting activities, due to the high abundance of insects. This difference may be due to habitat, as Mrykalo's (2005) rural population was not located on land grazed by cattle and owls may not be as accustomed to disturbance and thus spend a greater amount of time out of the burrow where potential predators may be spotted in time. Also the proximity of the owls to anthropogenically altered habitat in this study is much less than that in Mrykalo's study (2005).

During the course of this study there were a few sets of behavior that, while not captured in the observation samples, warrant discussion. The reason for the discrepancy may be that these behaviors occurred extremely infrequently and thus had very low probabilities of being captured by a behavioral sample. For instance, adult males appear to be teaching juveniles to hunt. In this situation, males would be on the perch provided at each burrow, while one or more juveniles would gather around below his perch, then the adult would fly a short distance to capture prey. The adult would vocalize and a juvenile or two would then approach on foot to the approximate area where the capture had occurred. The juveniles would then apparently "hunt" the prey the adult had found. This hunting behavior entailed flapping of the juvenile's wings and/or jumping on the prey with talons or grabbing it with their beak. These "training sessions" were observed only twice in the control population.

Also on two separate occasions owls were observed digging under, as well as flipping over cow dung piles and capturing insects often found under them. Upon subsequent examination of cow dung, many (≈ 90%) had at least one sizable insect underneath, though most (≈ 70%) had more. Other avian species such as cattle egrets and

sandhill cranes were also observed showing similar behavior by flipping over cow dung and capturing insects, albeit with less effort due to their larger size.

**Management Implications:**

For the time and energy spent on this type of study it may be more efficient to investigate wildlife behavior with some other method, such as instantaneous sampling. This method would require less effort on the part of the observer, while providing about the same quantity and quality of data. Many of the owls that were part of the translocation were not spotted after the translocation. These owls may have encountered difficulty during the translocation, because they were not observed again. If further behavioral studies are to be conducted on burrowing owls, it may be helpful to have some way of identifying and relocating them, such as radio collars. Ultimately the success of a translocation depends upon the establishment of self sustaining populations (Griffith et al 1989). This behavioral study indicates that Florida burrowing owls are able to quickly adjust to their new surroundings, but may need more than one translocation to establish a self sustaining population.

**Chapter 2: The Effects of Translocation on Prey Availability for Florida Burrowing Owls**

**Introduction:**

Studies of prey remains in Florida burrowing owl stomachs (Palmer 1896, Bent 1938, and Lewis 1973) regurgitated pellets, (Hoxie 1889, Palmer 1896, Neill 1954, Hennemann 1980, and Wesemann 1986), and burrows (Bent 1938, Neill 1954, Nicholson 1954, Owre 1978, Hennemann 1980, and Wesemann 1986) have shown that the diet of the Florida Burrowing Owl is quite expansive. Major prey items for rural Florida burrowing owls are invertebrates, especially arthropods (Ridgeway 1874, Cahoon 1885, Hoxie 1889, Rhoades 1892, Palmer 1896, Bent 1938, Sprunt 1954, Lewis 1973, Wesemann 1986, and Mrykalo 2005). Lewis (1973) investigated the contents of 57 Florida Burrowing Owl's stomachs. He reported that invertebrates make up the majority of diets at 82% volume for invertebrates (66% of which were Coleoptera) and 18% vertebrates. Hennemann (1980) reports that his analysis of regurgitated pellets contained only one instance of vertebrates, but found the remains of vertebrates at their burrows. Mrykalo indicates that diet of burrowing owls consists of 99% invertebrates (with 89% insects, 9 % spiders, and 2 % gastropods) and 1% vertebrates (2005). Ground dwelling insects tend to be the vast majority of food items consumed by Florida burrowing owls during the breeding season (Martin 1973, Wesemann 1986).

Florida burrowing owls have not immigrated to reclaimed phosphate mines. Perhaps the prey needed to support a burrowing owl colony is not available at these reclaimed sites. Because translocation may be a viable way to facilitate the return of stable colonies of Florida burrowing owls to these reclaimed lands, it is important to understand what prey availability exists at translocation sites. Preferably abundance and richness of the translocation site would be equal to or greater than that of the donor site (Griffith et al 1989). Conversely, reclaimed areas generally have less abundance and richness in vertebrates then to premined sites and this lower count may be due to lack of colonization (Mushinsky and McCoy, 2001). It is possible that invertebrates follow this same trend. Because one of the major food sources for burrowing owls is invertebrates, the availability of these prey items may determine the success of a translocation.

Therefore, my objectives are to investigate invertebrate prey availability to Florida burrowing owls (*Athene cunicularia floridana)* in relation to translocation onto reclaimed phosphate mines. Precise definitions of prey availability are elusive due to the large amount of factors that may determine availability, such as palatability, detectability, and digestibility, among others (Menge 1972). For my purposes I define prey availability as the combination of abundance of prey items in relation to the preference of Florida burrowing owls for those prey items. To investigate prey availability, I examined the relative prey abundance between two rural burrowing owl habitats and a reclaimed phosphate mine (recipient site). To investigate prey preference I also examined the frequency of prey items in the diet of two rural populations of Florida burrowing owls.

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**Hypotheses:**

*Relative prey abundance*

$H_0$: There will be no significant difference in prey abundance between study sites.

$H_A$: There will be significant differences in prey abundance between LM and FLW.


$H_0$: There will be no significant difference in prey abundance between LM and FGM.

$H_A$: FGM will be significantly lower in prey abundance than LM.


$H_0$: There will be no significant difference in prey abundance between FLW and FGM.

$H_A$: FGM will be significantly lower in prey abundance than FLW.


*Diet*

$H_0$: There will be no significant difference in diet between control and treatment populations.

$H_A$: There will be significantly different frequencies of prey items in the diet between control and treatment populations.


$H_0$: There will be no significant difference in the numbers of prey items consumed by the pre and post translocation populations.

$H_A$: There will be in significantly less frequency of prey items consumed by the post-translocation population compared to the pre- translocation populations.

*Prey availability*

$H_0$: There will be no difference in prey availability between LM and FLW.

$H_A$: There will be a difference in prey availability between LM and FLW.


$H_0$: There will be no difference in prey availability between FLW and FGM.

$H_A$: There will be less prey availability at FGM compared to FLW.


**Study Site:**

     This study collects behavioral data from two populations of burrowing owls at three locations. The control population is located in at Lonesome Mine, Mining Unit 16 (LM). The pre-translocated population is located at Fort Lonesome West (FLW), located adjacent to Mining Unit 16, on the west side if S.R. 39. Together these two tracts of land consist of approximately 1,432 acres of typical improved pasture in Hillsborough County, Florida. The post-translocated population is located at Fort Green Mine (FGM). FGM is located in Polk County, Florida and is a 590 acre reclaimed tract of land similar to improved pasture. This parcel of land was last mined in 1983 and reclaimed as Florida state law requires (Fla. Stat. Ch. 378 and Fla. Admin. Code Ch. 62C- 16). It is located approximately 5 miles south west of the two Fort lonesome sites.

**Methods:**

**Relative Prey Richness and Abundance**

Insect trapping was conducted at the LM, FGM, and FLW to assess the relative richness and abundance of prey items present for Florida burrowing owls among these sites. The trapping sessions occurred twice a month for one year (May 2005 to May 2006) at each site. Each sample consisted of 10 traps for 48 hours. Each site had five transects containing two pitfall traps each.

Transects were placed 200 m (as owls were rarely seen hunting this far from their burrow [≈ 5% of hunting activities]) from a randomly selected burrow or artificial burrow in a random direction. Randomness was achieved using a random number table to get compass heading. The pitfall traps were placed between 1 to 10 m in a random direction (a random number table was used to get compass headings) from that point. At the site receiving owls following the translocation, traps were set up randomly within the predetermined areas where the owls would be located. Here, a grid was constructed for the area and random X and Y coordinates were generated. The traps were then placed according to the above transect scheme.

Pitfall traps consisted of # 10 coffee cans buried flush with the ground. Each contained an inch of soapy water in the bottom to prevent the escape of trapped insects (Wesemann 1986). Traps were not covered to prevent flooding from rain; although they were checked more often on rainy days. This procedure allowed for the trapping of insects that use flying or jumping as their method of transport, such as Acrididae or Gryllidae.

Each day traps were checked at least once and insects were collected, counted, and recorded by Family for each of the three study areas. Traps were turned over after each session to prevent the unnecessary trapping of insects. Examples of collected insects were identified to the Family level using a dichotomous key (Bland and Jaques, 1978).

The frequencies of trapped insects from each site were categorized by Family and then their medians were compared using the Mann-Whitney U-test, as the data were not normally distributed (Sokal and Rohlf 1994). Due to large sample size (n > 20), normal approximation was used (Sokal and Rohlf 1994). Total counts of insects trapped at each site were also used in the weighed abundance index (Poulin and Lefebvre 1997) explained below in the prey availability methods.

**Diet Analysis:**

The diet of Florida burrowing owls was determined by analyzing regurgitated pellets. Regurgitated pellets were collected from anywhere within 10m of each active burrow at least twice a month. For each pellet the date and location were recorded during collection. Only intact pellets where collected if available, to ensure that they were regurgitated closest to the time of collection. Pellets breakdown very quickly in the rain, thus old samples tended to appear as a pile rather than as a pellet. Because it was difficult to see which burrowing owl produced the pellet, pellet contents for the entire study population (control or treatment) were reported, not per individual burrowing owl. The total numbers and Families of insects and other ingested prey items found in the pellets were calculated to indicate the frequency of prey in the owl's diet (Wakeley 1978).

Pellet analysis was conducted in a laboratory setting. First the pellets where dried in an incubator overnight, then dismantled using a 10 x 3 dissecting stereomicroscope. Dissection consisted of disassembling the pellet and separating the contents by type of prey, especially using easily identifiable exoskeletal sections, such as mandibles, head capsules, and elytra (Wesemann 1986; Gleason and Craig 1979; Bob Mrykalo pers. comm. 2003). Insect exoskeleton parts were compared to previously identified trapped insects, and identified to the lowest taxon possible. Vertebrate items were identified using specimen collection at the Florida Museum of Natural History in Gainesville, Florida. The animal parts were analyzed to discern the minimum number of prey items they represent per pellet. The frequency of prey ingested, as indicated by pellet contents were recorded to the level of Family and grouped according to site and date found.

Each study population's pellet contents were summed up for each month by Family. Mann-Whitney U-test was used to compare medians to test for differences between diets of the study populations at each site (Sokal and Rohlf 1994). The proportions of prey items consumed for each population were used in calculating the weighted abundance index given below.

**Analysis of Food Availability:**

The presence of prey items alone does not necessarily indicate the level of food availability for a given species within a given habitat (Hotto 1981 and Wolda 1990). In the case of burrowing owls, investigating relative insect abundance and richness, in conjunction with diet analysis when entered into a weighted abundance index, should indicate the presence of a suitable prey base (Poulin and Lefebvre 1997).

Prey availability was formulated by first calculating a burrowing owl preference score for each family of prey item, then using these scores concurrently with prey abundance for that population's respective location(s). I then utilize these figures in a weighted abundance index. To estimate food availability I adapted Poulin and Lefebvre's "weighed abundance index" (1997) to give a total abundance within an area for the whole sampling period. There index is designed to give a weighted abundance during a certain season within an area, where as mine is not. The weighed abundance is given by:

$$\text{Non-seasonal weighed abundance index} = \sum (P_i (T_i))$$

Where $P_i$ is the proportion of arthropods from group $i$ in the bird's diet and $T_i$ is the total number of arthropods in group $i$ collected from the study site.

The scores from the abundance index were used for each site and compared amongst themselves. Additionally, the scores were compared to the statistical results of each study site. This enabled us to observe how well the different tests and index represent the prey availability for these areas.

**Results:**

**Prey Abundance and Richness:**

Table 2. Insects Trapped from May 2005 to May 2006

| Insect Family | Study Site | | |
| --- | --- | --- | --- |
| | LM | FLW | FGM |
| Carabidae | X | X | X |
| Gelastocoridae | X | X | X |
| Mutillidae | X | X | X |
| Acrididae | X | X | X |
| Cicadellidae | X | X | X |
| Clubionidae | X | X | X |
| Coreidae | X | X | |
| Dryophthoridae | X | X | X |
| Gryllidae | X | X | X |
| Gryllotalpidae | X | X | X |
| Hymenptera | X | X | X |
| Labiduridae | X | X | X |
| Lepidoptera | X | X | X |
| Lycosidae | X | X | X |
| Pentatomidae | X | X | |
| Pseudophasatidae | X | | |
| Reduviidae | X | | |
| Scarabaeidae | X | X | X |
| Tettigoniidae | X | X | X |
| Theridiidae | X | X | |

The original habitats of our two owl populations had similar prey abundance ($z < 1.65$ for $p > 0.05$), except for Carabidae ($p = 0.043$), Scarabaeidae ($p = 0.0196$), and Clubionidae ($p = 0.0478$). The total and average numbers of insects trapped at LM were higher than that of FLW in all three of these cases. The prey abundance at LM did not reach that of FGM ($z < 1.96$ for $p > 0.025$) except for Carabidae ($p = 0.0096$), Scarabaeidae ($p = 0.003$), and Clubionidae ($p = 0.004$). Again, in all three cases LM had more in total and on average. FLW did not have higher abundance than FGM ($z < 1.96$ for $p > 0.025$).

Similarly, all three sites revealed the same richness, if only considering prey of the Florida Burrowing Owl.

**Diet:**

**Table 3. Frequencies and Proportions of Prey Families in Diet.**

| Prey Family | Control | | Pre- Trans | | Post-Trans | |
|---|---|---|---|---|---|---|
| | **Freq.** | **Prop.** | **Freq.** | **Prop.** | **Freq.** | **Prop.** |
| Carabidae | 400 | 12.13 | 401 | 19.40 | 145 | 22.27 |
| Gryllidae | 935 | 28.36 | 383 | 18.53 | 138 | 21.20 |
| Acrididae | 719 | 21.81 | 356 | 17.22 | 128 | 19.66 |
| Tettigoniidae | 9 | 0.27 | 28 | 1.35 | 7 | 1.08 |
| Scarabaeidae | 775 | 23.51 | 553 | 26.75 | 110 | 16.90 |
| Gryllotalpidae | 73 | 2.21 | 19 | 0.92 | 10 | 1.54 |
| Labiduridae | 235 | 7.13 | 195 | 9.43 | 65 | 9.98 |
| Curculionidae | 34 | 1.03 | 45 | 2.18 | 27 | 4.15 |
| Lycosidae | 24 | 0.73 | 18 | 0.87 | 0 | 0.00 |
| Clubionidae | 70 | 2.12 | 64 | 3.10 | 15 | 2.30 |
| Microhylidae | 9 | 0.27 | 0 | 0.00 | 0 | 0.00 |
| Ranidae | 5 | 0.15 | 0 | 0.00 | 0 | 0.00 |
| Emydidae | 0 | 0.00 | 2 | 0.10 | 1 | 0.15 |
| Soricidae | 3 | 0.09 | 0 | 0.00 | 1 | 0.15 |
| Spiraxidae | 3 | 0.09 | 3 | 0.15 | 4 | 0.61 |
| Cambaridae | 3 | 0.09 | 0 | 0.00 | 0 | 0.00 |
| Totals | 3297 | 100 | 2067 | 100 | 651 | 100 |

The control and pre-translocation populations shared the same medians for pellet contents ($u > 23$ and $p > 0.05$), with the exception of Gryllidae ($p = 0.0003$), Acrididae ($p = 0.0433$), and Gryllotalpidae ($p = 0.0232$). The contents of pellets for the control population were less than those found within the post-translocation population ($u > 1$ and $p > 0.025$), excluding Acrididae ($p = 0.0079$). The pellet contents from the pre-translocation population were not greater than post- translocation population ($u > 5$ and $p > 0.025$), except for Scarabaeidae ($p = 0.004$). Prey items Families found in the pellets but were not represented in the trapping results were Cambaridae, Curculionidae, Emydidea, Microhylidae, Ranidae, and Spiraxidae.

**Prey Availability:**

Using our Non-seasonal Weighed Abundance Index, the control population at LM received a score of 97.6. The pre-translocation treatment population at FLW had a score of 75.6. At FGM, the pre-translocation treatment population had a score of 55.2.

**Discussion:**

Species richness and species abundance when considered individually are poor indicators of biodiversity. The trapping results indicate that LM holds the most prey richness of the three areas, with FLW having two less families represented, and FGM lacking an additional three families. None of the taxa absent between these areas were found in the owl's diet.

Species abundance results indicate that except for Carabidae, Scarabaeidae, Clubionidae all of the sites share similar relative abundance. Without prior knowledge of the diet of the study populations, one may assume that FLW display a diminishing suitability for burrowing owls.

One potential problem with sampling prey abundance and richness in close proximity to active burrows is that the Florida burrowing owls may catch prey (especially insects) from one of the pitfall traps, thus introducing sampling error that would lower the scores for abundance and richness (Smith 2004). Unfortunately, this problem cannot be overcome by simply putting the traps where the owls are not found, as the owl's choice of nesting location may depend on insect abundance and again artificially deflating abundance and richness scores for the area (Smith 2004). To overcome this sampling problem, transects were placed where active burrows were present, but the distance was

far enough that the chance of owls catching prey destined for a pitfall trap was greatly reduced.

Another problem encountered is that traps tend to exclude certain types of prey. Though some studies report that owls often ingest those prey mentioned previously, other studies which attempted to trap burrowing owl prey, did not capture these insects in abundance relative to their observed abundance in the study area (Mrykalo pers. comm.). The study failed to trap some insects in similar abundance relative to what the owls had ingested, as evidenced in pellets that were analyzed.

The vast majority of prey items, for both sets of owls, prove to be arthropods. Though vertebrates were consumed, the irregularity indicates that these items are not specifically sought after, but may in fact be "bonus items." These vertebrates may be eaten when opportunistically encountered, as they represent a much larger capture of biomass. That the study sites were located on lands stocked with cattle may have had an effect on the constituency of the pellets. Most of the insects could be found in abundance underneath cow patties which provided microhabitats for a wide assemblage of insects (P. Nixon unpublished).

The control population, and pre-translocation population were similar in the prey ingested except for Gryllidae, Acrididae, and Gryllotalpidae. This is contrary to what was expected, as trapping results did not indicate any difference in abundance or richness of these taxa at either habitat. This could be explained by differential seasonal abundance that may not have appeared in trapping results, perhaps the landscape features made for easier capture of other taxa, or perhaps the owls simply did not prefer these prey items,

No significant difference between the contents of pellets before and after translocation of the treatment population may indicate that a prey abundance threshold or satiation point has been reached. Moreover, if there is less abundance of a desired species, then it is expected that the diet will shift to other less desirable species, rather than expend more energy to find decreasing numbers of the desired species (MacArthur and Pianka 1966). It is possible that due to the presence of cattle and their waste, arthropods are able to reproduce and maintain suitable numbers, which create plentiful prey items. Thus, anything that was immediately available would be ingested with assurance that other nutritious items would still be readily attainable.

The results of the Non-seasonal Weighed Abundance Index indicate LM as a site that holds the most suitable assemblage of prey items for these particular populations of burrowing owls. When compared with LM, we see that FLW is a less suitable habitat for burrowing owls. Even less suitable is FGM, with a score of about half that of LM. Thus we would expect the translocation site to be much less suitable. These findings are supported my finding in Chapter 3 suggesting that a more suitable habitat enables a population to produce more juveniles.

The results of the Non-seasonal Weighed Abundance Index offered new insight when compared to richness and abundance considered on their own. Also, the results of the Non-seasonal Weighed Abundance Index were contrary to those from the diet analysis. An area of further exploration may be a comparison of suitability for various habitat types, such as urban, suburban, rural, and with/without cattle grazing. Studies examining these factors may clarify the adequacy of the Non-Seasonal Weighed Abundance Index for predicting suitable prey availability at potential translocation sites.

**Management Implications:**

Without weighting abundance with the owls' preferences, a common forum to compare prey availability is not available. Wildlife managers would be faced with sets of data that are not dynamic in how they represent prey availability. With the availability index, one total score is reported and can be used in conjunction with other scores from other habitats, while still considering the same group of burrowing owls. In effect the index gives wildlife managers a tool to tailor abundance studies to the preferences of their translocation subject. As development occurs, translocation may become a common way of conserving this species.  As fragmentation increases, suitable habitat adjacent to current burrowing owl habitat may not be available. In this event, habitat will have to be selected with suitable prey availability.  This common index may yet be another tool to use when examining this aspect of their habitat and will offer land managers as well as state and federal agencies another management option.

**Chapter 3: Effects of Translocation on Florida Burrowing Owl Hatching Success**

**Introduction:**

The reproductive ecology of the Florida Burrowing Owl has been a large component of previous research. Past studies have examined the date of clutch initiation (Nicholson 1954, Courser 1976, Millsap and Bear 1988), date of juvenile and adult dispersal from breeding habitat (Courser 1976), prey preference during the breeding season (Lewis 1973, Hennemann 1980), date of dispersal from breeding habitat (Courser 1976), description of breeding habitat (Rhoads 1892, Ligon 1963, Hennemann 1980, Mrykalo 2005), dispersal distance (Mrykalo 2005) natal dispersal distance (Millsap and Bear 1988 and 2000), fecundity (Millsap and Bear 2000), mate and territory fidelity (Millsap and Bear 2000), breeding pair density (Millsap and Bear 1988), minimum annual survival of fledglings, juveniles, and adults (Millsap and Bear 1997), fledging success (Millsap and Bear 1988, Mealey 1997), causes of mortality (Mealey 1992), and post breeding habitat (Mrykalo 2005). Most of these studies have occurred in suburban or industrial areas. Conversely, little attention has been given to rural and natural areas. To date there are no published studies about Florida Burrowing Owl breeding ecology on phosphate mines, reclaimed mines, or in translocation situations.

One way to monitor the success of a translocation project is through long-term monitoring of the breeding ecology of the relocated population. Here the hatching

successes of two populations of Florida burrowing owls were examined and compared. Unlike the Florida subspecies (who have never undergone translocation as of this writing), translocation was studied in Western Burrowing Owls. These operations encountered both failures and successes. This study will be the first to closely investigate the effects of translocation on a population of Florida burrowing owls.

The breeding season can occur anytime from November and continue to May (Owre 1978). Mealey (1997) reports breeding and fledging activity from January through September. Prior to nesting, increased burrow maintenance and construction of satellite burrows generally coincide with this period. Decorating territory occurs just prior to reproduction; this behavior may help to draw prey to the burrow, which eases the parents' burden of feeding their hatchlings (Smith 2004). Both the male and female burrowing owl are able to reproduce at one year of age (Haug et al. 1993). Females usually lay eggs in the spring, (Nicholson 1954, Courser 1976, Millsap and Bear 1990); however, late production of eggs has been witnessed in cases of double brooding (Millsap and bear 1990). The females lay approximately 3-8 eggs (Sprunt 1954, Courser 1976) and are the only one of the pair to brood. During the brooding period, males do most of the hunting and the provisioning. After about two weeks the females spend continually more time outside the burrow, but the male still spends the most time hunting. This differentiation in activities between the males and females of a breeding pair is the cause of increased bleaching of the male's plumage. This bleaching helps to distinguish males and females during the breeding season, as they are very similar in size and plumage (Haug et al. 1993). With a bird in hand a brood patch can be detected on breeding females (Martin 1973). There is no available information on the number of days from hatching to fledging

for Florida burrowing owls, but the Western Burrowing Owl fledges 44 days after hatching (Landry 1979).

Many factors contribute to the breeding success during a translocation. While there is little information available about the translocation of Florida burrowing owls, studies have investigated translocation efforts involving the western burrowing owls.

**Hypotheses:**

*Hatching success*

$H_{null}$: There will be no significant difference in hatching success between control population and pre-and post translocation populations.

$H_{Alternative}$: There will be a significant difference in hatching success between control population and pre-and post translocation populations.

$H_{null}$: There will be no significant change in hatching success between pre and post translocation populations.

$H_{Alternative}$: There will be significantly less hatching success in the post translocation population compared to pre translocation population.

**Study Site:**

This study was conducted at three locations in Florida, with two populations of burrowing owls. One location, where the control population was found, is at Lonesome Mine, Mining Unit 16 (LM), Hillsborough County. The second location is the original home range for the pre-translocation population. The site is Fort Lonesome West (FLW), Hillsborough County, located adjacent to Mining Unit 16, on the west side

of S.R. 39. Together these two tracts of land consist of approximately 1,432 acres of typical improved pasture dominated by Bahia grass (*Paspalum notatum*) and stocked with 2 head of cattle per acre. The third location, Fort Green Mine (FGM) is reclaimed phosphate land and the new habitat of the post translocation population of burrowing owls. FGM is located in Polk County, Florida and is a 590 acre reclaimed (last mined in 1983 and reclaimed as Florida state law requires [Fla. Stat. Ch. 378 and Fla. Admin. Code Ch. 62C- 16]) tract of land similar to improved pasture. It is located approximately 5 miles southwest of the two Fort lonesome sites.

Climates for all three study areas were similar because they are located within 5 miles of each other. Southeast Regional Climate Center's weather station located in Fort Green (FORT GREEN 12 WSW, FLORIDA (083153)) reports the annual average temperature extremes ranged from 45.5F to 91.6F and the average annual precipitation to be 54.85 inches.

**Methods:**

This study was conducted from April 2005 to July 2006. Hatching success data were collected for two populations, the control population that was not disturbed and a treatment population that was translocated. To examine hatching success, we counted the starting number of eggs in each burrow and compared that to the largest number of juveniles that were spotted at that particular burrow. I define hatching success as the maximum number of juvenile burrowing owls spotted outside each active burrow known to contain a clutch of eggs. I assumed that juvenile owls would not occupy active burrows that were inhabited by other family groups. We counted the eggs at all three

study sites by carefully inserting a "burrow-cam," a small non-intrusive infrared camera that has a 1.5 inch diameter tube attached (Gervais and Rosenberg 1999). At each burrow, the burrow-cam was inserted until either birds or eggs were encountered or the end of the burrow was reached. At the translocation site Artificial Burrow systems (ABS) were provided. The ABS had openings through which the nest could be observed. These openings provided for easier access to the nest for counting eggs. Nests were considered to be successful if the pair laid eggs and juveniles were spotted at the nest after hatching. The duration of time between the first spotting of eggs in the burrow and first spotting juveniles was approximately 30 days in 2005 and 2006.

**Results:**

In 2005, prior to translocation, the control population, which consisted of 12 breeding pairs, laid 37 eggs. From these eggs 28 young were spotted outside the burrows. The pre-translocation population consisted of 4 breeding pairs that laid 12 eggs, after which 6 young were spotted outside the burrows. This gave a hatching success rate of 75.6% for the control population and 50% for the pre-translocation population.

After the translocation, in 2006, the control population which consisted of 9 breeding pairs laid 31 eggs total and produced 15 young. The post-translocation population which consisted of 2 breeding pairs that laid 6 eggs, of which 3 young were spotted outside the burrows. This gives a hatching success rate of 50% and 33%, respectively.

**Discussion:**

The null hypothesis was rejected due to differences between study groups. The reason for the much higher hatching success for the control population in 2005 may have been due to various factors. One factor that may have affected this change was that the pre-translocation population's habitat was bisected by a small industrial road. Also, the control population's habitat was more secluded. Trees surrounded the area and may have provided a buffer, which reduced disturbance from anthropogenic sources, such as roads. Insect trapping from the two areas (see Chapter 2) showed that there was higher relative insect abundance at the control habitat which may have provided better forage for burrowing owls.

During the end of the 2005 breeding season the control population was disturbed by sod farming, which collapsed one active breeding burrow. The sod farming disturbed four others due to close proximity (< 3m), as well as removing much (≈10% of breeding territory) sod from their habitat (personal observation 2005). In addition, extra disturbance and predation pressure by a large carnivore such as a coyote could have reduced hatching success. Signs of a large predator were evidenced by gopher tortoise carcasses and coyote scat.

Another possible factor that probably reduced hatching success in all the study sites was structural failure of burrows due to disturbance from cows. All three study sites were stocked with cattle for grazing. Cows were often seen grazing directly on top of or next to active burrows. On one occasion, in 2005, at the LM an active burrow with a breeding pair was collapsed by a cow. Fortunately, the owls tend to vacate the burrow while they are visited by the cows, and the pair returned after the burrow was fixed by

observers. This pair did not produce eggs (Nixon unpublished). In May of 2006, at the translocation recipient site, one of the artificial burrows provided was most likely disturbed by cattle. The cattle at this site were often seen scratching their heads against perches that were provided at all the ABS, as well as using the ABS themselves as scratching posts.

The decline in hatching success of the treatment population from the 2005 to the 2006 breeding season may have had many causes. The most obvious is that the translocation may have limited hatching success by introducing unfamiliar environmental factors and/or biological factors. In fact, coyote tracks were often seen around burrows after the owls were released in March. On one occasion there was evidence that a coyote was trying to dig up the ABS. At this point donkeys were introduced to the cattle herd in that area to allegedly drive the coyote away (Ron Concuby pers. comm.). Other predators were also present during their stay in the enclosures and after the release. These predators include: peregrine falcon, black vultures, kestrel, harrier, bobcat, fox, wild hogs, swallow-tailed kite, red-tailed hawk, red-shouldered hawk, and osprey. Prey abundance may have affected the post translocation population's success at breeding, as their new habitat had less relative abundance, richness, and prey availability (see chapter 2). Conversely, there is evidence that cow dung provides forage for many types of insects, which in turn increase the abundance of selected prey. This actually causes the owl's diet to reach a threshold where more prey availability will not confer any added benefit to the population. Behavioral studies indicate no significant difference in foraging behavior between control and pre and post translocation populations (see Chapter 1).

The hatching success  of the burrowing owl populations is similar to what was reported by Mealey (41 to 54%) for Dade and Broward counties, even though those populations were suburban (Mealey 1997). It may be that the decrease in hatching success will only occur initially. Perhaps it will be less pronounced in following breeding seasons, due to factors such as increased familiarity with the new habitat and environment.

**Management Implications:**

The results of this study imply that hatching success may be decreased for populations of Florida burrowing owls that undergo translocation. Thus, translocations of burrowing owls should be large enough or continue long enough to provide for populations, which are sustainable. Once translocated, it may be that there is decreased immigration and emigration for the population, at least initially, until the colony is able to interact with other colonies that occur within dispersal distance, at the Meta population level. Translocated owls should be encouraged to stabilize through little disturbance outside of their normal routine. Perhaps supplemental feeding beyond the release date may encourage owls to exhibit higher site fidelity or longer time spent in hacking enclosures may encourage fidelity as well. Although this study indicates lowered hatching success during translocation, long term studies should be undertaken to investigate future breeding success of these translocated populations after they have had time to stabilize and assimilate to their new habitat.

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**Appendices**

**Appendix 1: Translocation Details**

This translocation of Florida burrowing owls was conducted by Mosaic Fertilizer Company LLC (Mosaic). The initial plan for translocation was to capture seven breeding pairs of Florida burrowing owls from areas slated for mining and translocate them to a reclaimed phosphate mine. At the reclaimed recipient site, seven hacking enclosures would be provided where the owls would be held for 30 days. The hacking enclosures were used to encourage site fidelity and allow the owls time to assimilate to their new habitat while undisturbed. Within each of the seven hacking enclosures and Artificial Burrow System (ABS) would be provided for the owls to inhabit. Other ABS would also be provided out side the hacking enclosures and spread throughout the recipient site where appropriate. These extra ABS would provide an alternative to digging natural burrows if the birds so desired. Owls were to be fitted with radio transmitters to track their movements.

Trapping of owls to be translocated started on March 3, 2006 and continued until all owls were captured on March 6, 2006. The final number of owls captured was 7 pairs of adult owls and 4 unpaired adults. Three pairs of adults were not from the original pre-translocation population. These 6 owls were not included in my prey availability or nesting success investigations, but were included in the behavioral study. The 4 unpaired adults were released on March 7, 2006 at the recipient site. While in the enclosures, the

paired owls were supplementally fed fresh water, 20 crickets, and 2 mice per enclosure/day. Three fatalities occurred during the stay within their enclosures. One pair was found dead from unknown causes. The male of another pair was found dead and mutilated, the female was the suspected cause of the mortality, but she may have fed on the male's corpse post-mortem instead. Due to these mortalities, Mosaic was ordered to release the owls prior to the scheduled date. Radio transmitters were not attached to the owls to be released as the permitting state agency withdrew this part of the permit. The owls were released from the enclosures on March 24, 2006. After release 3 owls could not be accounted for by March 31, 2006. After release, most of the burrowing owls spread out away from the area where the enclosures had been. Two pairs of owls dug their own natural burrows and the others used the ABS provided around the recipient site.