EFFECTS OF PRESCRIBED BURNS ON SMALL MAMMAL POPULATIONS WITH COMMENTS ON HOUSTON TOAD POPULATIONS

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ABSTRACT

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Adaptive forest management has been an important tool to improve species diversity within a forest. Fire suppression and habitat fragmentation in Southern pine forests have resulted in habitat composition changes, potentially causing negative impacts on endemic species. Implementing prescribed fire helps restores the historic quality of the forest and effects can be monitored by indicator species. Bastrop State Park, home to the endangered Houston Toad (*Bufo houstonensis*) is located within the "Lost Pines" region of East Texas. Over the past 5 years, periodic burns have been conducted throughout the park. For my study, I conducted a small mammal survey to determine mammal diversity and relative abundance data in burned and unburned management units. The objectives of the study involve comparing diversity and relative abundance of small mammal (indicator species) and herptile populations between burned (2 trap lines) and unburned (2 trap lines) management units, assessment of vegetation differences between management units, evaluation of survivorship estimates using mark-recapture data, and the eventual incorporation of the results in evaluating habitat management for the Houston toad. Trapping was conducted from May 2005 until April 2006. Overall, 5 species of small mammals and 10 species of herptiles were collected. The white-footed mouse (*Peromysucs leucopus*) was the most commonly collected small mammal. A significant positive relationship ($P = 0.0209$) between body weight and body length was found in *Peromyscus sp.*, however when compared between burned and unburned units, the relationship was non-significant ($P = 0.3134$). Small mammal monthly capture averages were greater in the burned units ($P = 0.0073$) however, survivorship estimates were non-significant between habitats. Finally, Houston toad size and herptile abundance did not vary between habitats. Small mammal abundance and diversity was influenced by vegetative composition among the burned and unburned units. Burned units had a greater percentage of seedling trees, shrubs, and herbaceous vegetation, likely leading to an increase in seeds and food availability. The results from my study show that low intensity prescribed fire slowly and effectively changes habitat composition and small mammal abundance and qualitative diversity. Fire has influenced the evolution of southern pine forests, with the animal species within the system consequently able to adapt to habitat changes. When implemented correctly, fire creates beneficial changes toward a more natural ecosystem regime for small mammal, herptile, and other forest species.

CHAPTER I

INTRODUCTION

Fire has been a major factor in molding evolving forest types in the southeastern United States (Waldrop et al. 1992). For thousands of years, human-caused fires, along with natural fires, created mosaic patches of habitat and forests of varying composition and stand age (Chapman 1985, Buckner 1989). Fire sustained open forest areas and created grassland habitat (Waldrop et al. 1992) and edge, produced deadfall for cover, and rejuvenated herbaceous vegetation for small mammals. In areas lacking fire disturbance, other disturbances such as flood, wind, and logging (Powell and Brooks 1981) have influenced the evolution of forest habitat in similar ways. Animal communities exposed to 1 or more disturbances also have species adapted to habitat changes.

In the early 1900s, fire suppression was considered the best way to conserve forest vegetation and promote habitat regeneration (Waldrop et al. 1992). Catastrophic wildfires in 1910 burned 3 million acres across Idaho, Montana, and Wyoming resulting in severe economic damage and loss of life. Unfortunately the history, benefit, and necessity of fire to forest ecosystems were not well known and these destructive fires became a symbol of the Forest Service's war on wildfires (Schiff 1962). An aggressive

100% fire suppression policy was developed for all human and lightning caused fires (Pyne 1982). Missing from this policy was a complementary program for reducing the gradual accumulation of flammable materials within forests (Busenberg 2004). Years of fire suppression directly led to a decrease in habitat suitability and wildlife diversity, accelerated economic burdens (Mercer et al. 2000), and greatly increased the potential for catastrophic stand replacing wildfires (Keeley 2001). Fire fighting policy and negative attitudes about fire began to change in the late 1970s as forest managers realized the need to reinstate the frequent disturbance patterns of fire with which forests have evolved (Husari and McKelvey 1996). Currently, millions of dollars are spent each year to rebuild homes and businesses, replace commercial timber loss, restore tourism losses, and actively fight large destructive fires (Mercer et al. 2000).

Fire suppression, leading to catastrophic wildfires, are a danger to forest species especially those sensitive to habitat changes. The southern pine forest of North America is home to many endemic species such as the ivory-billed woodpecker (*Campephilus principalis*), red-cockaded woodpecker (*Picoides borealis*) (Master et al. 1998), and the Houston toad (*Bufo houstonensis*). These and many other species may respond negatively to changes in habitat composition as a consequence of fire suppression, and habitat fragmentation (Saunders et al. 1991). Prescribed fire is a common and successful form of forest management. Burns create mosaic patterns of unburned trees and vegetation that small mammals use for cover while foraging in burned areas (Fisher and Wilkinson 2005). Fires can also increase seed dispersal, resulting in increased food availability and increasing habitat favorable to granivorous mice (Ahlgren 1966). Fisher and Wilkinson (2005) concluded small mammal abundance increased with stand age with corresponding species-specific habitat and vegetation after fire. The increase in grasses and shrubs after a fire result in increased numbers of granivorous and folivorous mice (Fisher and Wilkinson 2005). Elliott et al. (1999) suggested that prescribed fires stimulated food production in the form of grasses and mast (berries). Shrews, however, which rely heavily on leaf litter, decrease in population after intense fires if the leaf and duff layers are destroyed (Fisher and Wilkinson 2005) but increase once ground cover has been re-established.

Population densities of indicator species may be used to assess habitat quality, habitat suitability, and population trends (Landres 1983, Verner et al. 1986). A successful indicator species must be sensitive to habitat change, exhibit little variability in response to environmental factors, inhabit a variety of habitats, have a large physical size (Ward 1978), and be permanent residents of the habitat (Bock and Webb 1984). Small mammals have the qualities to be effective indicator species. Small mammals fill many ecological roles, live in a wide variety of habitats, and have large population numbers, which makes studies of their population size and diversity important (Sullivan and Sullivan 2001). Small mammals help spread fungi beneficial to woody vegetation (Carey and Johnson 1995), and improve soil aeration and forest hydrology through burrowing and development of forage runways (Ursic and Esher 1988). All of these qualities make small mammals an effective composite indicator species and a convenient test of forest health and management success.

Fire affects various habitat types differently. This requires forest managers to study the habitat type and fire history of a particular forest before implementing prescribed fire (Hermann 1998). In fire evolved ecosystems, changes in small mammal abundance because of cyclic fire disturbance depend on fire intensity, season of burn, timing between burns (Tiedemann et al. 2000), and succession stage of the forest (Huston and Smith 1987). Southern pine forests benefit from low-intensity prescribed fires that occur every 4-to-5-years (Brose and Wade 2001). A 1-to-3-year fire interval in southern pine forests is beneficial in increasing species diversity (Means et al. 2004). Frequent fire intervals control and reduce the buildup of understory, prevent stand replacing fires, and prevent the growth and succession of invasive species. The season and intensity of a burn will affect fauna differently because of life-history differences between species (Taylor 1981, Braithwaite 1987). Penn et al. (2003) suggested low intensity fires kill few individual small mammals. Elliot and Swank (1994) reported highest vegetative and tree diversities occurred in the early establishment stage of forest development after disturbance. Fisher and Wilkinson (2005) found most small mammal species quickly return to disturbed areas in response to increased vegetative diversity in northern boreal forests. Generalist species, such as *Peromyscus leucopus* (Master et al. 1998) dominate in early successional stages, such as the initiation stage, while specialist species become more dominant in later stages (Fisher and Wilkinson 2005). Therefore, in forests evolved by fire, mimicking the natural fire regime by intensity, season, and forest succession stage, is imperative to adaptive management success. Implementing prescribed fire and timber management techniques is time consuming, but is the most successful way to restore the forests and replenish species diversity (Rideout and Oswald 2002).

Today, ecologists and forest managers have a new understanding and are adapting management practices to the concept of wildland fuel reduction instead of wildfire suppression (Busenberg 2004). Forest managers now implement various harvest management techniques, such as thinning practices (Miller et al. 1999) and prescribed fire (Rideout and Oswald 2002) in restoring wildlife habitat and producing diversity. Management plans that combine and administer different management techniques at different stages of forest succession produce the most beneficial habitat for conservation needs of that area (Brose and Wade 2002).

Few studies have addressed the effects of prescribed fire on small mammal communities within the pine forests of central Texas. Bastrop State Park is located within the Lost Pines region of Texas, an area noted for the endangered Houston toad (*Bufo houstonensis*) (Figure 1).

Since 1978, Bastrop State Park and the surrounding areas have been designated critical habitat for the Houston toad. Loblolly pine (*Pinus taeda*) and oak dominate providing adequate habitat for small mammals, reptiles, and amphibians. Years of fire suppression and historical logging operations have greatly altered the composition and structure of habitats within the park, increasing the concern for a catastrophic wildfire. A single destructive, stand-replacing wildfire could easily lead to the extirpation of many local wildlife species at the park (Cole 1996). The long-term stewardship objective for Bastrop State Park is to maintain and restore the natural forest structure and composition. Loblolly pine-oak woodlands found in Bastrop State Park are communities associated with periodic, patchy fires that maintain the ecological diversity characteristic of this habitat type (Schultz 1997, Brown and Smith 2000, Smith 2000) with little negative affect on soil structure or composition. Therefore, a prescribed fire management plan for Bastrop State Park is a key strategy for realizing this objective. A long-term prescribed fire plan has been approved by the United States Fish and Wildlife Service (USFWS) and

Figure 1. Map of Texas with all counties delineated indicating the location of the small mammal study site. Bastrop County is represented by the red star. The study site is located in Bastrop State Park, Bastrop County, Texas (north-central Bastrop).

is permitted under the Houston toad section of the Federal Fish and Wildlife Permit TE814933-3. It has been documented that periodic burning improves habitat for wildlife and increases species diversity and populations of forest fauna.

Periodic burns within Bastrop State Park began in December 2000 on designated management units. The burns were designed to help reverse the effects of historic fire suppression and to re-establish the natural fire regime to these management units. The primary objective of these prescribed burns is to reduce the fuel load and deep duff layer along with a slight reduction in the density of understory vegetation. These low intensity burns were conducted during winter months when fire danger was minimal and when Houston toads are in aestivation. During the winter Houston toads burrow under sandy loam soils (Dixon et al. 1989), suggesting protection from low intensity fires. While relatively little is known about the effects of prescribed fire on herptile populations (Penn et al. 2003), at least 1 study has shown that a single, low intensity fire does not produce any short-term effects on amphibian populations in habitats that evolved with fire (Lemckert et al. 2004). Regardless of the effects on the Houston Toad, other animals also may respond positively to fire reintroduction and could be monitored to gauge effects of these fires on other vertebrates in this system.

The objectives of my study were to compare diversity and relative abundance of small mammals (indicator species) and herptile populations between burned (2 trap lines) and unburned (2 trap lines) management units. I evaluated the survivorship estimates of small mammal populations using mark-recapture data, and compared small mammal capture data with forest structure data. My results were used to evaluate the impact of low intensity prescribed fire on lost pines ecosystem.

CHAPTER II

MATERIALS AND METHODS

For my study, 4 management units (2 burned and 2 unburned) were selected (Figure 2). One treatment unit (zone 6, Pond 1) was burned in 2003, and the second treatment unit (zone 11, Pond 2) was burned in 2004. Units 8 (Pond 10) and 10 (Harmon Road) have not been recently burned (Figure 2). Small mammal abundance was quantified by establishing trap lines of Sherman live traps and complementary pitfall traps.

Pit fall traps were used to facilitate the collection of shrews and herptiles. All trap lines were georeferenced with hand-held GPS receivers for the development of GIS mapping. Trapping was conducted for 4 consecutive days and nights, repeated monthly, for 1 full year. The study was from May 2005 to April of 2006. Each 500 m trap line originated from a pond or drainage area and extended across various habitat types. The most common habitat type found inside the park is loblolly pine – oak mix. Areas of dense yaupon (*Ilex vomitoria*) are also interspersed within various sections of each trap line. Placing traps in a transect pattern instead of a grid pattern, allows a longer area and greater variety of habitats to be sampled (Pearson and Ruggiero 2003). The transect design mimics the dispersal pattern of *Bufo houstonensis* further increasing my chances of collecting specimens. Each trap line is located among vegetation plots established by

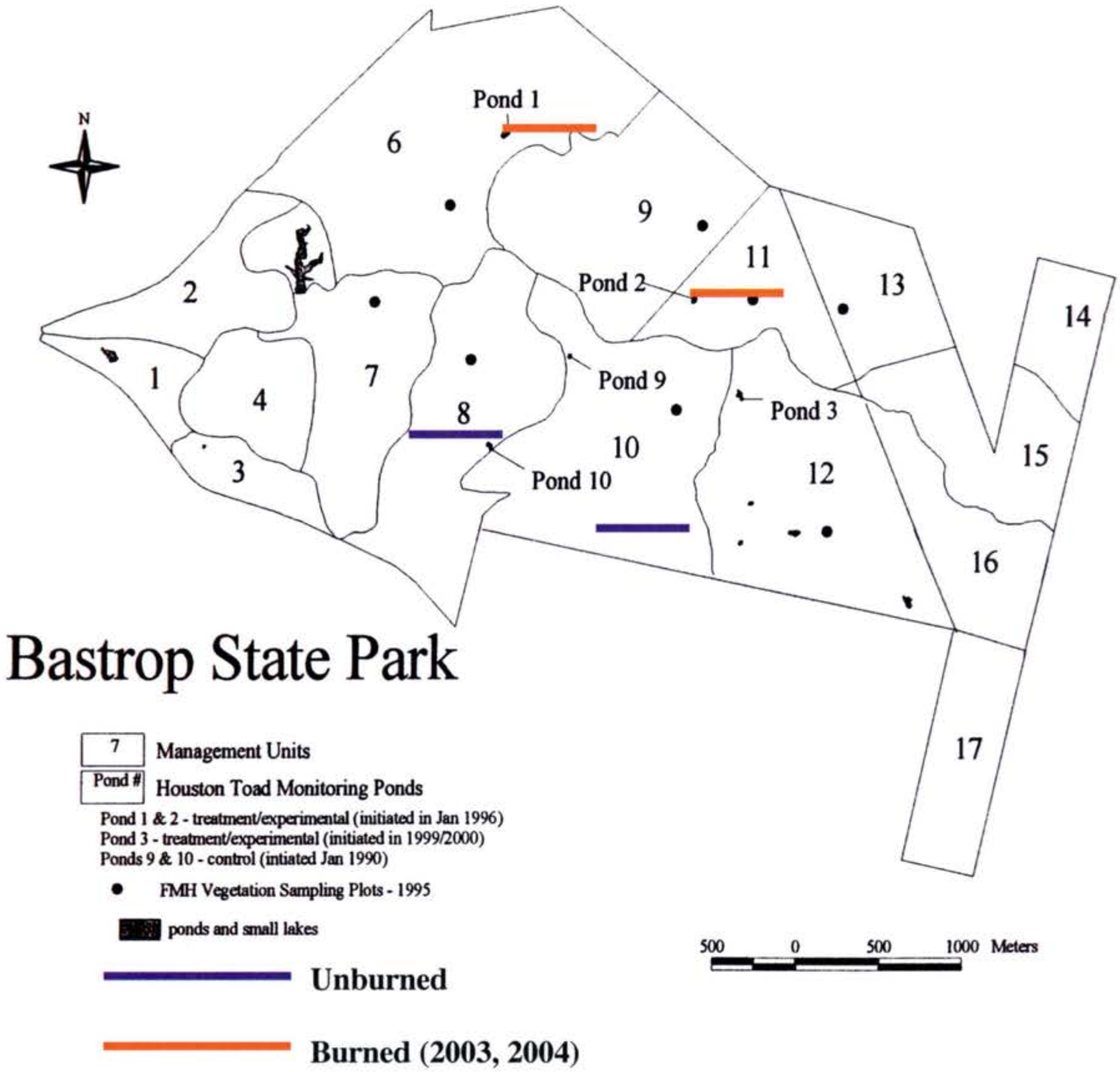

Figure 2. Map of Bastrop Sate Park, Bastrop County, Bastrop, Texas. The 2003 burned trap line originates at Pond 1 and the 2004 burned trap line originates at Pond 2. The 2 control (unburned) trap lines originate from Pond 10 and Harmon Road. All trap lines run west to east.

Texas Parks and Wildlife Department (TPWD) so quantitative vegetative data can be linked to mammal survey trap lines. Seven vegetation monitoring plots were established (Pond 2 = 1186, Pond 1= 1208, 1217, Pond 10 = 1200, 1216, Harmon road = 1202, 1203) (Figure 3). Although vegetative data were collected in 1999 by TPWD, only 3 of the 7 plots had been established, therefore, only 2005 data were used for analysis. Data collected included overall area totals for; basal area, tree total, seedling total, shrubs total, % vegetation cover, species total, and herb species total. Overstory, mid-story, seedling, shrubs and woody, and herbaceous areas were also calculated by individual species in the 4 trap lines (Eric 2005). Each trap line contained 40 Sherman traps (50.8-mm x 63.5-mm x 165.1-mm) spaced every 10-m and ten, 19-L bucket, pit fall traps spaced every 50-m. A total of 160 Sherman traps and 40 pitfalls were set each month. Sherman traps were opened from May 2005 – April 2006. Pit fall traps were placed along the trap lines in June. Each Sherman trap was baited with birdseed and oatmeal and all traps were checked and re-baited every morning. Peanut butter was explicitly avoided as bait due to fire ant prevalence. During the colder winter (Nov-Feb) bedding was provided to help reduce trap mortality. Plastic sandwich bags were filled with 4-to-5 cotton balls and sealed. The bedding was hung inside the trap for captured mammals to bite through the bag and pull out the dry bedding. Each bedding ball measured 40-cm by 60-cm and weighed 2 grams. Pitfall traps were not baited. To prevent desiccation of trapped animals, dampened sponges were placed at the bottom of each pitfall trap. Pitfall traps were opened during each 4-day trapping period. The study resulted in 640 Sherman trap nights per month and 160 pitfall trap nights per month. Species identification, sex, total length, tail length, hind foot length, ear length, and weight were collected for each individual

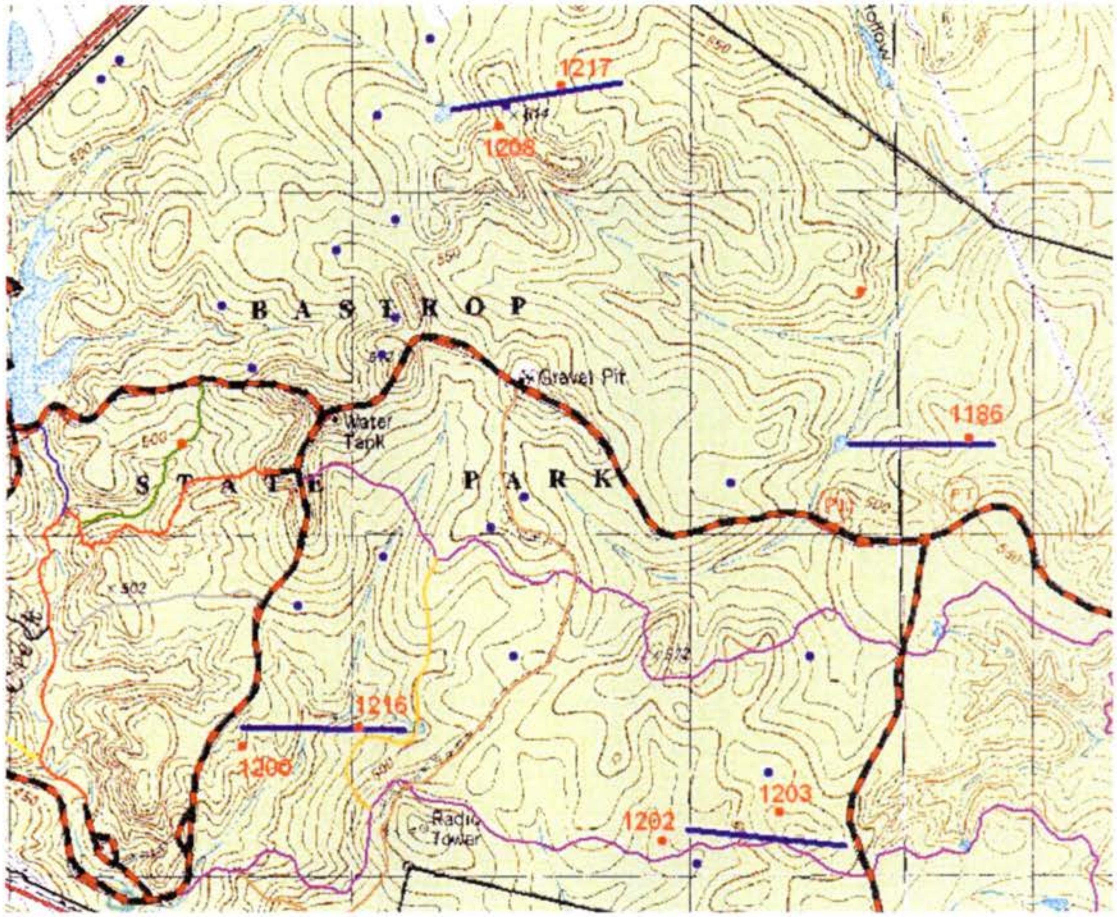

Figure 3. Topographic map of Bastrop State Park containing all 4 trap lines. Each trap line contains 1-to-2 red vegetation transects (pre-established in 1999 and 2005 by Texas Parks and Wildlife Department). Plots 1217 and 1208 = Pond 1, 1196 = Pond 2, 1216 and 1200 = Pond 10, and 1202 and 1203 = Harmon road.

trapped. Animals were categorized as adult or juvenile by comparison with limits of adult total length and pelage description given by Schmidly (2004). Upon capture, *Peromyscus* were either labeled transient or residential. Transient individuals are constantly moving through an area and usually captured and recorded once. These individuals are usually subadults nearing reproductive maturity (Terman 1968). Resident individuals already occupy a home range and are therefore more frequently captured. For this study, a resident mouse was one who had been caught 2 or more times.

Animals caught were marked by ear clipping and a photo voucher taken before release, preventing an over estimation of species density (Means et al. 2004). Ear clippings were retained as DNA samples for most specimens. The ear clipping number system was developed from the Cold Springs Harbor Laboratory ear punch system (University of Virginia Health Systems 1986). Trap mortality resulted in voucher specimens that were deposited at the Texas Cooperative Wildlife Collection (TCWC) at TAMU. Two field guides used for proper species identification were *Mammals of Texas* (Schmidly, 2004), and Peterson Field Guides- *A Field Guide to Mammals* (Burt 1998). Other data collected included, temporal data (date, duration of trap set, time of capture), location data (trap line #, trap type, UTM trap location, vegetation description) and weather data (temperature, relative humidity, wind speed, current weather conditions). All sprung traps were recorded to determine trap nights of activity (Masters et al. 1998). Any amphibians and reptiles caught in pitfall traps were weighed and measured accordingly and a blood sample, toe clipping, or tissue sample taken. Photos of pitfall captured individuals were also taken for identification purposes and as photo vouchers of released specimens.

Vegetative data were collected by Raven Environmental Services, contracted by Texas Park and Wildlife Department. Various levels of vegetation were measured at pre-established vegetative plots selected by TPWD in 1999. New plots were added along Pond 2 trap line in 2005 in order to compare data to small mammal captures on all 4 management units. Duff layer was not measured by the park, therefore I measured duff depth, to the nearest cm, for each of the 4 units. Four measurements (N, S, E, W) were taken at each of the 10 pitfall traps within each unit. These measurements were averaged to determine the average duff depth within a unit.

Analysis

I calculated diversity and estimated population size of small mammals between burned and control areas (Hartnett et al. 1996). I used the minimum number known alive (MNKA) method to estimate *Peromyscus* population size and compared abundance between burned and unburned units using a t-test. Body weight is one of the best criteria to determine the growth and health of an organism or population (Layne 1968), therefore I compared body weight, total body length, gender, and location of each *Peromyscus* using a multiple regressions. I also used a multiple regression and t-tests to compare Houston toad weight and snout-urostyle length between burned and unburned units and compared amphibian and reptile abundance between units. Only species caught by Sherman or pitfall traps or collected within a 10-m circumference of each trap were used in statistical analysis. Animals found outside this boundary, however, were recorded, photographed, and tissue sampled and data given as non-traditional voucher specimens to Texas State-San Marcos University Biology Department.

With the extensive information collected for each trapped individual, the program MARK will be used to report survivorship. Information, such as trap location, number of recaptures, date of recaptures, and recapture occurrence, was collected and used in the study. The model, $\phi(t)p(t)$, was chosen for the analysis using the Akaike's Information Criterion and reflects full time-dependence (t) for both survival (ϕ) and recapture (p). The Sin link was set as default and the '2nd Part' option was selected as the default setting for variance estimation. A t-test was used to compare the average monthly survivorship estimates between the burned and unburned units.

CHAPTER III

RESULTS

Trap dates, average monthly temperature, average monthly relative humidity, monthly rainfall estimates, and current moon phase were recorded and used for comparison analysis (Table 1).

During the study, 47 small mammals of 5 species were captured in 7,153 trap nights. Closed traps could not be counted as a full trap night, therefore, sprung traps (1,054) were divided by 2 and subtracted from the total possible trap night count (7,680) to determine the total trap nights of activity (Nelson and Clark 1973, Masters et al. 1998). Overall, 36 individuals of 3 species (34 *Peromyscus*) were captured in burned units and 15 individuals of 4 species (10 *Peromyscus*) were captured in control units. All small mammals were captured in Sherman live traps. The species included (white-footed mouse) *Peromyscus leucopus,* (deer mouse) *Peromyscus maniculatus*, (hispid cotton rat) *Sigmodon hispidis*, (least shrew) *Cryptotis parva* and (Elliot's short-tailed shrew) *Blarina hylophaga. Peromyscus leucopus* was the most common small mammal with 44 captured individuals (Table 2). A multiple regression of weight, length, and gender of all captured *Peromyscus* suggested a positive linear relationship exits between body weigh and total body length (Figure 4) ($P < 0.0209$; $R^2 = 0.5237$) (Table 3).

Table 1. Dates of monthly trapping, weather data, and monthly moon phase for small mammal trapping in Bastrop State Park, Texas from May 2005 – April 2006.

Trap Month	Dates	Temperature (C)	Relative Humidity (%)	Monthly Rainfall (cm)	Moon Phase
May 2005	28 - 31	25 00	77 78	7 84	Last Quarter
June	15 - 18	30 00	73 58	1 40	First Quarter
July	14 - 17	27 22	84 75	4 52	First Quarter
August	13 - 16	28.88	79 40	3.99	First Quarter
September	9 - 12	25.55	85 75	1.32	First Quarter
October	8 - 11	20.00	78 7	6.88	First Quarter
November	5 - 8	25.55	75.7	2.51	First Quarter
December	7 - 9, 12	1 66	72 25	0 51	First Quarter
January 2006	20 - 23	12 77	68 3	1.57	Last Quarter
February	25 - 28	21 11	75 1	0.87	New Moon
March	19 - 22	16 11	85 0	1 63	Last Quarter
April	20 - 23	25 9	88 2	4 26	Last Quarter

Table 2. Total small mammals captured in Sherman live traps along 4 trap lines located within 4 management units in Bastrop State Park from May 2005 – April 2006. Traps were set along 2 burned units (treatment) and 2 unburned units (control).

Small Mammal Species	Burned 2003 Pond 1	Burned 2004 Pond 2	Control Pond 10	Control Harmon rd	Total
Peromyscus leucopus	11	17	6	2	**36**
Peromyscus maniculatus	1	5	2	0	**8**
Sigmodon hispidus	2	0	0	0	**2**
Cryptotis parva	0	0	1	1	**2**
Blarina hyglophaga	0	0	3	0	**3**
Total	**14**	**22**	**12**	**3**	**51**

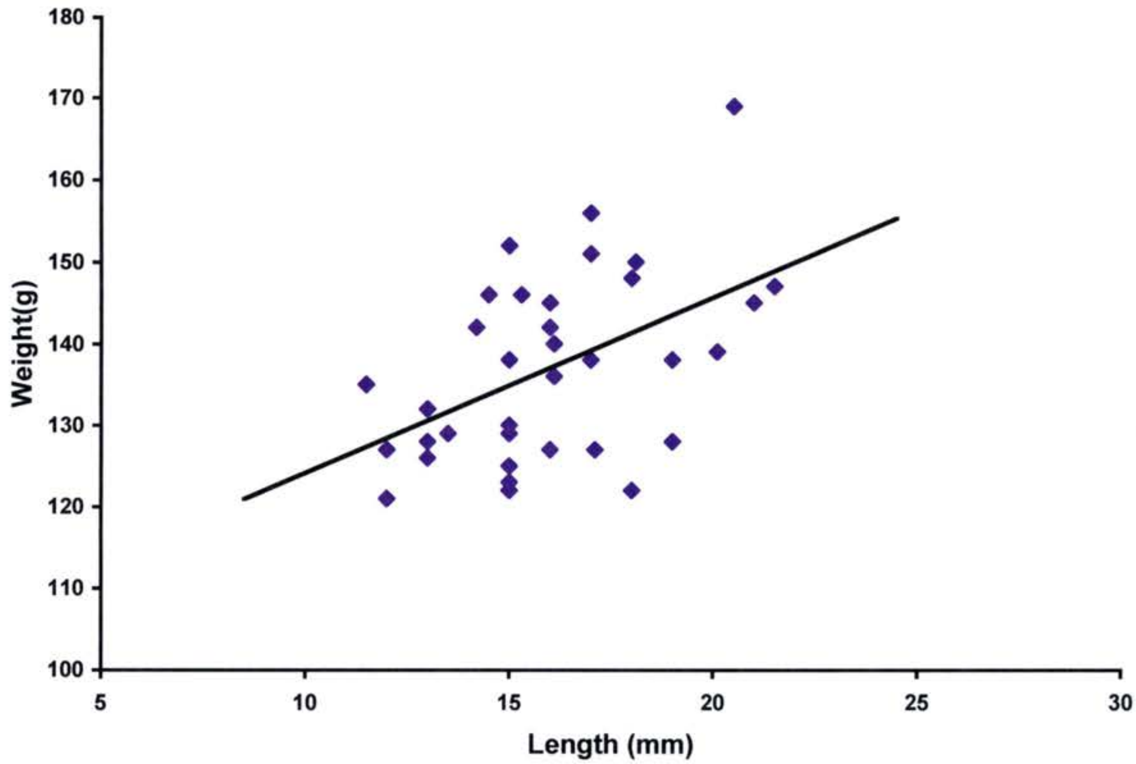

Figure 4. Multiple Regression of body weight and total body length between the 40 *Peromyscus* captured (May 2005 – April 2006) in Bastrop State Park, Bastrop, TX. (R^2 = 0.5237)

Table 3. Small mammal capture multiple regression results for body weight and total body length using measurements from captured *Peromyscus* during May 2005 – April 2006. Adult and juvenile *Peromyscus* were used to assess the weight and length relationship.

Variable	Coefficients	Standard Error	T Statistic	p-value	R^2
Body Length	100.5824	12 9494	7.7673	P < 0.001	0 5237
Weight	1 9621	0 8102	2 4217	0 0209	
Gender	-13 1140	16 2272	-0 8082	0 4246	
Weight:Gender	1.3077	1 0230	1 2783	0.2098	

Gender was found to have no correlation with body weight and body length relationship ($P = 0.4246$). When length and weights were compared between burned and unburned units, no significance was found ($P = 0.3134$) (Table 4). The monthly capture average for initial *Peromyscus* captures on burned units (3) was significantly greater than the monthly capture average for the unburned units (1.25) ($P = 0.0073$, t-stat = 2.956, df = 22).

Recapture Results

Because of low capture rate and low sample size for small mammals, only *Peromyscus* data were used in the recapture analysis. Of the 51 original captured individuals, 23 were recaptured at least once leading to a recapture rate of 45.1%. The 23 recaptured individuals resulted in 84 recaptures. Fifteen individuals (64 total recaptures) reside along the burned trap lines, whereas 8 individuals (20 total recaptures) reside along the unburned trap lines. The 2 most commonly recaptured individuals were specimen MJ-17, and MJ-14, both *Peromyscus leucopus*. MJ-17 was recaptured 18 times over the course of 8 months and MJ-14 was recaptured 10 times over the course of 5 months.

The average monthly survivorship and recapture estimates for burned units were graphed (Figure 5). Sample size of *Peromyscus* in the unburned units was small (10), therefore a survivorship graph was not constructed.

Pitfall Trap Results

The 40 pitfall traps resulted in 1,760 total traps nights. No small mammal was caught in the pitfall traps, however, many species of herptiles were collected. Herptile species included juvenile Houston toad (*Bufo houstonensis*), gulf coast toad (*Bufo*

Table 4. Multiple regression analysis for the relationship of body weight and total body length comparing burned and unburned units using measurements from *Peromyscus* collected during May 2005 – April 2006 in Bastrop State Park. Only adult *Peromyscus* were used for analysis.

Variable	Coefficients	Standard Error	Test Statistic	p-value	R^2
Length	126 0901	25 3026	4.9833	P < 0 001	0 2629
Weight	0 5335	1 7142	0 3112	0 7577	
Unit	-28 6306	28 6267	-1 00001	0 3250	
Weight Unit	1.9382	1 8912	1 0249	0 3134	

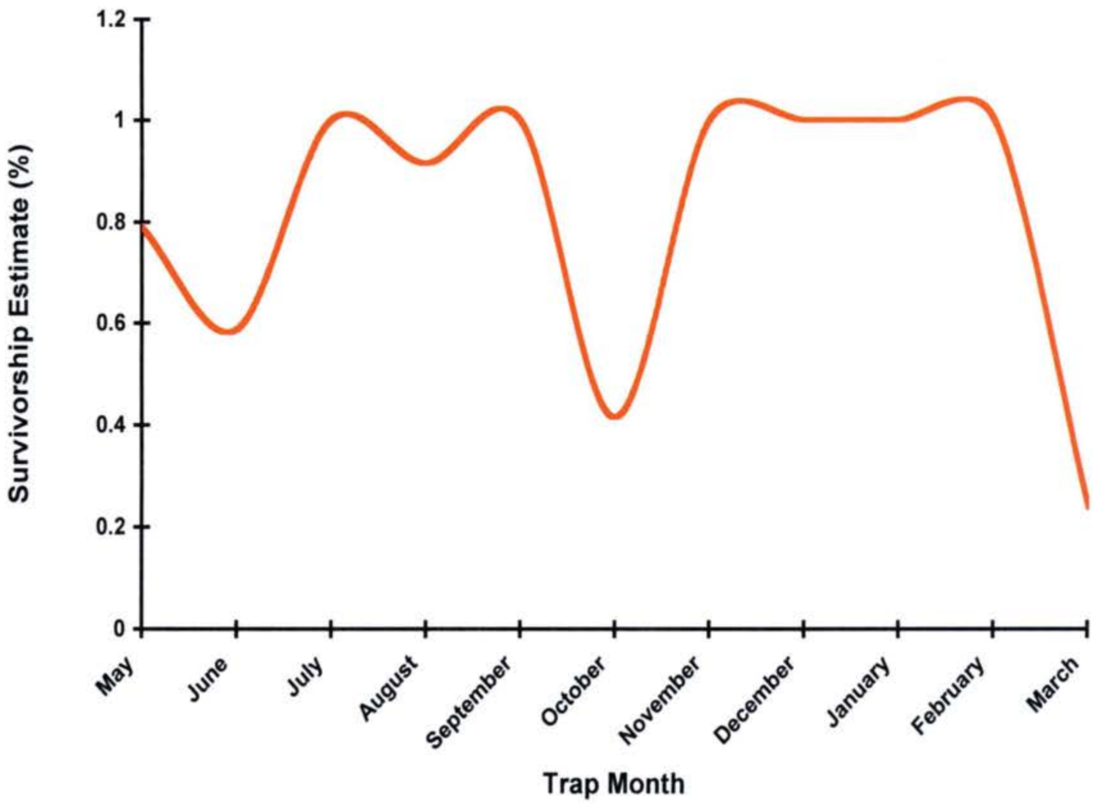

Figure 5. Monthly survivorship estimates using program MARK for *Peromyscus* captured in the 2 burned units from May 2005 – April 2006.

valliceps), cliff chirping frog (*Syrrophus marnockii*), ground skink (*Scincella lateralis*), fence lizard (*Sceloporus undulatus*), black-headed snake (*Tantilla*), Hurter's spadefoot toad (*Scaphiopus hurteri*), green tree frog (*Hyla cinerea*), narrow-mouthed toad (*Gastrophryne olivacea*) and grey tree frog (*Hyla versicolor/chrysoscelis*). Herptile captures were recorded monthly and averaged for burned and unburned units (Table 5). No significant difference was found between amphibian (P = 0.2218, t-stat = 1.2575, df = 22) or reptile (P = 0.5064, t-stat = -0.6754, df = 22) abundance along the burned and unburned trap line.

Houston toad juveniles were collected at Pond 10, Harmon road, and Pond 1. Pond 10 is a designated Houston toad breeding pond. Since 1990 (Dixon et al. 1990, Price 1990 1992 1993), nightly call surveys have been conducted during rainy nights of the breeding season. During my study, toads were not found at the Pond 2 Treatment 2 management unit that was burned in 2004.

All Houston toads captured during my study were juveniles (using body length estimates and pelage coloration), therefore to compare size differences, the SUL and weight ratio was used. The mean ratio of toads found in the treatment units was 0.06175 and the mean ratio of toads found in the control units was 0.058. The results from the SUL and weight ratios showed no significant difference (P > 0.80; t = 0.2046; df = 8) between burned and unburned units. Amphibian (P = 0.3064, t-stat = 1.0497, df = 20) and reptile (P = 0.6456, t-stat = -0.4669, df = 20) abundance was also found to be non-significant between units.

Table 5. Monthly amphibian and reptile total captures from the 4 trap lines during May 2005 through April 2006. Specimens were collected in pitfall traps or found while walking the trap line. Only those individuals collected within 10-m of the trap line were counted.

	Burned		Unburned	
Trap Month	Amphibians	Reptiles	Amphibians	Reptiles
May - 05	0	0	0	1
June	1	5	8	2
July	9	1	4	1
August	6	0	2	6
September	8	3	2	4
October	5	1	0	0
November	3	3	0	0
December	0	0	1	0
January - 06	0	1	0	0
February	0	0	0	1
March	0	0	0	3
April	3	2	0	4
Total	**35**	**16**	**14**	**14**

Vegetation Plot Results

Few forest structure differences were seen between burned and unburned units. The area of mid-story and over-story was comparable among all 4 management units (Figure 6). No difference was seen between loblolly pine and oak basal areas among the burned and unburned units (Figure 7). Eastern red cedar (*Juniperus virginiana*), however, was absent from both burned units and was the only species not found along all 4 trap lines. Differences were seen between herbaceous cover within the burned and unburned units (Figure 8). Pond 2, Pond 1, and Pond 10 had comparable average duff layer depths (Figure 9). Harmon road had the deepest average duff layer depth of 10.3-cm.

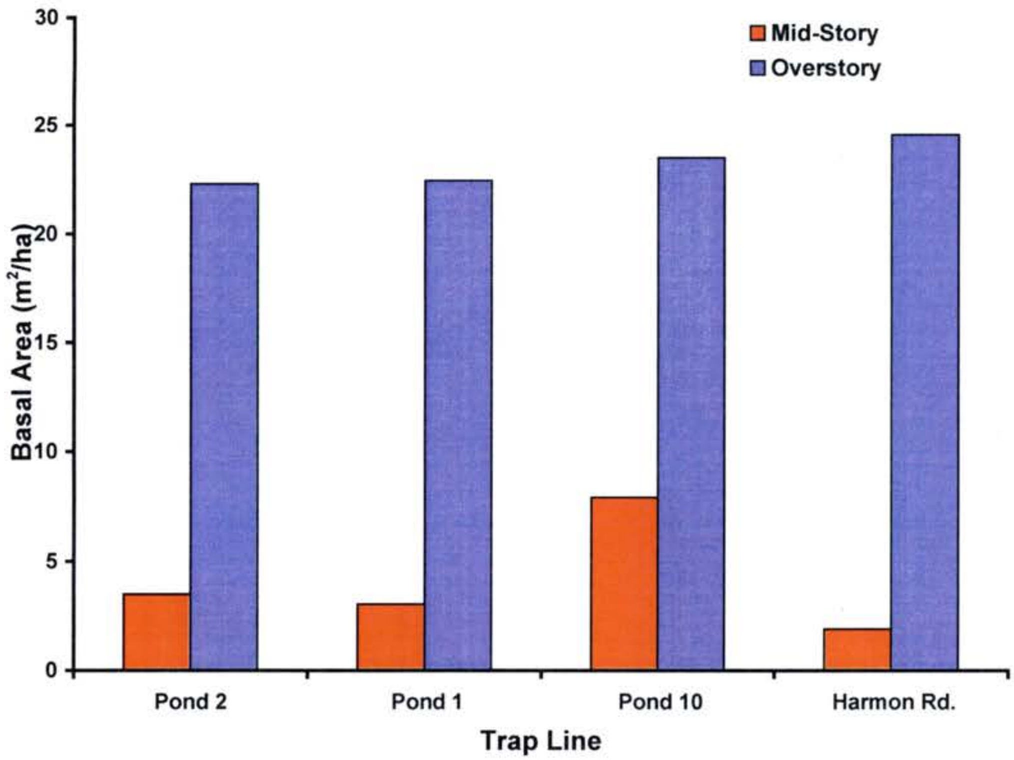

Figure 6. Basal Area (m^2/ha) of mid-story and over-story forest structure within the burned and unburned management units. Over-story measurements were recorded in a 50-m X 20-m plot and mid-story measurements were recorded in a 25-m X 10-m plot. Data were collected in summer 2005.

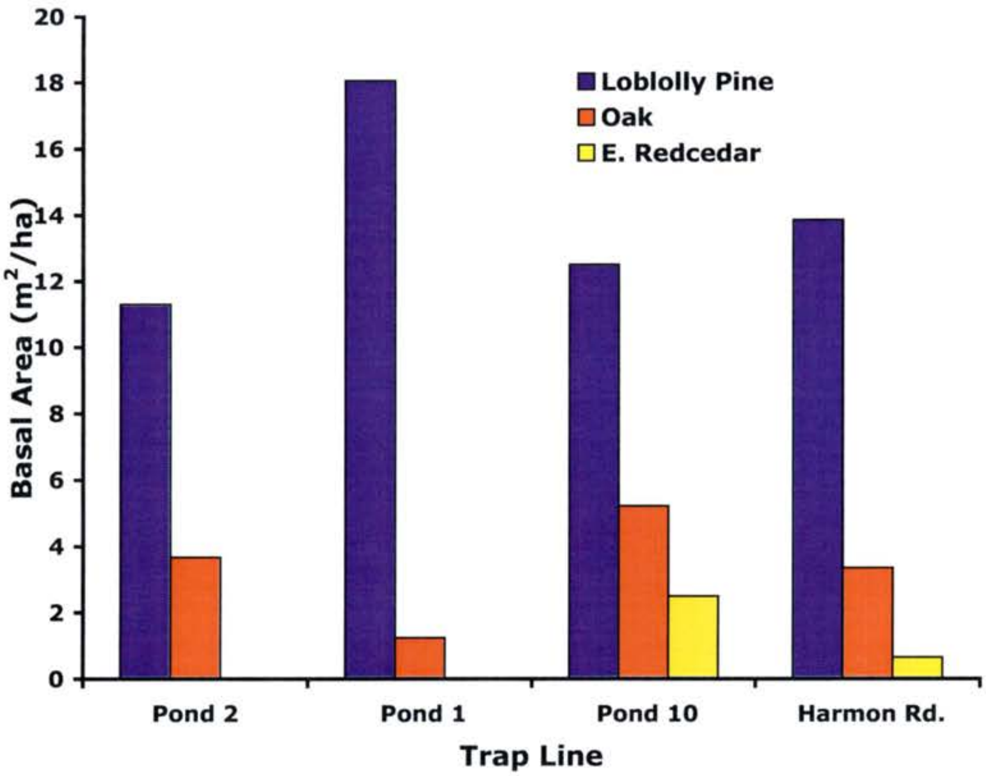

Figure 7. Basal areas of loblolly pine, oak, and redcedar were measured along the 4 management units. Area was defined as m^2/ha. All species were recorded in a 50-m X 20-m plot. Measurements were taken in summer of 2005.

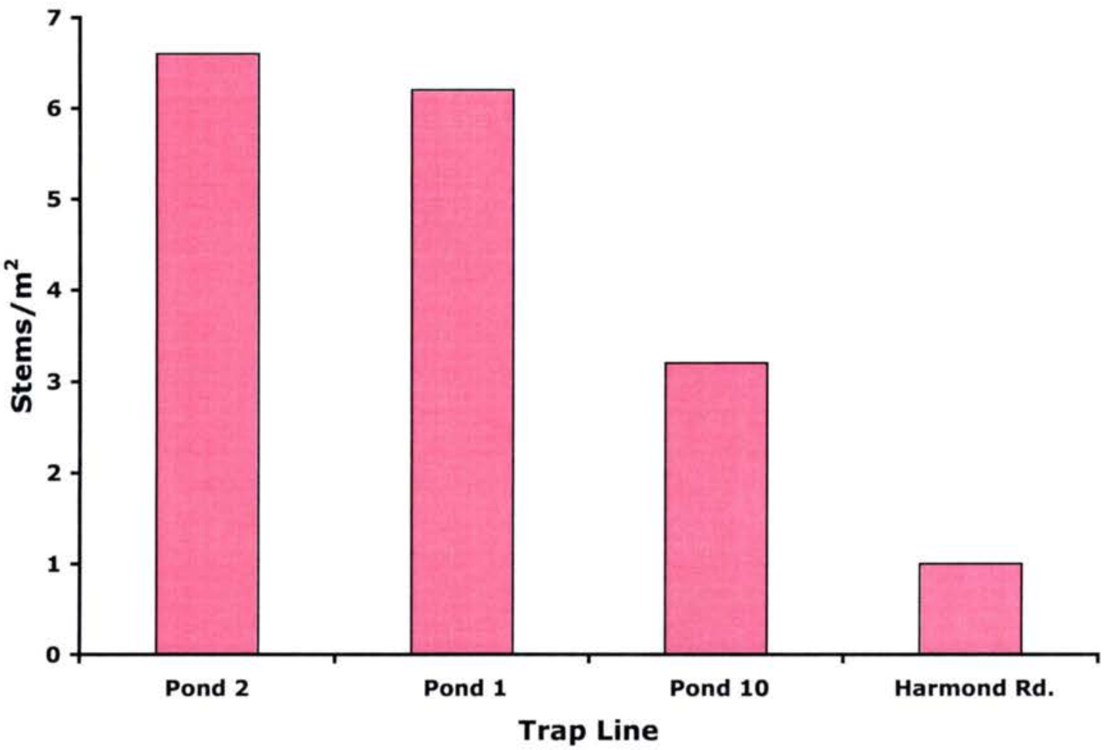

Figure 8. Basal area of herbaceous vegetation found along the burned and unburned management units. Herbaceous cover was measured by stems/m^2. Measurements were taken in summer of 2005.

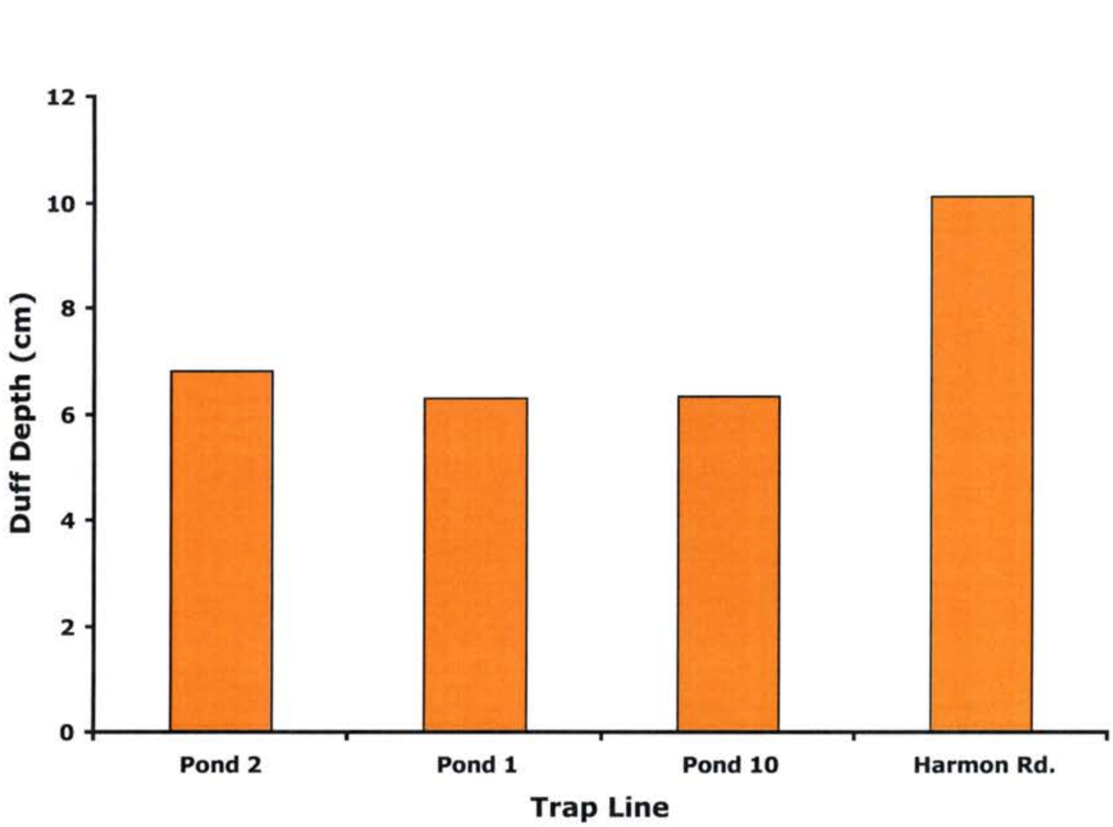

Figure 9. Duff depth measured to the nearest cm along each of the 4 management units. Measurements were conducted using metal flagging and then measured against a ruler. Four measurements (N, S, E, W) were taken at each of the 10 pit fall traps located along each unit. The measurements were averaged to get duff depth average.

CHAPTER IV

DISCUSSION

Small mammal abundance differed among burned and unburned units (Figure 10). In multispecies mammalian communities, generalists are expected to be more numerous than specialists (Churchfield 1991). During my study, *Peromyscus* were the most abundant and most commonly collected small mammal. Burned units contained greater numbers of *Peromyscus* than unburned units.

Small mammal diversity was also compared between burned and unburned units. Unburned units had higher species diversity (4 species) than burned units (3 species). *Peromyscus* were found on all 4 trap lines, however, shrews were only collected in the unburned units and 2 hispid cotton rats (*Sigmodon hispidus*) were only collected in the burned units. *Peromyscus* are considered generalist species and are therefore found in a wide variety of habitats. Shrews, on the other hand, are specialists and can be more selective in habitat preference. Shrews commonly occupy moist environments with rank ground vegetation with > 50% herbaceous cover (Miller and Getz 1977) and an abundance of invertebrates (Churchfield 1990). Shrews may not be present after fires if intensity was high enough to consume the litter layer (Fisher and Wilkinson 2005). Duff layers among 3 of the management units had comparable average depths. Harmon road was the only trap line with a visually deeper duff layer. Since duff depth was

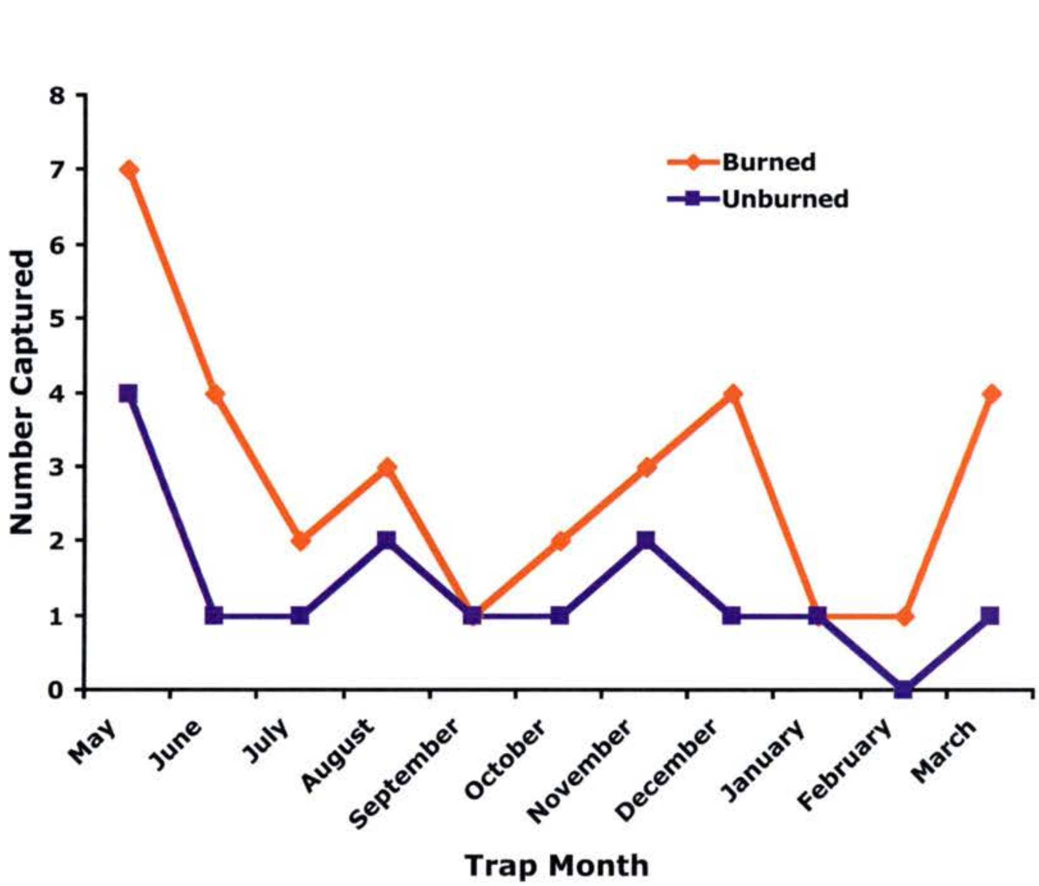

Figure 10. Total capture numbers for all small mammals captured in each of the 4 management units (May 2005- April 2006) in Bastrop State Park. Only original captures are used in analysis.

similar between burned and unburned units, another environmental factor, such as invertebrate abundance, might explain shrews' preference for the unburned trap lines. An interesting evolutionary adaptation has been found among the shrews captured in Bastrop State Park. Three shrews, 2 *Blarina* and 1 *Cryptotis* have been found lacking external eye openings (Jones et al. in review 2006) although developed and possibly functional eyes exist underneath. Shrew eyesight is limited and is not a major sense used in foraging (Churchfield 1990), therefore it is suggested that this phenomenon has no negative effects towards survival.

The presence of cotton rats along my burned (Pond 1) trap line was not expected due to their habitat preference. Cotton rats prefer tall grassland areas that allow for movement under a protective canopy (Schmidly 2004). These 2 captures could possibly suggest a small population exists along the burned trap line or the captures could be the result of transient rats in search for more suitable habitat. Small patches of grassland areas are found in the park and within close proximity of the Pond 1 trap line.

During my study, small mammal trapping frequency was 4.88 new individuals per month. May 2005 had the highest trap rate with 14 initial captures. This coincides with the spring breeding season of *Peromyscus*. *Peromyscus* undergo 2 periods of reproductive activity, spring and fall (Goundie and Vessay 1986) with a decrease in summer births (Rintamaa et al. 1976). Millar (1978) studied *Peromyscus* breeding season from April through October, however, breeding season can vary by geographic location. The trapping frequency of my study was similar to the trapping frequency reported by Dixon et al. (1989, 1990). Dixon et al. (1990) showed a monthly trapping average of 4 individuals per month. Five small mammal species were captured during my study.

In the 1989 survey in Bastrop State Park (Dixon et al. 1989) *Baiomys taylori* (northern pygmy mouse), *Neotoma floridana* (eastern woodrat) and *Reithrodontomys fulvescens* (fulvous harvest mouse), were captured. These 3 taxa were not captured during my study. The absence of these species from my trap data is likely a consequence of the habitat in which trapping occurred. The pygmy mouse and fulvous harvest mouse prefer and are commonly captured in grassy and open field areas (Schmidly 2004). During my study, all 4 trap lines were devoid of any grassy open field areas.

Recapture Results

My study had a highly successful recapture rate of 45.1 %. Seventy six percent of the recaptures were from the burned trap lines. In months with high recapture rates, initial capture rates dropped (Figure 11). Similar mark recapture studies have shown higher monthly recapture rates compared to initial capture rates (Chitty and Kempson 1949, Morris 1955). One possible explanation for this trend is reproduction. In an open population, recruitment due to breeding season can affect capture rates. The only months when initial captures were higher than recaptures were during the spring breeding season. During the summer, when births rates are low, it can be expected to have a higher recapture rate. Differences might also be habitual, resulting from a predictable food source. Although recruitment might be the primary factor, habituation to traps and a predictable food source could increase recapture rates. Several conclusions can be drawn from *Peromyscus* weight and body length comparison among burned and unburned units. A significant positive linear relationship exists between body weight and total body length of *Peromyscus leucopus* ($R^2 = 0.5237$), therefore, as body length

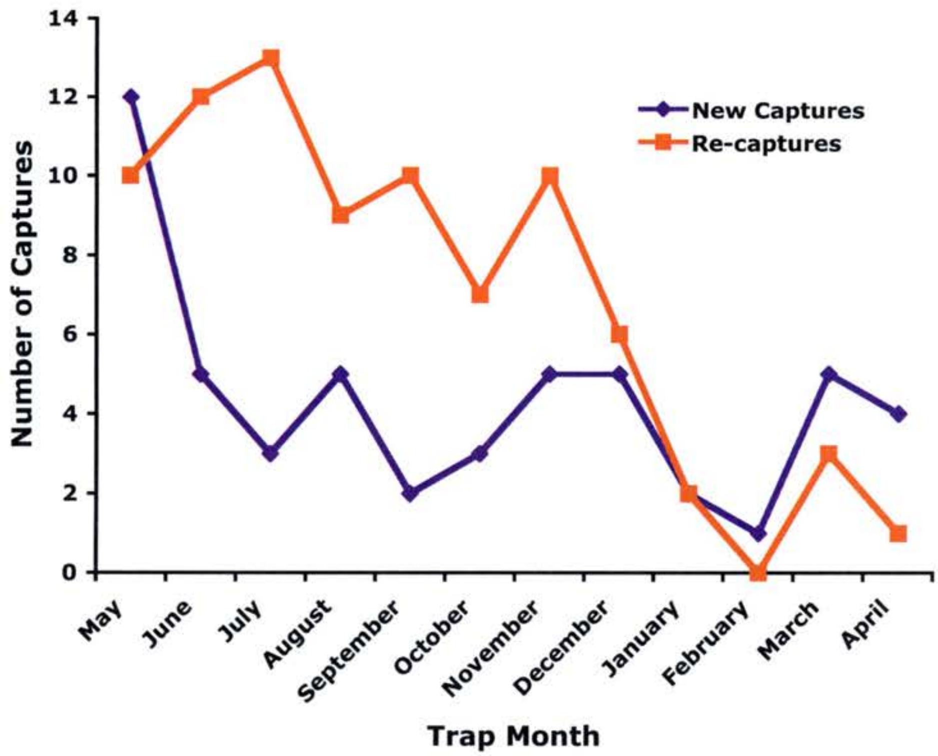

Figure 11. Monthly captures (new and recaptures) from burned and unburned management units during each trap month (May 2005 through April 2006). Only *Peromyscus* captures were included in the capture totals.

increased total body weight also increased. Body weight is a measurable parameter used to suggest the health of a population (Layne 1968, Latto 1992). When comparing populations of the same species in the same geographic regions, the populations with heavier body weight usually suggests a healthier population because it is a better predictor of fecundity and food consumption than other characters (Latto 1992). When body weight was compared among the burned and unburned units, the relationship was not significant ($p= 0.3134$). Body weight has been found to fluctuate seasonally in *Peromyscus* due to winter weight loss and pregnancy effects (Iverson and Turner 1974, Millar 1975). A scatter plot of body weight from all adult *Peromyscus* collected during my study shows no support that seasonally weight fluctuation is affecting the regression analysis (Figure 12). Therefore, it cannot be concluded that *Peromyscus* from the burned units are heavier, therefore healthier than those individuals from the unburned units.

Changes in abundance are dependent upon reproduction, mortality, and movement (Terman 1968). During my study, many individuals were recaptured monthly, allowing me to calculate survivorship and recapture estimates. Survivorship estimates, just as weight comparison, can help suggest the health of a population. The life expectancy of a *Peromyscus* is fairly short. Limited evidence has shown that very few *Peromyscus* survive a year in the wild (Burt 1940, Blair 1953). Short life expectancy allowed me to collect mark-recapture on complete life spans starting at sexual maturity. For *Peromyscus leucopus,* the estimated percentage of mortality by 1 year is 96% and is 99% in *Peromyscus maniculatus* (Howard 1949, Blair 1953). There are a few environmental and small mammal natural history factors that might explain the survivorship curve seen in the burned units (see Figure 5). Estimated survivorship during

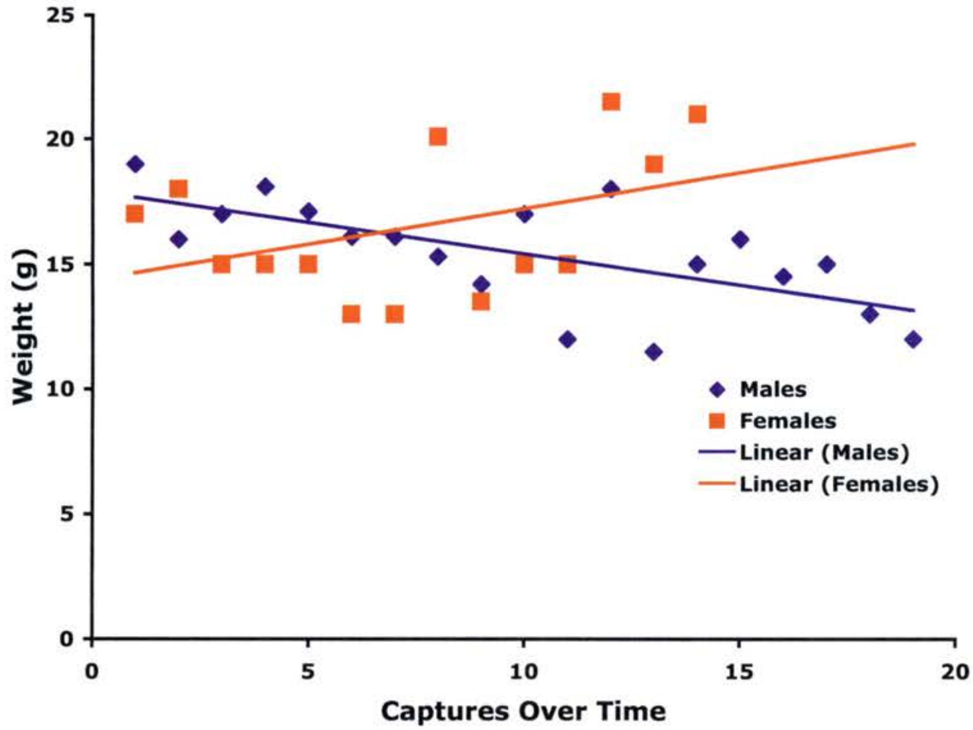

Figure 12. Weight of male and female adult *Peromyscus* captured from all 4 management units (May 2005 and April 2006). Data points are from 16 males and 13 females. Only the original capture and initial weight was used in the calculations. Mice not yet showing adult pelage coloration were considered juveniles and were not included in the calculations.

the summer months (June – September), was ≥ 80%. Breeding occurs in early spring, possibly increasing estimated survivorship due to recruitment. Spring and summer are characterized by vegetative growth, leading to an increase in seed abundance and overall food supply for small mammals.

If health is not a distinguishing factor in explaining the greater *Peromyscus* abundance of the burned units, perhaps home range availability is the key factor. Food supply, vegetative structure, weather, sex, age, and season are all factors that determine a species home range (Stickel 1968). The number of transient mice in burned units (64%) was greater than unburned units (30%). The burned units had 14 resident mice and 16 transient mice, whereas, unburned control units had 7 resident mice and 3 transient mice. The number of transient mice is possibly related to recruitment. The greater number of transient mice found in the burned units suggests *Peromyscus* are taking advantage of open canopy and exposed seed bed, and therefore moving into the area. Increased recruitment also suggests the habitat in the burned area is healthier due to the increased food supply.

My results from weight comparisons, abundance estimates, and resident mice populations, and survivorship estimates between burned and unburned units suggest *Peromyscus leucopus* are not negatively affected by low intensity fire. Masters et al. (1998) suggested harvest treatments benefit small mammal communities by increasing sunlight penetration, reducing forest floor litter, and creating the re-sprouting of hardwoods. Fisher and Wilkinson (2005) found white-footed mice initially dominated in burned pine forest following disturbance by fire and timber harvest due to their ability to find food in burned areas where seeds are abundant. McMurry et al. (1996) reported a peak abundance of white-footed mice on disturbed (fire and herbicide) sites as opposed to control sites. In my study, differences in relative abundance between burned and unburned units could possibly indicate low intensity fires provide more suitable habitat than unburned areas by increasing food supply and provide necessary home range factors.

Vegetation

The vegetative composition of the burned and unburned management units did not significantly differ in number of trees, seedlings, herbaceous vegetation or total percent vegetative cover. Fire suppression has been linked to hardwood encroachment on pine forests (Waldrop et al. 1992). When fire is removed hardwood seedlings become established and quickly out compete pine seedlings for sunlight and nutrients. The shaded pines become week and susceptible to disease and are eventually replaced by hardwood trees and thick woody vegetation. Stand replacing fires are able to alter forest habitat quickly and destructively. Pine tree seedlings, however, have ecological adaptations to survive low intensity fires (Hermann et al. 1998) all of which hardwood species lack. Even low intensity fires can prevent hardwood seedlings from surviving. Although differences were not seen between loblolly pine and oak abundance in my management units, the burns are fairly recent. It may be too early to determine if these fires are reducing hardwood seedlings. In order to accurately support or reject fire as an effective management tool vegetative data will need to be recorded for a number of years following a burn.

There were some significant differences in vegetation composition between burned and unburned units. Differences in duff layer height from my study may further suggest fire is effectively, although slowly, reversing the effects of fire suppression. Pond 1 contained a greater abundance of herbaceous ground cover. The ground cover abundance is a result of fire opening up the canopy and clearing the dense leaf litter, allowing for sunlight penetration and seed implantation and growth. Eastern redcedar was the only plant species not found within the 2 burned units. Eastern red cedar is the most rapidly expanding woody species on rangeland (Wilson and Schmidt 1990) and has been estimated to have infested over 550,000 ha in east-central Texas (Grumbles 1989). It has been suggested that primary factors behind its rapid expansion are expanded seed source, soil disturbance, and fire suppression (Schmidt and Stubbendieck 1993). Along with controlling hardwood seedlings, low intensity fires may also prevent redcedar from being established.

Although prescribed fire is an effective forest management tool, burns must be administered on a continual cycle to control succession. Studies have shown that southern pine forests benefit from low intensity fires that occur every 1-5 years (Brose and Wade 2001, Means et al. 2004) and that herbaceous plants increase with increasing fire frequency (Waldrop et al. 1992). These close fire prescriptions closely mimic the historic fire regime.

Overall, the current vegetative data do not conclude that significant differences exist between the burned and unburned units. Therefore it is not surprising that significant differences in diversity, health, and survivorship of small mammals were not seen between the 4 management units.

Weather and Trapping

Weather patterns did not seem to have a strong effect on the rate of capture throughout this study. Average monthly temperature and relative humidity showed no correlation with monthly capture rates (Figure13, Figure 14). Changes in weather patterns have been found to affect trapping rates in other small mammal studies. Drickamer and Capone (1977) found more mice were caught on overcast nights or light rain than dry or heavy rain evenings. Vickey and Bider (1981) reported relative humidity did not affect capture rate as much as temperature and cloud cover. Extreme temperature during my winter trapping months did not seem to have any effect on capture rates. A hard freeze during the trap week in December forced temperatures drop from 25.55 ° C (Novembers average temp) to 1.66 ° C. During the freeze, 5 new individuals were captured resulting in the second highest monthly capture rate. Rain also accompanied the freeze, possibly increasing movement and foraging behavior of *Peromyscus* during extremely low temperatures. Vickery and Bider (1981) showed small mammal species, including *Peromyscus*, were most active on nights when rain fell and temperatures were high. Although temperatures were considerably lower in December, the presence of rain during severe drought conditions might have lead to the high monthly capture rate.

Results From Pitfalls

None of the 40 pitfall traps captured shrews during my study. Drift fences were not used due to trap line length and difficulty of maneuvering around downed logs and and woody vegetation. Dixon et al. (1990) placed drift fences along their trap lines in hopes of funneling shrews and increasing pitfall trap efficiency. During their study, 2

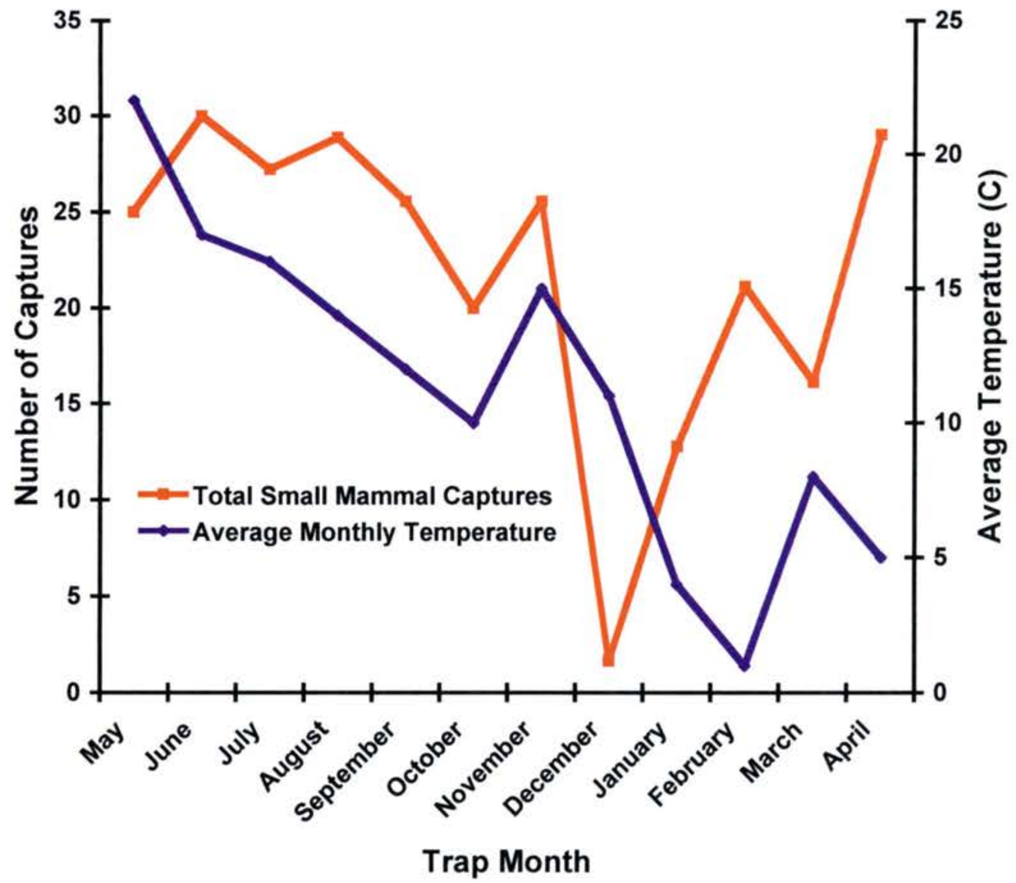

Figure 13. Comparison of monthly capture rates to average monthly temperature for *Peromyscus* captures from 2 treatment (burned) and 2 control (unburned) management units in Bastrop State Park (May 2005 – April 2006). The captured individuals are illustrated in red and the average monthly temperature is illustrated in blue.

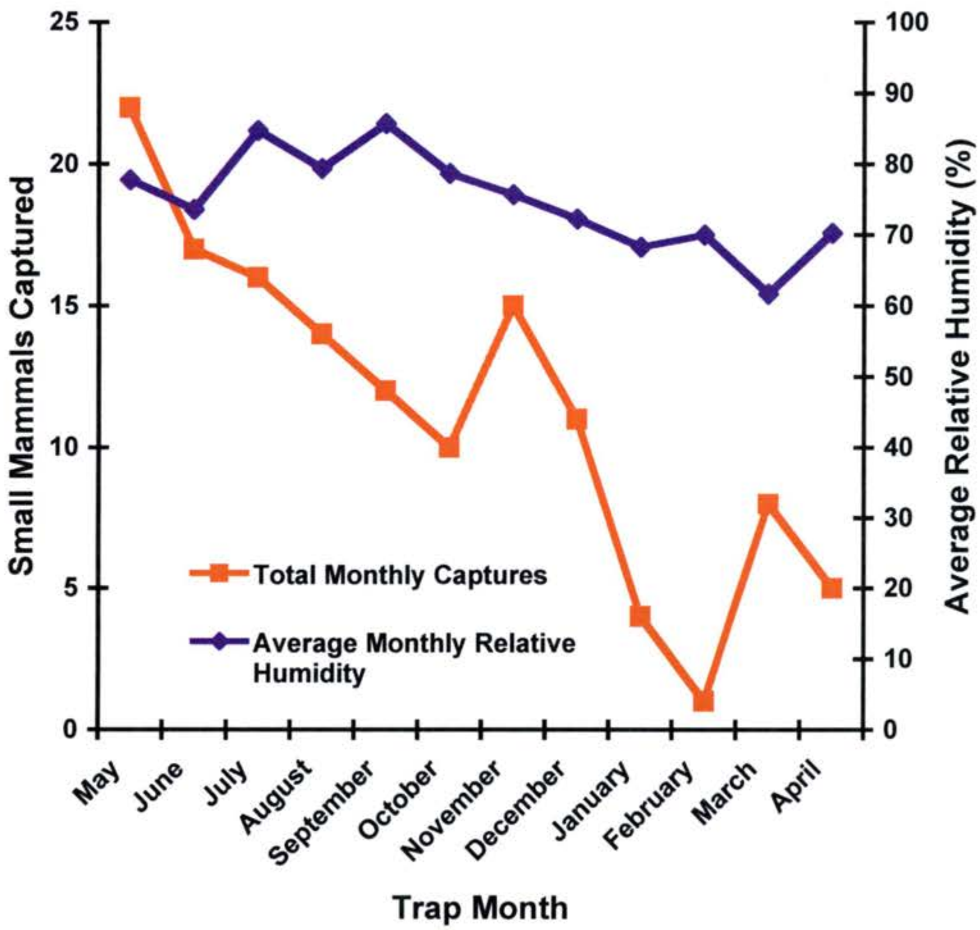

Figure 14. Comparison of monthly capture rates to average monthly relative humidity for *Peromyscus* captures from 2 treatment (burned) and 2 control (unburned) management units in Bastrop State Park (May 2005 – April 2006). The captured individuals are illustrated in red and the average monthly relative humidity is illustrated in blue.

shrews were captured in pitfall traps with only 1 capture post drift fence (Dixon et al. 1990). As a result of Dixon et al. (1990), and difficulty in instillation, no drift fences were placed along my trap lines. Pitfalls successfully captured a number of amphibians and reptiles on all 4 trap lines. The collection of 2 cliff chirping frogs (*Syrrophus marnockii)* was an unexpected find. The *Syrrophus* county record was recorded in 1989 with the capture of 2 gravid females (Dixon et al. 1989) and was suggested that these specimens might have been a relict of a formerly widespread distribution. Collecting 2 more specimens (1 gravid female) during my study, further supports the possibility of a remaining population in Bastrop State Park. One specimen, collected on 17 August, 2005, was prepared as a voucher specimen (MF 19168) and deposited at TCWC in College Station, TX (TCWC 90737).

Eleven juvenile Houston toads were captured in pitfall traps in 3 management units. The collection of juvenile Houston toads suggests successful breeding is still occurring within the park. Five toads were captured along the Pond 1 trap line (burned 2003) and 3 toads were captured in each of the unburned units. No toads were captured in along the Pond 2 trap line (burned 2004). These data suggest a decrease of Houston toad abundance might occur shortly after prescribed fire, however, leading to quick and successful recolonization 1 year later. Unfortunately preburn populations are unknown, therefore, full fire impacts cannot be concluded. Further studies should be done to determine the population before and after prescribed fire is implemented around a known breeding pond.

Differences in Houston toad weight and SUL were non-significant between the treatment and control units; therefore, it cannot be suggested that toads in the burned treatment units are healthier. Amphibian and reptile abundance had no significant difference between burned and unburned units. Amphibians can be sensitive to slight habitat change and composition. Since vegetative differences and Houston toad weights did not vary between management units, differences in amphibian and reptile abundance were not expected.

Pitfall predation, although not considered a primary possibility, could have been a factor in the absence of small mammal captures and impacted herptile collection. Pitfall trap predation has been documented in shrews and other small mammal capture studies (Jenkins et al. 2003). Ferguson et al. (unpublished thesis 2005) quantified activities and impact of vertebrate predators on captured animals. Photographs successfully captured predators around pitfalls and partially consumed amphibians were discovered within and around the traps. Studies conducted in areas containing endangered or threatened species susceptible to extinction, such as the Houston toad, should be executed cautiously. No evidence of pitfall trap predation was documented during my study.

Impact on Houston Toads

Pond 1, Pond 2, and Pond 10 are known breeding ponds for Houston toads. In 1989, Pond 10 was documented as having the highest concentration of Houston toads within the park (Dixon et al. 1989). Houston toads are known to breed in permanent ponds surrounded by sandy loam soils (Dixon et al. 1989). Currently, the state of Texas is in a severe drought. Drought conditions began in the summer of 2005 and have extended well into the spring of 2006. The drought caused many of the known Houston toad breeding ponds in Bastrop State Park to become dry. By October 2005, Pond 1was dry and by January 2006, Pond 2 also was dry. A series of thunderstorms during April 2006 temporarily provided small amounts of water to Pond 1 and Pond 2. Evening call surveys were conducted in Bastrop State Park during this week. Houston toads were heard chorusing throughout the park, however, no toads have been heard this year at Pond 1 and Pond 2. Toads were heard chorusing at Pond 10.

CHAPTER V

CONCLUSION

From this study it can be determined that prescribed fire is an effective forest management tool. Significance difference in small mammal abundance suggests prescribed fire is beneficial to their populations. Amphibian and reptile populations are not affected by low intensity fire, further suggesting that these fires are not drastically altering habitat composition and are instead slowly restoring the natural fire regime. Most importantly, the prescribed fires administered by the park are not negatively affecting Houston toad populations.

Houston toad abundance dramatically decreases every year. Habitat loss is thought to be the primary factor leading to their declining numbers. Leaf litter build up makes burrowing in the sandy loam soils difficult for the toad, therefore fire management began to remove the thick duff layer. If toads are unable to burrow, they can suffer from various effects of exposure such as adverse weather and predation. Results from my study concluded that fire has been effective in removing the duff layer, making burrowing easier. Unfortunately drought conditions are affecting the Houston toad populations.

Vegetative composition between burned and unburned units were found to be similar but their implications are significant. Vegetative data conclude that the fire prescriptions are being correctly and effectively implemented. Low intensity fires should slowly alter habitat and allow for forest species to adapt to the slight changes. Speeding up the process by increasing the fire intensity can quickly decrease populations of sensitive species, such as the Houston toad.

My current research will provide Bastrop State Park with an informative analysis of the progress and success of their management burns. Further research should be done on Bastrop State Park further documenting forest succession and future vegetation changes. Vegetative measurements should be done on an annual basis and graphed over an extended period of time. Small mammal trapping should be continued in order to increase sample size, therefore providing more accurate survivorship estimates.

Appendix 1: List of all captured *Peromyscus* from May 2005 until April 2006 at Bastrop State Park, Bastrop County, Texas. All specimens were collected in Sherman Live Traps along four trap lines (2 burned, 2 unburned). Standard measurements were taken for analysis purposes. Question marks represent unknown data due to loss of individuals while collecting data.

Date	Voucher #	Trap Line	Species	Gender	Total Length (mm)	Tail Length (mm)	Hfoot Length (mm)	Ear Length (mm)	Weight (g)
28-May-05	MJ-02 # 6	Pond 2	P. leucopus	F	138	70	19	9	17
29-May-05	MJ-03	Harmon Rd.	P. leucopus	F	122	61	18	13	18
29-May-05	MJ-04	Pond 2	P. leucopus	M	128	72	20	11	19
29-May-05	MJ-05 # 4	Pond 2	P. leucopus	F	152	64	20	9	15
29-May-05	MJ-07 # 1	Pond 10	P. leucopus	M	142	65	16	15	16
29-May-05	MJ-08	Pond 10	P. leucopus	F	125	67	18	12	15
30-May-05	MJ-10	Pond 2	P. leucopus	F	122	60	18	13	15
30-May-05	MJ-11	Pond 10	P.maniculatus	F	128	54	19	14	13
30-May-05	MJ-48	Pond 1	P. leucopus	F	132	66	19	14	13
31-May-05	MJ-14 # 11	Pond 2	P. leucopus	M	151	70	20	14.5	17
15-Jun-05	MJ-16 #2	Pond 2	P. leucopus	M	150	66	20	12	18.1
15-Jun-05	MJ-17 #3	Pond 1	P. leucopus	M	127	60	19	13	17.1
15-Jun-05	MJ-18 #5	Pond 1	P. maniculatus	M	140	61	19	14	16.1
17-Jun-05	MJ-24 # 10	Pond 10	P. leucopus	M	136	64	19	13	16.1
18-Jun-05	MJ-26 # 20	Pond 2	P. leucopus	F	139	60	?	?	20.1
14-Jul-05	MJ-43 # 13	Pond 10	P. leucopus	M	146	73	19	14	15.3
15-Jul-05	MJ-45 # 14	Pond 1	P. leucopus	M	142	65	18	13	14.2
13-Aug-05	MJ-53 # 16	Pond 2	P. maniculatus	M	156	81	19	16	17
14-Aug-05	MJ-57 # 21	Pond 10	P. leucopus	M	121	66	19	12	12
14-Aug-05	MJ-58 # 22	Pond 2	P. leucopus	F	129	60	18	12	13.5
15-Aug-05	MJ-59 # 23	Pond 2	P. leucopus	M	148	73	20	13	18
9-Sep-05	MJ-62 # 24	Pond 2	P. leucopus	M	169	79	21	15	20.5
8-Oct-05	MJ-67 # 25	Pond 2	P. leucopus	F	130	61	18	15.5	15

Date	Voucher #	Trap Line	Species	Gender	Total Length (mm)	Tail Length (mm)	Hfoot Length (mm)	Ear Length (mm)	Weight
9-Oct-05	MJ-68 # 26	Harmon Rd.	P. leucopus	M	135	61	19.5	15	11.5
11-Oct-05	MJ-69 # 30	Pond 1	P. leucopus	F	129	62	19	12.5	15
5-Nov-05	MJ-72 # 31	Pond 2	P. leucopus	F	147	67	19	15.5	21.5
6-Nov-05	MJ-73 # 32	Pond 2	P. maniculatus	F-Juvi	113	51	18.5	?	9.5
7-Nov-05	MJ-75 # 33	Pond 10	P. leucopus	M	138	61	20	15	15
8-Nov-05	MJ-76 # 34	Pond 1	P. leucopus	F	149	71	18	13	19
12-Dec-05	MJ-77 # 35	Pond 2	P. leucopus	F	134	62	19	14	?
7-Dec-05	MJ-78 TM	Pond 1	P. leucopus	M-Juvi	105	42	15	12	7.6
8-Dec-05	MJ-80 TM	Pond 1	P. leucopus	M-Juvi	120	55	17	18	11
8-Dec-05	MJ-82 TM	Pond 2	P. leucopus	M	145	73	18	20	16
22-Jan-06	MJ-84 # 36	Pond 2	P. leucopus	F	145	67	18	13	21
26-Feb-06	MJ-85 # 40	Pond 2	P. maniculatus	M	127	61	18.5	13	16
19-Mar-06	MJ-86 # 41	Pond 2	P. leucopus	Juvi	106	51	19	11	9.5
19-Mar-06	MJ-87 # 42	Pond 1	P. leucopus	Juvi	117	53	19	14	12
20-Mar-06	MJ-88 # 43	Pond 2	P. leucopus	Juvi	121	63	18	13	12
20-Mar-06	MJ-89 #44	Pond 1	P. leucopus	Juvi	121	63	19	13	9
21-Mar-06	MJ-90 # 45	Pond 10	P. maniculatus	M	146	60	20	13	14.5
21-Apr-06	MJ-91 # 50	Pond 2	P. leucopus	F	146	61	18.5	13	?
21-Apr-06	MJ-92 # 51	Pond 2	P. leucopus	M	123	63	19	15	15
21-Apr-06	MJ-93 # 52	Pond 1	P. leucopus	M	126	61	18	13	13
22-Apr-06	MJ-94 # 53	Pond 1	P. maniculatus	M	127	65	19	12	12

Appendix 2. List of all captured amphibians and reptiles from May 2005 until April 2006 at Bastrop State Park, Bastrop County, Texas. All Specimens were collected in pitfall traps located along 4 trap lines (2 burned, 2 unburned). *Bufo houstonensis* captures are highlighted in blue.

Date	Trap Line	Species
15-Jun-05	Pond 1	Scincella lateralis
15-Jun-05	Pond 1	Rana spenocephala
15-Jun-05	Pond 10	B. houstonensis
16-Jun-05	Pond 10	Syrrohpus marnockii
16-Jun-05	Pond 2	Sceloporus undulatus
16-Jun-05	Pond 2	Bufo?
16-Jun-05	Pond 2	Bufo Unknown
16-Jun-05	Pond 10	Scincella lateralis
16-Jun-05	Pond 1	Sceloporus undulatus
17-Jun-05	Pond 10	B. houstonensis
17-Jun-05	Pond 1	Sceloporus undulatus
17-Jun-05	Pond 2	Tantilla sp
17-Jun-05	Pond 1	Scincella lateralis
18-Jun-05	Pond 10	Scincella lateralis
10-Jul-05	Harmon Rd	B. houstonensis
13-Jul-05	Pond 1	B. houstonensis
13-Jul-05	Pond 1	B. houstonensis
14-Jul-05	Pond 1	Rana spenocephala
14-Jul-05	Pond 10	Bufo valliceps
14-Jul-05	Pond 10	Bufo valliceps
14-Jul-05	Pond 10	Hyla chrysoscelis
14-Jul-05	Pond 10	Syrrohpus marnockii
14-Jul-05	Pond 2	Bufo valliceps
14-Jul-05	Pond 10	Sceloporus undulatus
15-Jul-05	Pond 1	B. houstonensis
15-Jul-05	Harmon Rd	B. houstonensis
15-Jul-05	Harmon Rd	B. houstonensis
15-Jul-05	Pond 1	Rana spehenocephala
15-Jul-05	Harmon Rd	Scincella lateralis
16-Jul-05	Pond 1	Rana spenocephala
16-Jul-05	Pond 2	Bufo valliceps
17-Jul-05	Pond 1	Bufo houstonensis
17-Jul-05	Pond 2	Terrapene carolina
12-Aug-05	Pond 10	Terrapene ornata
13-Aug-05	Pond 1	Rana sphenocephala
13-Aug-05	Pond 1	Bufo valliceps
13-Aug-05	Pond 1	Rana sphenocephala
13-Aug-05	Pond 1	Bufo valliceps
14-Aug-05	Pond 10	Scincella lateralis
14-Aug-05	Pond 10	Bufo valliceps
14-Aug-05	Pond 10	Bufo houstonensis
15-Aug-05	Pond 2	Scaphiopus hurteri
16-Aug-05	Pond 1	Rana Spenocephala
16-Aug-05	Pond 10	Scincella lateralis
9-Sep-05	Pond 10	Scincella lateralis
9-Sep-05	Pond 10	Scincella lateralis
9-Sep-05	Pond 1	Sincella lateralis
10-Sep-05	Pond 10	Rana sphenocephala
10-Sep-05	Pond 10	Scincella lateralis
10-Sep-05	Harmon Rd	Sincella lateralis
10-Sep-05	Pond 2	Bufo valliceps
10-Sep-05	Pond 2	Bufo valliceps

Date	Trap Line	Species
10-Sep-05	Pond 2	Bufo valliceps
11-Sep-05	Pond 1	Rana sphenocephala
11-Sep-05	Harmond Rd	Sceloporus undulatus
11-Sep-05	Pond 2	Bufo valliceps
11-Sep-05	Pond 2	Bufo valliceps
11-Sep-05	Pond 10	Bufo valliceps
11-Sep-05	Harmon Rd	Sceloporus undulatus
12-Sep-05	Pond 1	Bufo valliceps
12-Sep-05	Pond 1	B.houstonensis
12-Sep-05	Pond 1	Micrurus fulvus
12-Sep-05	Pond 1	Scincella lateralis
12-Sep-05	Pond 2	Rana sphenocephala
12-Sep-05	Pond 10	Scincella lateralis
8-Oct-05	Pond 2	Scincella lateralis
10-Oct-05	Pond 1	Rana sphenocephala
10-Oct-05	Pond 2	Bufo valliceps
10-Oct-05	Pond 2	Bufo valliceps
11-Oct-05	Pond 2	Bufo valliceps
11-Oct-05	Pond 1	Bufo valliceps
5-Nov-05	Pond 2	Bufo Valiiceps
6-Nov-05	Pond 2	Scincella lateralis
6-Nov-05	Pond 2	Rana sphenocephala
8-Nov-05	Pond 1	Scincella lateralis
8-Nov-05	Pond 2	Rana sphenocephala
8-Nov-05	Pond 2	Scincella lateralis
7-Dec-05	Pond 10	Gastrophryne olivacea
20-Jan-06	Pond 1	Sceloporus undulatus
28-Feb-06	Harmon Rd	Sceloporus undulatus
19-Mar-06	Harmon Rd	Scincella lateralis
19-Mar-06	Harmon Rd	Scincilla lateralis
21-Mar-06	Pond 10	Scincella lateralis
20-Apr-06	Pond 10	Sceloporus undulatus
20-Apr-06	Pond 1	Rana sphenocephala
20-Apr-06	Harmon Rd.	Scincella lateralis
20-Apr-06	Harmon Rd.	Scincella lateralis
21-Apr-06	Pond 1	Bufo valiceps
21-Apr-06	Pond 2	Scaphiopus hurteri
22-Apr-06	Pond 1	Sceloporus undulatus
22-Apr-06	Pond 1	Scincella lateralis
22-Apr-06	Harmon Rd.	Scincella lateralis

Appendix 3. List of all captured *Bufo houstonensis* from May 2005 until April 2006 at Bastrop State Park, Bastrop County, Texas. All specimens were collected in pitfall traps along four trap lines (2 burned, 2 unburned). Toads were only collected from 3 of the four trap lines. Only those toads used in analysis are listed. An 11th toad (toadlet) was collected along Pond 1.

Date	Voucher #	Trap Line	Species	Gender	SUL (mm)	Head Width (mm)	Weight (g)
15-Jun-05	MJ-15	Pond 10	B. houstonensis	Juvinile	25	7	0.9 g
17-Jun-05	MJ-23	Pond 10	B. houstonensis	Juvinile	20	4	0.3 g
10-Jul-05	MJ-30	Harmon Rd	B. houstonensis	Juvinile	33	10	2.9 g
13-Jul-05	MJ-28	Pond 1	B. houstonensis	Juvinile	19	7.7	0.7 g
13-Jul-05	MJ-29	Pond 1	B. houstonensis	Juvinile	24	10	1.7 g
15-Jul-05	MJ-44	Pond 1	B. houstonensis	Juvinile	27	8	0.9 g
15-Jul-05	MJ-46	Harmon Rd	B. houstonensis	Juvinile	27	8	1.5 g
15-Jul-05	MJ-47	Harmon Rd	B. houstonensis	Juvinile	32	8	2 g
14-Aug-05	MJ-56	Pond 10	B. houstonensis	Juvinile	34	9	3 g
12-Sep-05	MJ-64	Pond 1	B. houstonensis	Juvinile	32	10	3.4 g

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